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SANITATION WITHOUT SEWERS – THE AQUA PRIVY

by Henry T Mann

A common problem in rural areas. The stream can be contaminated by seepage from the pit privy (p 2) situated to the left of right-hand house.

No 174 – also Duncan Mara, "Sewage Treatment in Hot Countries", Jan 77

Overseas Division
Building Research Establishment
Department of the Environment

BIOGRAPHICAL NOTE

Mr Henry Mann joined the Water Pollution Research Laboratory in 1941 and worked mainly on sea-water desalination until joining the Army in 1944. Service with the Army gave many opportunities for observing environmental and other problems associated with water and sanitation in may parts of the Far East including India, Pakistan, Malaysia and Thailand.

On returning to WPRL the author spent a number of years on pollution studies of the Thames, Colne and other rivers. From 1955 he studied the effects of detergents and other substances on fish life and also on sewage treatment processes. This was followed by a period of more general study of various biological filtration processes, including small-scale treatment plants and methods of tertiary treatment for effluents. In 1967 the author was seconded to the Government Chemist's Laboratory in Uganda to develop small-scale water treatment and sanitation systems for rural areas in the tropics. Several simple methods of water filtration were studied, as well as oxidation pond systems of sewage treatment, and the effects of chlorination on the cercaria of Bilharzia.

Since 1970 Mr Mann has been mainly concerned with low-cost treatment processes for farm wastes but has maintained contact with tropical problems and has carried out short studies on sewage purification in Libya and Algeria. He is at present with the Water Research Centre, which now incorporates the organisations of the Water Pollution Research Laboratory and the Water Research Association.

Mr Mann's papers have been published in a variety of journals including the IPHE (Institution of Public Health Engineers) and the East African Medical Journal.

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SANITATION WITHOUT SEWERS - THE AQUA PRIVY

by Henry T Mann, MIWES

This Note reviews low-cost sanitation systems that may be used when sewers cannot be provided, and describes one system - the aqua privy - in more detail.

INTRODUCTION

Modern waterborne sanitation is not possible in many parts of the tropical world and developing countries. Important reasons for this are shortage of water, lack of a piped supply to many dwellings, the need to employ low-cost systems, and the high cost of providing sewers for large numbers of people living in areas of very low population density. A smaller but significant number of people live in low cost, overcrowded, temporary housing without piped water or sewers in areas sometimes called shanty towns, often within the boundaries of established towns. Even when piped water is available, many areas experience long periods of water shortage every year. Since sanitation systems that use little or no water are of importance in all these situations, a number of such systems are briefly described here, with their advantages and disadvantages, to enable comparisons to be made.

When comparing sanitation systems in this context the following conditions should be met as far as possible, though no single system can satisfy every condition in every case. There may be times when choice is influenced more by what is possible than what is desirable. It must be emphasised that the best system will fail if improperly built or badly used.

The aqua privy is selected as a system that offers very good sanitary conditions. It probably involves less cost and requires less attention than any other system with the same standard of protection from smells, fly breeding and disease transmission.

CHARACTERISTICS REQUIRED OF SANITATION SYSTEMS

1 Wastes should be contained in a manner which involves little risk of either disease transmission to the users or infection of the soil, groundwater or surface water.

2 The possibility of contact between discharged wastes and people, animals or flies should be minimal.

3 Sanitation systems should not be unclean places; they should be kept as free as possible from smell nuisance and unsightly conditions.

4 Systems should not rely heavily upon abundant water supplies or skilled attention.

5 They should be simple to build, cheap, reliable, and easy to use and to copy.

6 Systems should be able to accept without malfunction the personal cleansing materials locally used which may include sticks, stones, corncobs, or large handfuls of grass or leaves.

An important parameter in the design of a sanitation system is the quantity of waste that it must accept. Many attempts have been made to quantify this in terms of kilograms per person per day. The variations between individuals in terms of size, diet, water consumption and general state of health all affect the amounts of waste excreted. The following quantities are proposed as a basis for design purposes in most tropical countries.

Average daily output of wastes per person

Faeces	400 g (wet weight)
Urine	1200 g
Total	1600 g = approximately 1.6 litres

To this figure an allowance should be added for the quantity and nature of the personal cleansing materials used.

THE CHARACTERISTICS OF SOME SANITATION SYSTEMS USED IN TROPICAL COUNTRIES

1 The overhung privy (Figure 1a): A squatting plate is built on a platform with the hole directly above a river of sea. It is commonly found in the Far East where many quite large communities live on coasts and riversides. Usually little smell or fly nuisance results from this system, which is the cheapest of all systems to build and uses no piped water or sewers. Where, however, rivers serve simultaneously as a water supply, a water transport system and a sewage system, the health risks are exceptionally high. The overhung privy cannot be recommended at all for community use.

2 Night soil buckets. (Figure 1b): A squatting plate or seat is built directly over a container - usually a bucket, but occasionally a large tank. Night soil systems are found in many parts of Africa and the Far East. The cost of the bucket device is very low but there must be a regular and reliable maintenance service to remove waste from the buckets and transport it to a site where it can safely be disposed of. Staff for this purpose are becoming increasingly costly and difficult to obtain. Mechanised removal systems go only part of the way to solving these difficulties; thus a system which seems cheap to install may become increasingly expensive to operate. Bucket systems need no piped water supply or sewers but may present more difficulties when it is necessary to dispose of waste water other than excreta. Smell and fly nuisances can

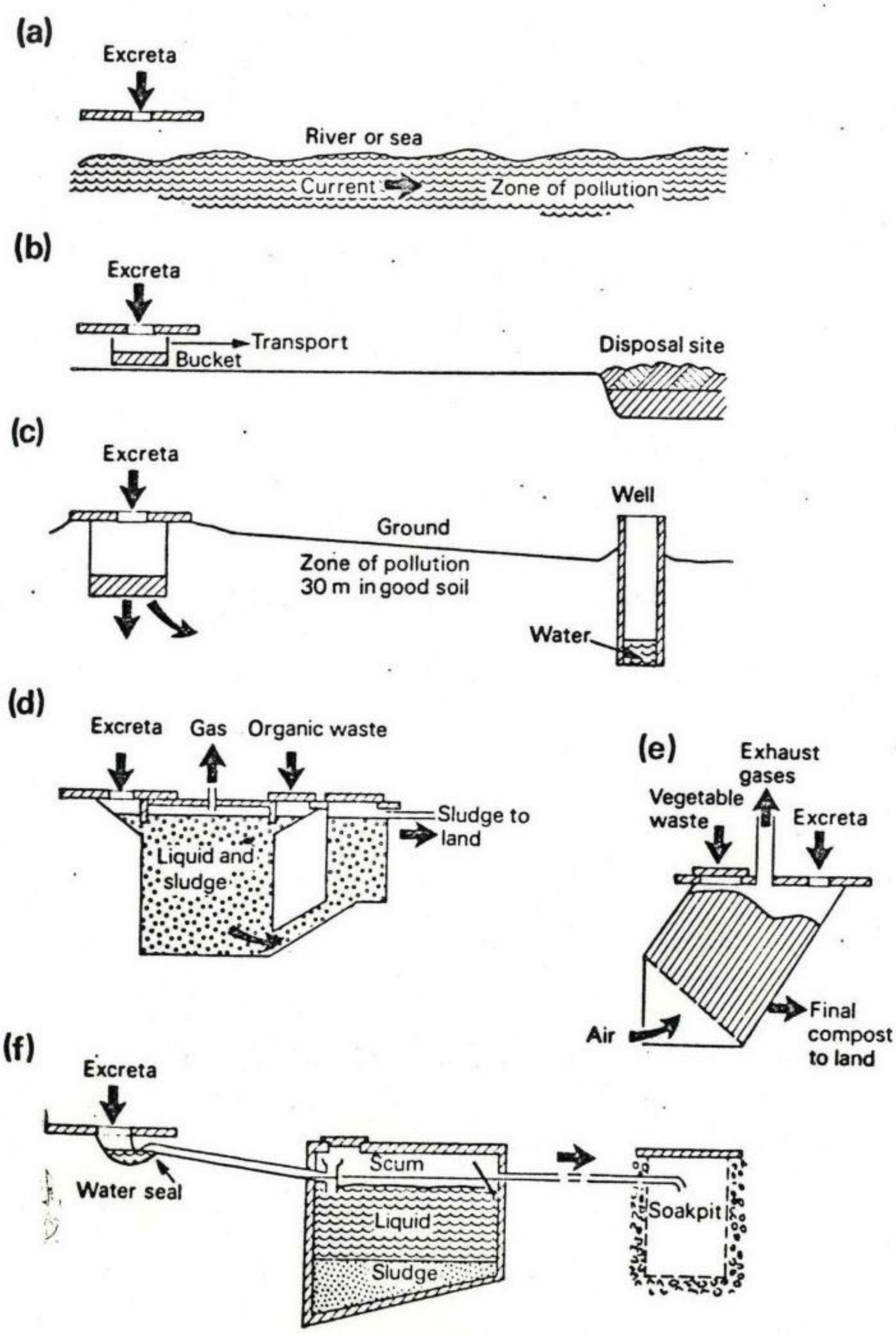

Figure 1 Some sanitation systems without sewers.
- a Overhung privy
- b Nightsoil bucket
- c Pit privy
- d Anaerobic digester
- e Compost privy
- f Septic tank with soakpit

be severe but with sufficient care can be reduced: health risks can be low but are rapidly increased by neglect or accidental spillage. Modified bucket systems include cesspit systems which must be built large enough to contain all discharged wastes for long periods: besides being supported by adequate transport and disposal facilities. Chemical closets are essentially bucket systems which employ chemicals to eliminate local health risks as well as odour and fly nuisances. These are much more costly, require a reliable supply of the appropriate chemicals and may present many more difficulties in final disposal unless the wastes can be diluted with sufficient sewage and treated in conventional sewage works.

3 The pit privy. (Figure 1c): A squatting plate or seat is built directly over a pit dug in permeable soil. Waste is dispersed into suitable soil in which considerable biological breakdown of organic matter occurs. Many types of soil are unsuitable; impermeable soil does not allow dispersal; coarse gravels, water-logged soil or fissured rock allow too rapid dispersal which permits bacterial pollution to penetrate long distances. A typical rural homestead is shown on the cover, with a pit privy situated just to the left of the right-hand house. The pit is so close to the stream that contamination is inevitable. Water for domestic use is being collected just downstream of the source of pollution. This situation is repeated at intervals along the stream, so that none of the users have access to safe water. To safeguard water supplies pits should be situated not less than 30 metres from wells or streams even in good soils; the safe distance may be considerably greater in other types of soil. In addition pits should not be situated too close together as this may overload the ground's capacity to absorb waste, which makes them of limited use in crowded areas. Pit privies, if kept clean, can be hygienic systems, and with care smell and fly nuisances can be virtually eliminated. Pits are comparatively cheap to construct, though they require periodic renewal as they become full. Pit privies are in use throughout the world. They can be very satisfactory in many uncrowded rural situations where they can be easily built of local materials, well spaced to avoid pollution, and where the waste can be of some agricultural value after it has been allowed to decompose for about 12 months.

In suitable soil conditions pit privies can be fitted with a variety of water seal closet bowls which can operate with very little added water and do not need a piped supply; the water seal is the best protection from smell and fly nuisance. Pits without drop pipes are vary rarely clogged by bulky cleansing materials but some types of water seal device with U traps are prone to blockages if such materials are used.

4 The anaerobic digester. (Figure 1d): Undiluted excreta or conventional sewage are not favourable raw materials for anaerobic digesters. Anaerobic digesters are becoming increasingly important in many rural areas in India where temperatures are high enough to enable mixtures of vegetable waste and usually diluted cow dung to be digested without the use of supplementary heating. The process produces methane gas which can be stored and used as a fuel, and a stable sludge with little smell and low health risk which can be used as a fertilizer. The digester consists of a watertight pit designed to hold the mixed wastes for 30 to 80 days, and where the gas is to be used a safe storage and dispensing system is necessary.

Where anaerobic digesters are in use they can have squatting plates and drop pipes connected to them to allow excreta to be treated with the other waste materials. Costs can however be high and the technology of digestion and gas utilisation may be beyond the resources of many types of rural community.

5 The compost privy. (Figure 1e): As with the anaerobic digester, the main objective of the compost privy, to which squatting plates can also be connected, is the treatment of a suitable mixture of vegetable waste and excreta. The process operates differently from that of the anaerobic digester and requires a large ventilated bin to retain the waste for about 30 to 50 days. During this period aerobic decomposition occurs and allows the waste to heat to temperatures of more than 65°C. This ensures a very high degree of protection from health risks in the disposal of the final product, which can be used as a fertiliser. In parts of North Africa simple compost privies are in use, and factory made units have been developed in Scandinavia. Compost privies are usually bulky and comparatively costly, but with this system smell and fly nuisances can be controlled, health risks are low and the final product presents no problems in rural areas. Neither piped water nor sewers are needed with compost privies and further development could make the equipment cheaper, though the degree of care required to operate them would remain fairly high.

6 The septic tank. (Figure 1f): This is a well-known system used throughout the world and adaptable to every kind of domestic waste water including kitchen and bathroom wastes. Septic tanks may be built as single family units or may be fitted with piped sewers to collect wastes from 500 people or more. A piped water supply is usually necessary. Basically the toilets and other drains (excluding roof drains) are connected to a watertight tank which serves two functions. Quiescent conditions in the tank allow solid matter to separate to form sludge and scum which are both retained in the tank. The clarified liquid is then discharged partially treated, and usually dispersed in soakpits. These can be at some distance, enabling them to be sited with the same care as pit privies to avoid health risks. The second function of the septic tank is to promote anaerobic biological action which starts in the sludge layer. The biological action is increased at high temperatures: thus the septic tank, which usually removes only about 50 per cent of the polluting matter from sewage in temperate climates, can remove up to 80 per cent in tropical climates. Septic tanks are comparatively expensive but are simple and reliable, usually requiring very infrequent attention for sludge disposal. The sewers supplying the tank are costly and are prone to blockages if bulky cleansing materials are used. Smell and fly nuisances are almost negligible and health risks are low where proper control is maintained on the final disposal of effluents and sludge. Further treatment of septic tank effluents can be carried out in oxidation ponds or biological filters.

7 The aqua privy. (Figure 2): In many ways the aqua privy is a simplified version of the septic tank, using the same physical and biological processes. It is intended to deal directly with excreta and requires only a small volume of added water to clean the entry funnel and to maintain the fluid level. The aqua privies can be smaller and cheaper, producing less effluent than septic tanks though the effluent is stronger. Protection from fly breeding, odours and disease is as high as in septic tanks.

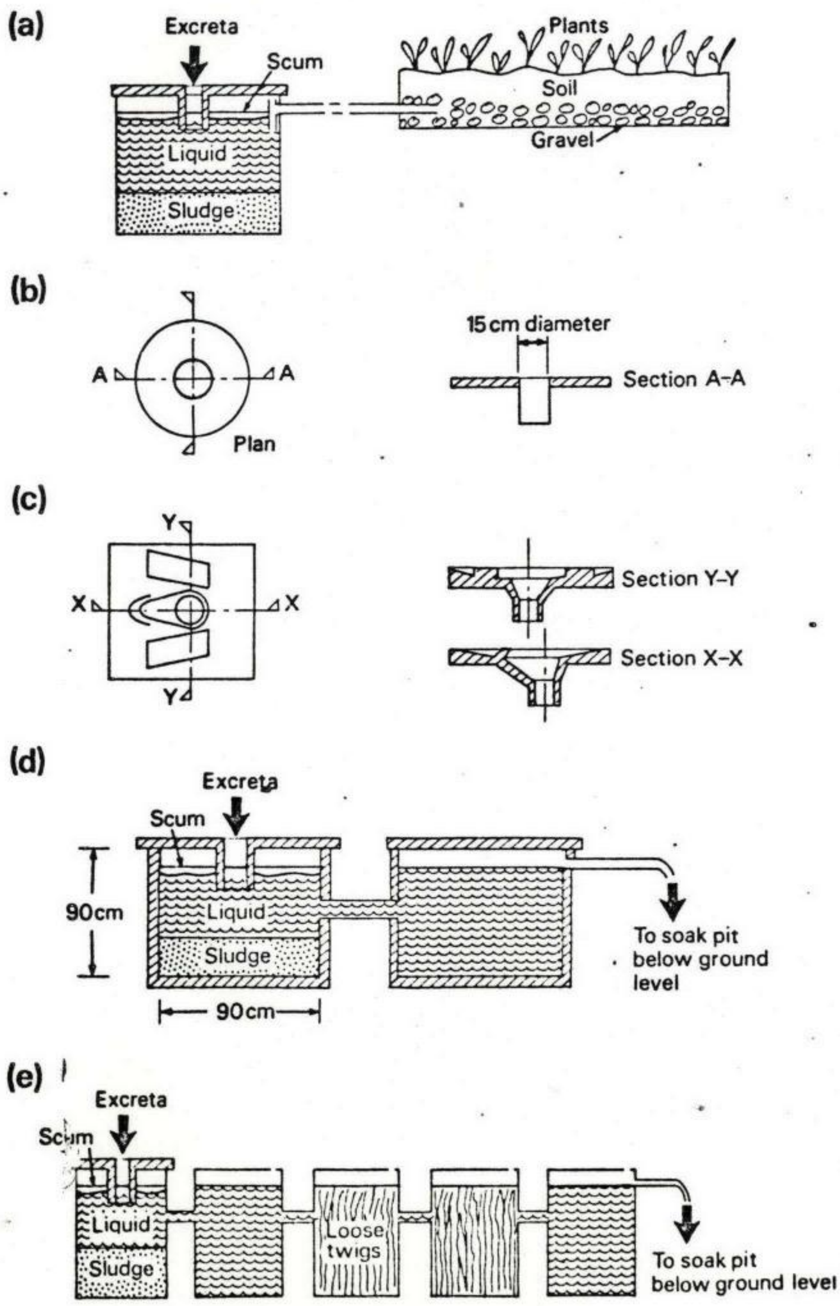

Figure 2 The aqua privy.
- **a** Basic aqua privy and transpiration trench
- **b** Simple concrete squatting plate
- **c** Improved squatting plate

Aqua privies provide one of the best compromise systems of sanitation as they need less water, les capital equipment, and less maintenance than any other system capable of the same degree of protection from nuisance and disease. The aqua privy is less prone to blockage than any other water-sealed system.

The aqua privy must accept, as has already been stated, 1.6 litres of excreta per person per day. Undiluted excreta contain too much nitrogenous matter to permit uninhibited anaerobic digestion without inhibition. Therefore a minimum quantity of water must be added to dilute the excreta to a satisfactory concentration, assuming all faeces and urine are present, and to compensate for evaporation which may be very high in the tropics. A minimum practical quantity of about 7 litres of added diluting water per person per day is suggested to suit most tropical situations. The diluting water does not have to be drinking water. Discarded washing water or even untreated surface water will suffice. If more than the minimum quantity is used the aqua privy is not harmed provided there is sufficient retention capacity in the design of the tank.

A design formula for the tank volume can be used as follows:

$$V = PQ + SP$$

when V = operating volume of the tank (litres)

P = average number of users

Q = average volume of liquid discharged: litres per person per day

S = the volume of sludge storage capacity allowed in the tank per person. A reasonable allowance is about 120 to 150 litres per person which allows for desludging about once every two years provided no bulky cleansing materials are used.

This formula gives the minimum size for the number of people; larger tanks can be built without loss of efficiency.

For a family of 10, discharging on average 9 litres per person per day (1.6 l. waste + 7.4 l. wash waters) the minimum volume should be 1290 l. (284 Imperial gallons). For two families totalling 20 people using the same aqua privy (which can be provided with more than one squatting plate) and discharging 9 l. per person per day, the minimum volume should be 2580 l. (568 Imp gal). If water use is increased so that 20 l. are discharged per person-day, a family of 10 would require a tank of 1400 l. (308 Imp gal).

If the waste water discharged to the aqua privy is less than 9 litres per person-day, water should be added to make up the difference. If the rate of evaporation is so high that the level of the water seal is seen to fall, extra water will be required to maintain the seal.

The basic construction and operation of the aqua privy

It is very worth while expending some care on the construction of the squatting plate (Figure 2, b and c). A concrete slab is required, shaped to drain towards the hole, which should be provided with a tapered drop pipe about 30 cm deep with an aperture at the lower end about 10 to 15 cm in diameter, dipping about 10 to 15 cm below the level of liquid in the tank. Footrests and a raised edge at the front of the hole both help in keeping the plate clean. Very simple squatting plates can be made by casting the plate in a simple mould incorporating about 30 cm length of 15 cm diameter concrete or asbestos cement pipe. These are cheap but require more care in cleaning. All squatting plates must be strong enough to bear the weight of any potential user.

The tank must be watertight. Brick, concrete or masonry are all very suitable construction materials. The capacity of the tank can be calculated from the formula given but about 15 cm freeboard should be allowed above the liquid level. A variety of shapes can be used but a sloping base is preferred as it assists in the removal of sludge. The minimum operating depth suggested for small tanks is 1 metre but many have been built with a depth of only 0.75 m. Large tanks can be constructed 2 m deep or more.

The discharge pipe or effluent pipe should be about 10 cm bore, though 5 cm bore pipes can be used in very small systems. The pipe should be installed so that no floating solids are able to pass into it. This can be accomplished in several ways, but a T piece or a sloping baffle are probably the best. The effluent can be disposed of in soakpits, or for very large installations it can be piped to some simple secondary treatment system such as an oxidation pond. In poorly permeable soil, small volumes of effluent can be disposed of in transpiration trenches containing

It is most important that sufficient water is added to the aqua privy every day. Newly commissioned tanks should be filled with water before use. A dipstick can be used to measure the level of sludge in the tank at about monthly intervals. When the level is within about 10 cm of the maximum, surplus sludge can be removed with a dipper or pump. After desludging, water should be added to restore the proper level in the tank. The partially digested sludge may still contain viable parasite eggs; therefore it should be handled with care and disposed of by burying in a safe place or by composting.

The gas produced in small aqua privies can be allowed to escape from a vent, but in large communal aqua privies a fixed ventilating pipe is preferable.

Many variations are possible in the basic design. Seat type toilets can be used as effectively as squatting plates, and large tanks can be provided with a number of squatting plates and designed to accept drainage from showers and washing facilities. Some very small units have been built using improvised materials: one type is illustrated using two chambers made from concrete chamber rings (Figure 2d), which is easy to build and very durable but costly. Standard oil drums have also been used (Figure 2e): these are much cheaper but less durable.

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