IRC

International Water and Sanitation Centre

Centre international de l'eau et l'assainissement

WHO Collaborating Centre / Centre ... OMS

Scanned

TECHNOLOGICAL OPTIONS FOR HUMAN EXCRETA DISPOSAL FOR LOCATIONS WITH HIGH GROUNDWATER TABLES

Desk review for technical options requested by SAWA, Ede.

For SAWA project on Rehabilitation of drinking water and sanitation systems in Pursat, Cambodia (EC Emergency Aid Programme)

Jo Smet
IRC

The Hague
November 1993

Table of Contents

1. DESCRIPTION OF EXISTING HUMAN EXCRETA DISPOSAL SYSTEMS IN PURSAT

The human excreta disposal systems of Pursat, a provincial town in Cambodia, can be divided in two main groups mainly defined by the areas of the town (according to information from SAWA, appendix 1).

a. In the small town centre where houses are connected to the piped water supply, most houses have a water-flushed toilet with a septic tank. The centre has no sewerage system or other drainage system.

b. In the quarters around the town centre, with a high population density, dwellers get their water from public standposts or water vendors. A substantial part of the households have their own latrine. The types of latrines range from pour-flush latrines to simple pit latrines. Overhung latrines over ponds are also found here. The topography is relatively low with usually high groundwater tables. Drainage conditions are poor due to limited infiltration into the ground and the absence of surface drainage systems. These conditions regularly lead to local temporary floods.

The description of systems further refers to the low-income areas outside the town centre.

Most latrines are built near or above a pond. The common type of latrine is a simple pit latrine. Lining materials vary from concrete to drums etc. and often there is no lining at all. The latrine floor is usually made of timber, concrete slabs are rarely found as floor.

Superstructures are described as simple: some have some timber walls or just grass.

Pursat has private construction workers capable to build pour-flush latrines with septic tanks (indicative costs US$ 200-250/each).

2. PROBLEM DEFINITION

Due to poor vertical drainage (infiltration in soil) and surface water drainage, the low-income areas outside the town centre get regularly flooded, particularly during the rainy season. This causes problems for the existing pit latrines that may overflow. In case the soil is not very stable pit latrines without proper lining may collapse.

The high groundwater table and the flooding of the areas usually prevent people from building proper permanent structures for human waste disposal.

The low coverage figure of toilets and latrines, probably remarkably less than 50%, will cause serious health risks for the people living in those areas. The flood water easily transfers the pathogens closer to the people and the contact bridge between pathogen and man is obviously laid. Higher incidence of faeco-oral diseases during periods of rains and floods have been reported in literature from other countries.

Therefore the need to improve the sanitary conditions of the low-lying areas of Pursat is high.

3. TECHNICAL OPTIONS

Literature search done using IRCDOC, the IRC-in-house database on water supply and sanitation, resulted in an overview of experiences, presented in Appendix 2.
From this literature review, three main technical options could be given further consideration:

- raised pit latrine
- double or twin pit latrines
- raised pour-flush toilets

3.1 Raised pit latrine

A good description is given in the Brief Literature Review.

The principle design features for a raised pit latrine type suitable for Pursat conditions are: (see figure 1; notice that the raised height is at its maximum)

> # the bottom of the pit should reach up to the minimum groundwater level (at the end of the dry season);
> # for practical reasons the height above the ground should be limited to 1.5 m; the upper 0.5m direct under the slab is not to be filled up for hygienic reasons;
> # the lining of the pit should be strong but porous (e.g. honeycomb masonry) to allow for infiltration of liquids at all levels;
> # a ring of coarse building material (gravel, crushed bricks or stones) will be put around the outside of the lining;
> # the upper 1 m of the mound will be made of puddled clay to prevent seeping out of heavily contaminated pit liquids;
> # the slopes of the mound should be at least 1:1, and be planted with grasses to prevent erosion.

The purpose of the ring of coarse material around the lining is to reduce the settleable solids in the seepage; these would quickly clog the pores and cause substantial reduction of infiltration capacity of soils.

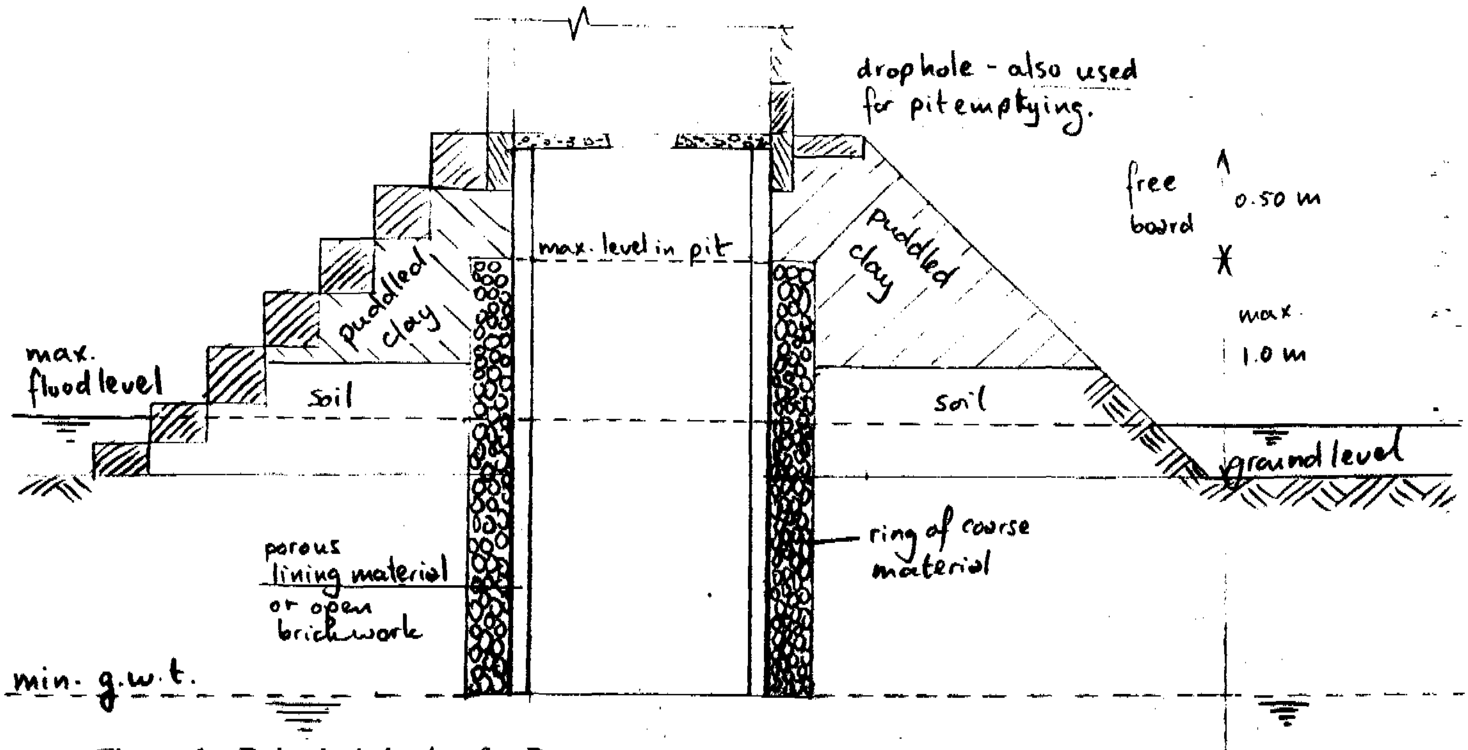

Figure 1. Raised pit latrine for Pursat conditions

Performance

The performance of the raised latrine is expected to be without problems in the beginning of the use period. *If the gwt (groundwater table)* is below ground level than the seepage of pit liquids will remain under the ground level. When gwt rises above ground level (flooding) than the liquid level in the pit will be at least the same as outside. Seepage that may reach the environment (flood water), will have travelled through the soil pack which will significantly reduce the bacterial density and organic load.

When the filling rate of the pit exceeds the maximum flood water level, seepage may reach the flood water. However, contamination levels are expected to be low.

When the gwt drops to the minimum groundwater level, the infiltration will be in the underground and seepage will not reach the open environment, even when the pit is nearly full.

In general, the performance of this type of latrine will be more optimal if the gwt remains below ground level.

Furthermore, as the amount of liquids that can infiltrate into the surroundings are limited, this type of latrine is less suitable for situations where people use a lot of water for anal cleansing. Obviously, the type is unsuitable for pour-flushing.

Required pit volume

The filling rates of pit latrines quoted in literature are 60 and 40 l per person per year (lcy) for respectively dry and wet latrines. In practice the latrines appear to fill slower. However, the high gwt may reduce the infiltration rate. Therefore, a filling rate of 50 lcy is used here for calculations for these wet latrines, which figure is rather conservative.

Required volume V = n x 0.050 x y m^3

with n: number of users of the latrine (say 6 people)
y: intervals between emptying (in years)

For emptying intervals of 3 years: V = 6 x 0.050 x 3 = 0.90 m^3

the depth of the pit would then be H = 0.90 plus 0.5 m (free board)= 1.4m if cross-sectional area is 1 x 1 m^2

For emptying intervals of 10 years: V = 6x 0.050 x 10 = 3.0 m^3

the depth of the pit would then be H = 3.0 plus 0.5 m (free board) = 3.5m if cross-sectional area is 1 x 1 m^2

The present practice in Pursat's peri-urban areas of digging a new latrine when it has filled up, is not recommended for reasons of high construction investment. Furthermore, shifting may not be feasible in future because of the high density of settlement. More permanent structures should be considered. These permanent latrines have then obviously to be emptied regularly. How often depends on the availability of pit emptying services and the volume of the pit that can be constructed using the criteria described above. The required pit depth considering the minimum gwt and the maximum 1.5 m above ground level may not be available, so shorter emptying internal periods are to be applied.

Pit emptying techniques
The traditional pit emptying technique using scoops creates unsanitary conditions to the environment. This is due to spillage of fresh human waste in the direct living environment of people and also due to its disposal usually done close to the excavation site. Pit emptying by trucks is often not possible because of the simple fact that vacuum trucks are not available or not in functioning condition, or that the pits can not be reached with such heavy trucks. The cost aspect of emptying by vacuum truck may be another reason for households to apply another cheaper method.

In Tanzania an appropriate technology was developed and tested for pit emptying in densely populated areas using locally manufactured and maintainable equipment. Appendix 3 gives some more details on the so-called MAPET, Manual Pit Latrine Emptying Technology.

3.2 Double-of twin pit latrines

This option is well described in the Brief Literature Review. This option may function well if the gwt is not too high, i.e. no flooding. The principle is that the human excreta will decompose into harmless dry organic material within a one- to two-year period. This principle will also work if the human waste, and so the pits, are located above the gwt. The relatively short alternating cycles of say two years, result in small pit/compartment volumes required, which may be constructed above gwt.

More detailed information on design is on IRC-OP "On-Site Sanitation: Building on Local Experience" section 6.3 (attached).

3.3 Raised pour-flush toilets

Some information is given in the Brief Literature Review on this technology.

One of the crucial requirements for pour-flush toilets is the availability of water for flushing. The water supply service level should be at least a yard connection if this option is to be considered. In principle, water for flushing can be collected from the public standpost, but practice often shows that then insufficient water is being flushed causing blockage.

The pour-flush technology usually applied in the Indian sub-continent is the twin off-set leaching pit. This technology demands a good infiltration capacity for pit liquids from the surrounding soil. The functioning principle is that the content in the pit not in use, will dry and decompose. (see also On-Site Sanitation)

Considering the flooding conditions in the concerned areas, a pour-flush system for further consideration is the cesspool with soakaway or drainfield. In this case the cesspool acts as a septic tank. In Figure 2 this system with a soakaway is given.

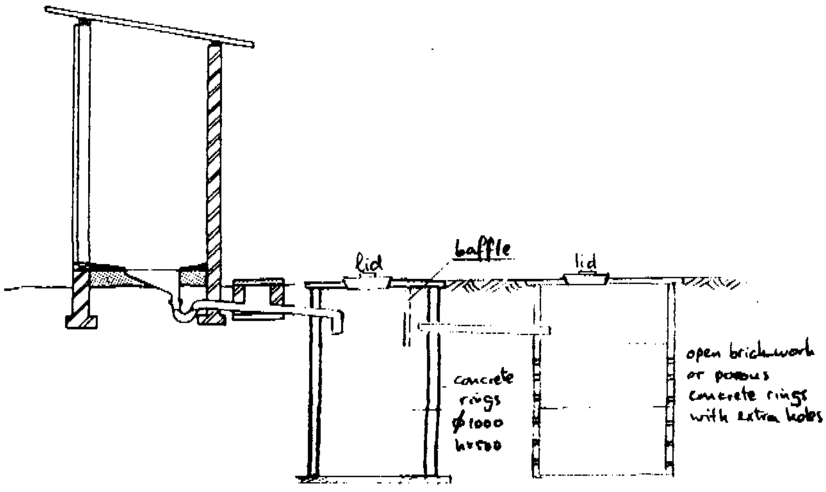

Figure 2: Pour-flush system with off-set cesspool (small septic tank) and soakaway.

Instead of a soakaway, an evapo-transpiration mound can be constructed. Grasses or vegetables can grow on this mound.

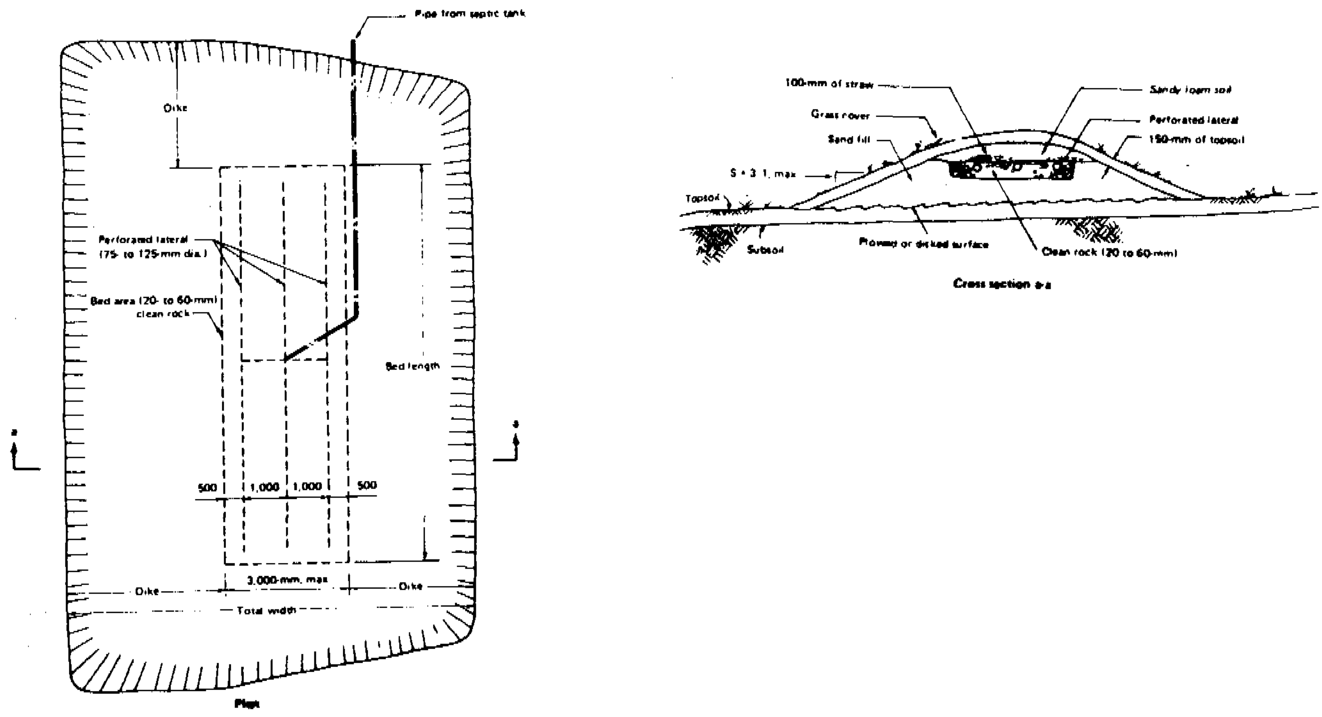

Figure 3: Evapo-transpiration mound
(source: Kalbermatten et al. 1982)

When the area would be landfilled and the trend to change from simple pit latrine to a pour-flush system would take place, sewerage development in the direction of small bore (diameter) sewer system could be considered. This system requires the primary settlement of solids in the sewage prior to entering the sewer to avoid clogging of the sewer with solids. Such primary sedimentation can be performed by a simple septic tank. In Phnom Penh the simple septic tank system (Figure 2) was introduced by PADEK using concrete rings.

4. SUGGESTED SUPPORTIVE ACTIVITIES

Socio-cultural data
It is important to collect socio-cultural and economic data to be used to develop and design a latrine system and the design should fully take into account the views of the people in the area, in respect of present problems and constraints, beliefs and taboos, perceptions, plans etc. The IRC-OP 16 (in its appendix 1) gives some ideas on this views & data collection.

Leaching capacities of local soils
Leaching capacity of the soil can be determined in-situ. The technique for this has been described in IRC-OP 16.

Pit emptying services capacities
Investigations should be made to find out the municipal and private capacity for pit/septic tank emptying. Issues to investigate include type of technique, capacity, conditions, costs, procedures etc. Environmental issues of desludging practice and the procedures and legislation for disposal of sludge should be considered.

Development of field-models of latrines
The survey, people's views and other information would lead to some technical options for human excreta disposal in the low-lying areas. These selected systems could be further developed at pilot scale in the areas to assess their acceptance, functioning and replicability. These test models could include the systems indicated in chapter 3. Usually a range of options would allow people to choose the system most suitable for their requirements and environmental conditions.

Monitoring of field-models of latrines
This monitoring should include problems encountered, constraints, filling rate, environmental pollution, insects, etc.

REFERENCES

Franceys, R.;Pickford, J.;Reed, R. (1992) A guide to the development of on-site sanitation. WHO Geneva

Kalbermatten, et al. (1982). Appropriate Sanitation Alternatives: a Planning and Design Manual. John Hopkins University Press, Baltimore.

Wegelin-Schuringa, M. (1991). On-Site Sanitation: Building on Local Practice. IRC Occasional Paper Series no. 16. The Hague

see also references of Brief Literature Review (Appendix 2)

APPENDIX 1

DESCRIPTION OF ASSIGNMENT

AND

DESCRIPTION OF SANITATION CONDITIONS IN PURSAT (CAMBODIA)

OPDRACHT BESCHRIJVING

SAWA werkt in Pursat aan de rehabilitatie van het drinkwater systeem en sanitatie faciliteiten.

In het kader van het drinkwater en sanitatie voorlichtingsprogramma is naast de voorlichting ook de bouw van latrines opgenomen.
Het project valt in kader van het noodhulp programma van de E.G. waarbij het accent van het project op rehabilitatie van het huidige drinkwater en sanitatie systeem. Hierdoor is in deze fase nog geen aktiviteiten opgenomen voor de aanleg van een nieuw drainage systeem in Pursat.

De stad kan grofweg in 2 doelgroepen worden verdeeld:

1. De bevolking in het kleine "stedelijke" centrum met een aansluiting op het drinkwater systeem. Er is geen drainage of riolering systeem in het stadje. De meeste huizen in dit gedeelte hebben een eigen water-latrine met een septic tank.

2. De wijken rondom het centrum waar de bevolkingsdichtheid groter is en men toegang tot drinkwater heeft via centrale waterverkooppunten of waterverkopers aan de deur.
   Deze wijken liggen vaak in lagere gedeelte en hebben daardoor ook regelmatig last van overstromingen, als gevolg van slechte oppervlakte als vertikale drainage.

Een korte beschrijving van de actuele situatie van het drinkwater en sanitatie faciliteiten is als bijlage toegevoegd.

SAWA wil graag een advies over:

1. De bouw van latrines in de gebieden waar de (schijn)grondwaterspiegel hoog is en bovendien regelmatig problemen zijn met tijdelijke overstroming als gevolg van overtollig regenwater.
   Aangezien de latrines bedoeld zijn voor mensen met een laag inkomen gaat onze voorkeur uit naar een goedkope maar duurzame latrine. Een uitwerking voor 1 of 2 verschillende types met de voor- en nadelen van deze latrines.

2. Het onderhoud van deze bovengenoemde latrines.

are situated in certain parts of town (see map, Appendix 1) and also do not always have water, probably due to the low pressure in the network. Moreover, some private watersellers sell the water at a cheaper price than the waterdepartment. One informant complained about the taste of the water from the railway station.

3.2 Latrines

34 out of 62 interviewed households use a latrine; in addition 7 households reported to use latrines of family members nearby or of neighbours.

In general larger/richer houses anywhere in town have a water-latrine, and concrete storage, normally consisting of a large concrete storage tank, a manhole and pipe. In the more densely populated areas in town many people have a latrine. Main reason for building one is convenience, if there are many houses nearby, one has to go far to find a suitable place to defecate. Some interviewed households also mentioned hygiene as an additional reason.
Except from water or pour-flush latrines, the type of latrines ranges from dug pits concrete lined, dug holes with a drum or just dug holes to latrines with just a hole above pools. Most latrines have a wooden superstructure, and a hole between two wooden boards instead of a slab. Most floors and slabs looked reasonably clean. The simplest ones have grass walls, or just a few wooden shelves to hide certain parts of the body.

If the pit or drum is full, one covers it with earth and replaces the superstructure to a next pit. One person reported his concrete storage tank to be pumped out by motorcycle with drum. Others said their septic tanks or storages had never been full.

Generally everybody in the household except for the small children reported to use the latrine. Cleaning oneself is done either by paper or with water. In some latrines (especially pour-flush) water is kept in a small basin or pot; if paper is used one may throw it in the dry latrine, or put it into a waste-bucket.

Those households who do not use a latrine go to the railway area or farmfields to defecate. Everybody reported to dig a small hole to cover the stools. Some women said they only wanted to defecate in the dark.

Prices range from 200-250 dollars to build a pour-flush latrine with storage tank to almost nothing when one just dug a pit and used some old wood to build the house. Several people hired private construction workers who are specialized in building water or pour-flush latrines and storage.

Quite a few people in the densely populated areas reported lack of space as a reason for not having a latrine or feared the day the pit would be full.
An additional problem is that many areas are at least temporarily flooded in the rainy season. Almost every latrine is built near a pool or pond.

At least 7 people expressed the wish to build a pour-flush latrine; several others said they wanted to improve their latrine or to build one.

3.3 Waste

Most interviewed people reported to collect and throw their waste behind the house, in a pool, or just next to their neighbours. Some households said they burnt the waste in the nights and to use the smoke as a protection against the mosquitoes. One or two families mentioned throwing the waste into a pool to fill it and to cover it with earth. One interviewed person mixed the ashes with cowdung and used it as fertilizer on his farmland. It seems most waste is organic, with tin and plastic already taken out. However, this must be investigated further.

Some houses looked really clean; the compound was swept and waste put at a certain place. However two-thirds of the households did not seem to do that. There was no clear relation with wealthier or poorer houses.

3.4. Water, sanitation and health

Most interviewed households do seem to see some link between water and sanitation practices and health risks. Many people

heard the cholera message and seemed to be very afraid to get it. Quite a few people drink tea or hot water; however most of them will also drink raw water or mix with (unreliable) ice.
Most people seem to make a difference between 'good' and 'bad', dirty ponds and pools, that are clearly not suitable for washing and bathing.
Although the first mentioned reason for having a latrine is convenience, some people mentioned hygienic reasons as well.

The most prevalent diseases in the past few weeks mentioned by the interviewed households are fever, cold, malaria and measles. Only in phum Chanka Cher Cheung half of the interviewed people mentioned their children having had diarrhoea in the last few weeks; in the area even some children just recently died.

If somebody in the family is ill, most people call a private nurse to give an injection, go to the hospital, or just buy medicines from a pharmacy in town.

The most frequent diseases in Pursat province mentioned by a representative of MSF are: malaria, dengue, respiratory infections, measles, diarrhoea and tb.

3.5. Drainage

The mission discovered two small 'drainage systems' in Pursat Town, consisting of concrete channels of approx. 40 cms wide and 40-50 cms deep: near the old market, and the multi-storey buildings around the new market.
Where the system is integrated into the (concrete) sidewalks (some parts near the new market) covers of approx. 80x80 cm2 at regular intervals appear in the sidewalks and the channel underneath is well protected. At the same time, the same channel continues unprotected by the cover of sidewalks but covered by concrete slabs, most of which are broken or have completely disappeared. Although the multi storey buildings' waste water is disposed into these channels, the system probably gets clogged regularly due to solid wastes being thrown into it as well.
The system near the old market is not functioning at all since it has been interrupted at several places for thorough fares into the market; the remaining parts of the channel are mostly uncovered and full of solid disposal.

In both cases, the mission failed to discover where the drainage systems finally discharge or discharged its waste and storm water.

Apart from these official drains, the uncountable number of pools (small and large, sometimes alongside roads) serve as first catchment areas for both waste and storm water. But, after a few early showers in what is still considered to be the dry season (March 1993), we observed that pools are quickly filled and several main roads are flooded for several hours.

3.6 Organisations

3.6.1. Health services

Like all other governmental structures, the health services are organised at the national, provincial, district and khum levels, rather than at the town level.

The national level

The ministry of health comprises of four departments:
(i) preventive and curative medicine
(ii) pharmaceuticals
(iii) management and training
(iv) finance

Most of the country's health care system falls under the responsibility of the department of preventive and curative medicine: the central, provincial and municipal health services and the following centers: Centre National d'Hygiene et d'Epidemiologie (CNHE), the centre de Protection Maternelle et Infantile (PMI), the centre de Malariologie and the Institut National Anti-Tuberculose (INAT). The national level does not have a direct implementation responsibility. The provincial level is budgetary and managerially autonomous and falls under the political-administrative body of the province[5].

[5] see Ch. 3 UNICEF: Cambodia. The situation of Children and Women. 1990.

APPENDIX 2

Brief Literature Review

on Human Excreta Disposal Systems

for Areas with High Groundwater Table

based on search within IRCDOC, the Documentation Database of IRC International Water and Sanitation Centre

November 1993

Twin pit latrines

When latrines are to be built in areas with a high groundwater level, the construction of two shallow pits instead of one deep one will reduce the risk of pollution. Pits are used alternately and should each be large enough to last for two years. When the second pit is full, the first one can be emptied and reused. A full operational cycle therefore takes at least four years. Double pits can be used for both VIP and pour-flush latrines.

The **double-pit VIP latrine** has two pits, divided by a wall, under a single superstructure (see fig. 1). Each pit may have its own squat hole or seat. Alternatively, slabs may be movable, one with a hole for the pit in use and a plain slab for the other pit. The pits should extend beyond the superstructure, either to the sides or at the back, with removable slabs for emptying. (Franceys, Pickford and Reed, 1992: 50-52). More design details are given in: Van Nostrand and Wilson, 1983 [isn 872] ; Mara, 1984 [isn 1989] ; and Mara, 1985 [1230].

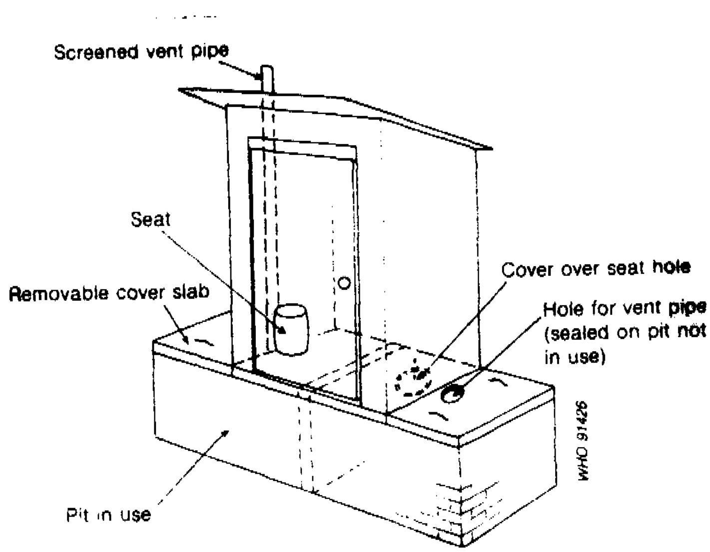

Fig. 1 **Double-pit VIP latrine**
(Franceys, Pickford and Reed, 1992: 51)

Double-pit offset pour-flush latrines have a single water-seal pan connected to both pits by pipes (see fig 2). An inspection chamber containing a Y junction is normally used to channel the excreta to the appropriate pit. (Franceys, Pickford and Reed, 1992: 55-57). More design details are given in: UNICEF, 1987 [isn 10258] ; Mara, 1985 [isn 2212] ; and Roy et al., 1984 [isn 3270]

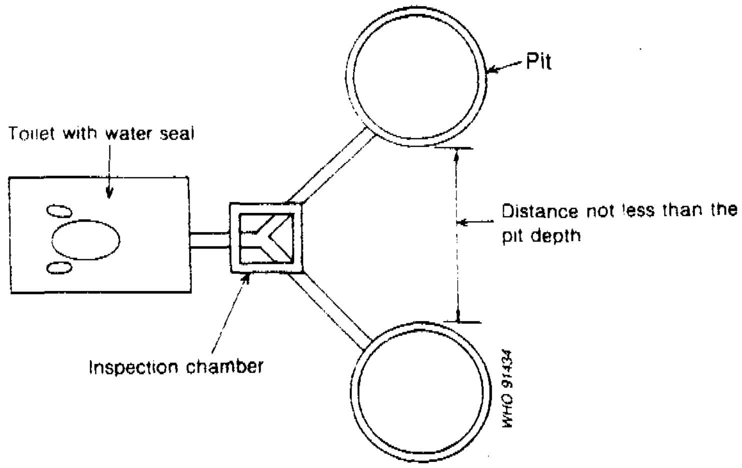

Fig. 2 **Double-pit offset pour-flush latrine**
(Franceys, Pickford and Reed, 1992: 56)

Planners should be aware of the **disadvantages,** mentioned in Table 1, when switching from single pit systems to double pits.

TABLE 1 **Disadvantages of double pits vs single pits**

- Construction and maintenance costs of double pit latrines are usually higher.
- The handling of (decomposed) excreta may be a taboo in many, especially Islamic, cultures, so that user education will be needed
- To ensure proper operation, external support should be available for one complete cycle of operation (4 years or more)
- In the case of pour flush latrines, slightly more water may be required to prevent blockage of the Y junction
- In the case of composting latrines, the moisture content has to be controlled by adding organic material

(Franceys, Pickford and Reed, 1992: 50-52, 55-57, 73 ; Cairncross, 1988: 17 ; Cross and Strauss, 1986: I.8-I.16)

Raised pit latrines.

Another way of dealing with the problem of high groundwater tables is to construct raised pit latrines (fig. 3a,b,c). The pit is excavated as deep as possible, working at the end of the dry season. If groundwater levels are permanently high and the soil is stable, a portable pump can be used to remove water from the pit during excavation. The water-tight pit lining is extended above ground level until the desired pit volume is achieved. The lining should also extend for at least 0.6 m below ground level. (Franceys, Pickford and Reed, 1992: 57 ; Cairncross, 1988: 31 ; Mara, 1984: 49 [isn 1989] ; Institute of Rural Development, 1989: 7, 12 [isn 6888])).

When there is insufficient infiltration area below ground level, the raised portion of the pit can be surrounded by a mound of soil (fig. 4). The section above ground (excluding the top 0.5 m) can be used for infiltration provided the mound is made of permeable soil, well compacted with astable side slope, and is thick enough to prevent filtrate seeping out of the sides. Earth mounds are not recommended on clay soils as the filtrate is likely to seep out at the base of the mound rather than infiltrate the ground. (Franceys, Pickford and Reed, 1992: 57-58)

If in addition to a high ground-water table, the soil is also coarse (soil particles > 0.2 mm), the following measures should keep the distance travelled by pathogens to within 15 m of the pit (fig. 5):

a. Seal the bottom of the pit with wet clay, cement mortar or plastic sheeting
b. Dig the pit 1 m larger in diameter than the lining and fill the 0.5 m space with fine sand (effective size < 1 mm)

(Cairncross, 1988: 31 ; Mara, 1985: 22-23 [isn 2212])

Several countries report the use of raised pit latrines. No references could be found, however, to practical applications of the design with the sealed pit and sand envelope shown in fig. 5. In Tonga, the Institute of Rural Development trained women to construct raised VIP latrines for low-lying swampy areas, or areas with a high water-table (Fleming, 1986 [isn 9631] ; Institute of Rural Development, 1989: 7, 12 [isn 6888]). Quite a number of pit latrines in Dar es Salaam, Tanzania, are mounded because of the high (0-3 m) groundwater table (Mnyanga, 1991: 43 ,53).

Raised pour-flush latrines were constructed in low-lying peri-urban and slum areas of Colombo, Sri Lanka, during 1986-1990. These areas had high groundwater levels and were often flooded. The latrines were raised to prevent them from overflowing and polluting the open wells which were used for drinking water. Well rings were used to line the 1 metre deep pits and to raise the latrines another half metre above ground level. The raised latrines cost about Rs. 5000, or two-and-a-half times the price of conventional pour-flush latrines (Rs. 2000). Beneficiaries paid about 60% of these costs, while the project run by the National Housing Development Authority and a local NGO, the Sarvodaya Shramadana Movement, contributed the remainder. (Heijnen, 1993 [Heijnen, 1993. Personal communication. The Hague, The Netherlands, IRC International Water and Sanitation Centre]).

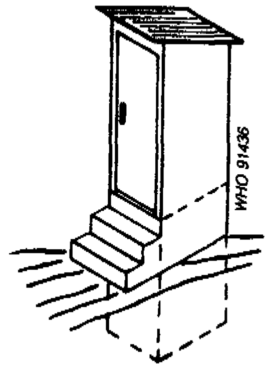

Fig. 3a Raised pit latrine
(Franceys, Pickford and Reed, 1992: 57)

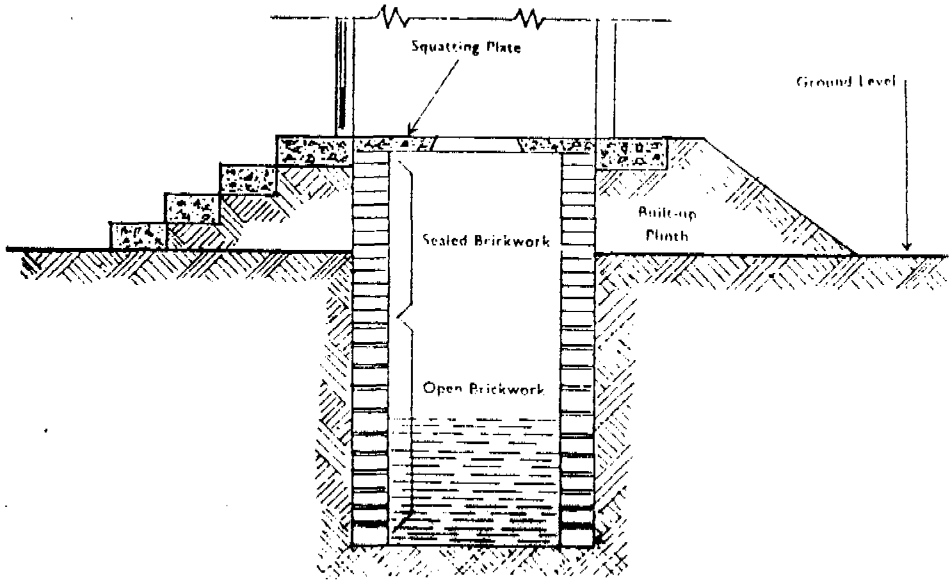

Fig. 3b Raised pit latrine
(Cairncross, 1988: 30)

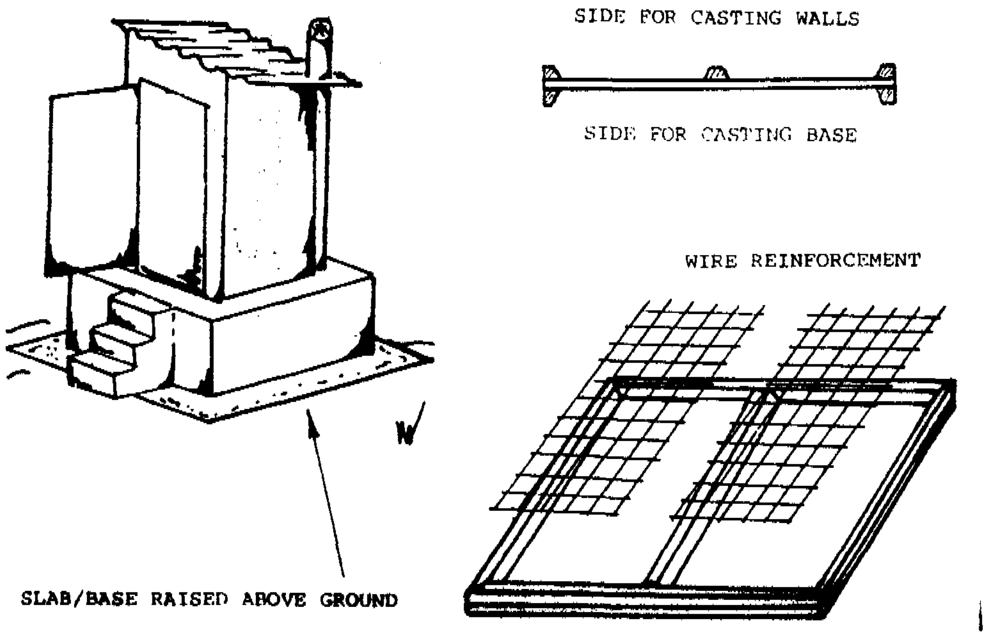

Fig. 3c Raised pit latrine design Tonga
(Institute of Rural Development, 1989: 12 [isn 6888])

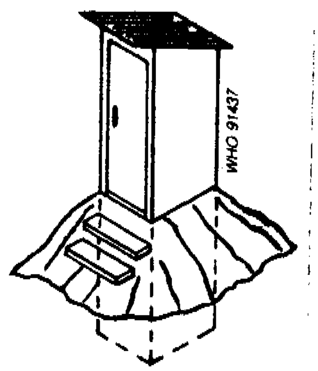

Fig. 4 Mound latrine
(Franceys, Pickford and Reed, 1992: 58)

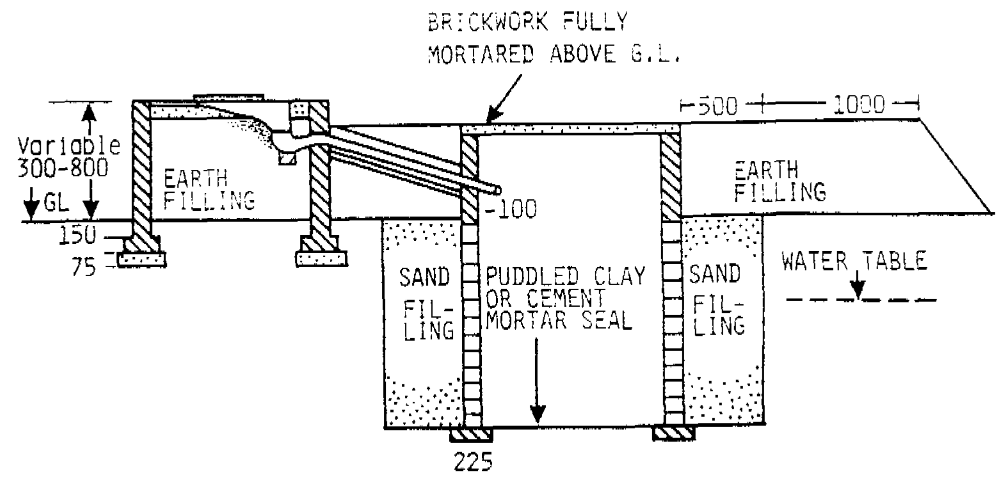

Fig. 5 Pour-flush latrine with sealed pit and sand envelope
(Roy et al., 1985: 47 [3270] or Cairncross, 1988: 45)

Non-chemical insect control

Chemical pollution by insecticides can be eliminated if alternative methods are used to keep latrines fly-tight and dry:

- o Constructing a squatting-hole lid, preferably a self-closing flap-trap inside the chute and repairing all holes and cracks immediately
- o Creating a solar-heater by painting the external part of the pit cover black or placing a blackened piece of aluminium sheet over it
- o Sprinkling ashes, lime, husks or powdered earth over each deposit of excreta
- o Encouraging lizards, frogs, spiders and *Bacillus thuringiensis* (rod-shaped bacillus which attacks fly and mosquito larvae)
- o Pouring 2 mm beads of expanded polystyrene into the pit to form a 20mm thick layer, through which female mosquitoes cannot lay their eggs and larvae cannot breathe

(Winblad and Kilama, 1985b: 83, 149-150 ; Cairncross, 1988:40)

Emptying practises

Large and deep pits are often dug, as in Dar es Salaam, to extend the life of latrines. In areas with high groundwater tables this obviously creates a pollution risk. Shallower pits can be constructed if there is an efficient and appropriate pit emptying service. Since low-income areas are often inaccessible for regular vacuum-tankers, pump carts can be used to empty latrines. The sludge can then be transported to transfer stations which in turn can be emptied by vacuum tankers. A pilot project using this system, called Manual Pit Latrine Emptying Technology (MAPET), was carried out by the Netherlands-based WASTE foundation in Dar es Salaam. (Rijnsburger, 1990 [isn 7409])

Septic tank systems

Two modifications of the conventional septic tank-soil absorption system have been widely used in North America to overcome natural soil limitations: **mound systems** and **low-pressure pipe soil absorption systems**. Table 23 lists characteristics of both systems. There were, however, no references to their application in developing countries.

The **mound system**, is essentially an elevated soil absorption system (fig. 6). A pump elevates the effluent from the septic tank to the distribution system within the mound. A siphon may replace the pump if the mound is downslope.

The mound is comprised of a fill material (usually medium-textured sand), an absorption area, a distribution system and a cap of topsoil. The effluent flows through the fill material where it is purified before entering the natural soil. The cap serves as a barrier to infiltration and promotes the runoff of precipitation. (Canter and Knox, 1985: 38-43 ; Easson et al, 1988: 5-10)

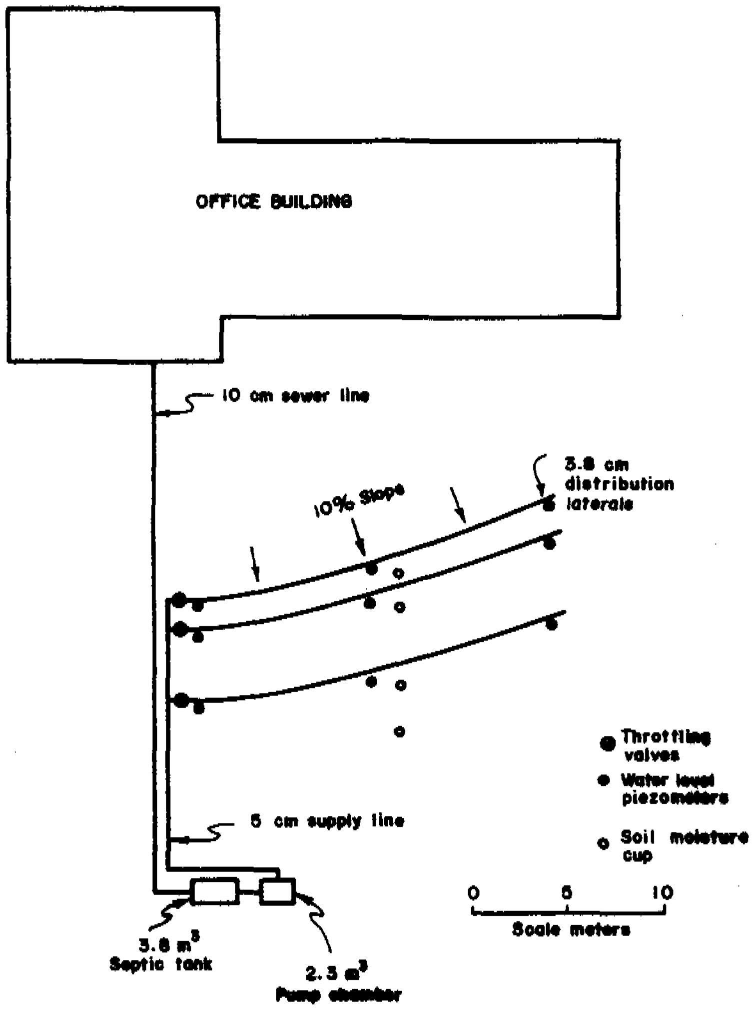

Fig. 6 **Septic** tank-mound system
(**Easson** et al, 1988: 6)

Conventional serial distribution systems for septic tank effluent always overload some of the seepage trenches. Laboratory tests have shown that uniform parallel distribution of septic tank effluent, as is the case in LPP systems, may reduce the potential of groundwater pollution. Faecal coliforms were reduced by 99.99% in parallel systems compared to 90% for conventional serial distribution. (Mote, Mucke and Allison, 1990 [Mote, C.R., Mucke, F.A. and Allison, J.S. Septic system efficiency : parallel and serial methods for distributing effluent. In: Journal of environmental health ; vol. 52, no. 5 ; p. 283-287]

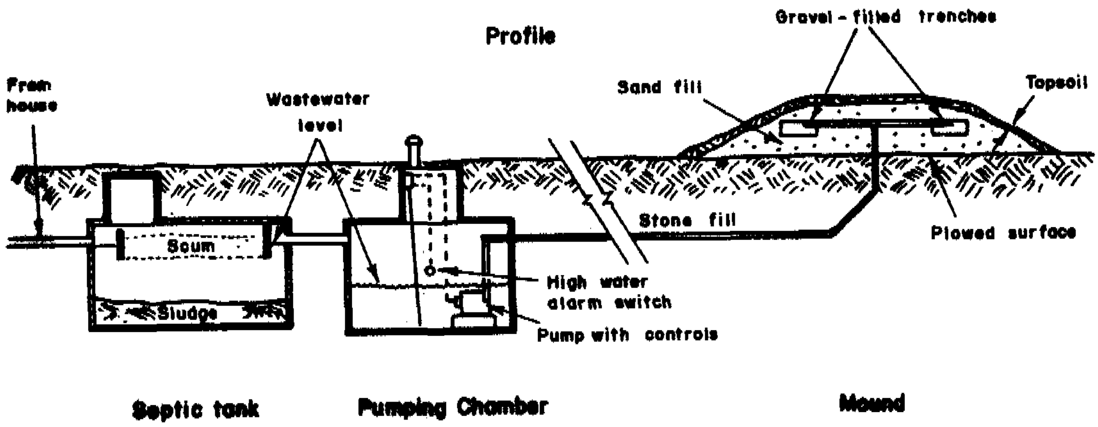

Fig. 7 Low-pressure pipe soil absorption system
(Easson et al, 1988: 15)

TABLE 2. Modifed septic tank systems for adverse soil conditions

	Mound systems	Low-pressure pipe systems
Components	Septic tank Dosing chamber with pump or siphon Infiltration pipes Sand filled mound	Septic tank Pump chamber Throttling valves Infiltration pipes
Distribution system	Serial	Parallel
Minimum soil depth	60 cm	60 cm
Construction costs	US$ 3,500-4,800 (1982)	US$ 2,833 (1987)
Reported use	USA: thousands Alberta, Canada: 300 Victoria, Australia: several	North Carolina, USA: > 2,000
Advantages	Appropriate for areas with low permeable soil and/or high water table	Appropriate for areas with low permeable soil and/or high water table Flexible layout Removes more faecal coliforms Uniform distribution results in less flooding
Disadvantages	More expensive More maintenance Easily clogged 15-20% failure rate Requires more space Not suitable on steep slopes Does not remove nitrates	More expensive More maintenance Design for uneven ground difficult

(Easson et al, 1988: 5-10,14-18 ; Canter and Knox, 1985: 38-43 ; Mote, Mucke and Allison, 1990 ; Brouwer and Van de Graaff, 1988 [in isn 6241: p. 83-97])

Other systems designed for adverse soil conditions such as the **at-grade soil absorption system**, **in-drains technology**, and **contour trenches** are new developments and not yet widely used. (Easson et al, 1988: 11-13, 19-26)

Other pollution control measures for septic tank systems include:

- o involving competent hydrogeologist, soil scientists and engineers in siting septic tanks
- o constructing percolation systems which do not compact the infiltrative system
- o alternate loading and resting of the percolation systems
- o annual removal of scum and grease from the septic tank
- o draining off half the sludge rather than pumping out entire contents
- o reduce hydraulic loading by segregating household waste waters

(Canter and Knox, 1985: 38-43)

REFERENCES OF THE BRIEF LITERATURE REVIEW

Canter, L.W. and Knox, R.C. (1985). Septic tank system effects on groundwater quality. Lewis Publishers, Chelsea, USA

Cairncross, S. (1988). Small Scale Sanitation. Ross Institute of Tropical Hygiene Bulletin no. 8. London School of Hygiene and Tropical Medicine, London

Cross, P. and Strauss, M. (1986) Health aspects of nightsoil and sludge use in agriculture and aquaculture. International Reference Centre for Waste Disposal, Duebendorf, Switzerland

Easson, et al. (1988). Sanitation technologies for temperate and cold climates. Asian Institute of Technology, Bangkok

Fleming, S. (1986). Training Women to build ferro-cement water tanks and latrines. In: Waterlines; Vol.5, no. 1

Foster, S.S.D. (1985). Potable groundwater supplies and ow-cost sanitary engineering: how compatible? In: National Resources Forum; Vol. 9, no. 2

Franceys, R.; Pickford, J.; Reed, R. (1992). A guide to the development of on-site sanitation. WHO, Geneva

Institute of Rural Development (1989) Making a ventilated Improved Pit Latrine. University of South Pacific, Tonga

Mara, D.D. (1984). The design of ventilated improved pit latrine. TAG Technical note no. 13. World Bank, Washington

Mara, D.D. (1985). Ventilated Improved Pit latrines. Guidelines for the selection of design options. TAG Discussion Paper no. 4. World Bank, Washington

Mara, D.D. (1985). The design of pour-flush toilets. TAG Technical note no. 15. World Bank, Washington

Meng Zun et al. (1992). New achievements of hygienic efficiency for biogas in China. In: Biogas Newsletter no. 39

Mnyanga, V.P. (1991). Groundwater contamination by pit latrines: Dar es Salaam (Manzese squatter area) - case study. M.Sc-thesis - IHE - Delft

Parra, M. (1988). Latrinas sanitarias aboneras a base de tambor: Chile. In: Saneamiento alternativo o alternativas al saneamiento

Roy, A.K. et al. (1984). Manual on the design, construction and maintenance of low-cost pour-flush water seal latrines in India. TAG Technical Note No. 10. World Bank, Washington

Rijnsburger, J. (1990). Emptying pit latrines: WASTE fills vacuum in Dar es Salaam, Tanzania. In: AT Source; Vol 18, no 2

Schiere, J. (1989). LASF: una letrina para la familia. Guatemala

Van Nostrand, J. and Wilson, J.G. (1983). The ventilated improved double-pit latrine: a construction manual for Botswana. TAG Technical Note no. 3. World Bank. Washington

Winblad, U. and Kilama, W. (1985). Sanitation without water. MacMillan, Basingstoke, Hants (UK)

UNICEF (1987). Towards better health: Water-seal latrine (technical details). UNICEF Regional Office for South-Central Asia, New Delhi

APPENDIX 3

An alternative pit latrine emptying system

by Maria S. Muller, Jasper Kirango and Jaap Rijnsburger

19th WEDC Conference ACCRA, Ghana 1993

WATER, SANITATION, ENVIRONMENT and DEVELOPMENT

An alternative pit latrine emptying system

Maria S Muller, Jasper Kirango, and Jaap Rynsburger

Introduction

This paper addresses the development of an appropriate pit emptying service, including the design of suitable equipment, in Dar es Salaam, Tanzania. The basic perspectives which guided the project partners are presented as well as some information on how the Manual Pit Latrine Emptying Technology (MAPET) service is functioning. MAPET is community based, but will provide better service if integrated in the city-wide service system of Dar es Salaam. Project partners for this pilot project (1988 - 1992) were WASTE Consultants and the Dar es Salaam Sewerage and Sanitation Department.

Situation in Dar es Salaam

In Dar es Salaam, as in other large Third World cities, the great majority of houses have on-site sewage disposal, i.e. mostly pit latrines, some septic tanks. Pit latrines are used by 80% of the households. On the 1992 population of over two million inhabitants or 450,000 households, this means that Dar es Salaam has about 170,000 pit latrines. Obviously, when the pits are full, they must be emptied[1]. It is estimated that yearly about 50,000 m^3 of sludge from latrine pits need to be emptied. Add to this the demand for the desludging of septic tanks, and one realises that any pit emptying service agency faces a formidable task. Are the authorities in Dar es Salaam able to respond to this demand?

The Dar es Salaam City Council operates, through the Dar es Salaam Sewerage and Sanitation Department (DSSD) and the Health Department, its own vacuum tanker services with about five cesspit tankers in continuous operation each.

Apart from the formal system, there are informal, self-employed, pit emptiers who practise the traditional method[2]. Characteristic of this method is that, next to the full latrine pit a shallow hole is dug on the resident's plot, and that the sludge is scooped into this new hole by manual labour. Another characteristic is that, the pit emptier and the house owner deal with each other personally, without the interference of a (bureaucratic) organisation. In a process of face to face negotiations they agree on the price to be paid and the day of starting the work, and on the location of the hole for burying the sludge.

The existing services together do not have sufficient capacity to handle the rising need for pit emptying. A major shortcoming is that the voluminous size and weight of the vacuum tankers is unsuitable for narrow and unpaved roads in the densely built, unplanned areas. Especially the low-income areas lack adequate services because of the unsuitability of the vacuum tankers. The main requirement was, therefore, to design equipment appropriate for the densely settled areas; equipment that is manufactured and maintained locally. However, technical innovation alone is not enough to improve service delivery.

An alternative service

The new equipment and service is called MAPET (Manual Pit Emptying Technology). DSSD took responsibility for introducing MAPET through its own organization in Dar es Salaam, while WASTE Consultants acted as the advisor. The equipment is manually operated and is sufficiently small to be manoeuvred through narrow roads. Using local materials and components and widely known construction techniques, the equipment can be locally produced and repaired in small workshops. The operation of the equipment requires team work of three men, who - as experience bears out - stay voluntarily together for several years. As MAPET can function to a large extent independently from a centralized administrative organization and workshop, it is possible to decentralize its service to the neighbourhood level.

MAPET technical features and operation

A MAPET team consists of three men. One is the leader. In order to be allowed to rent the MAPET equipment he needs a certificate from DSSD. For this certificate the team must first do a training at DSSD. If a pit emptier is found dumping the sludge somewhere behind the bushes, he loses his certificate.

The MAPET team goes with two hand carts (one pump cart and a tank cart of 80 cm width) from the community centre to the customer. They can cover a distance of a couple of kilometres. They first negotiate with the customer where to dig a hole to bury the sludge. They then insert the hose-pipe into the squatting hole and connect it to the tank cart. The tank cart is connected to the hand pump with an air hose. The air is pumped out of the tank and the resulting vacuum causes the sludge to be sucked into the tank. The full tank is emptied into the hole.

Digging the hole constitutes most of the work and takes more than one hour. The 200 litre tank is full within five minutes. With heavy sludge it takes longer. Water is mixed into the sludge. By draining the hose-pipe out at full vacuum ('plug and gulp') the sucking can be intensified. Customers generally ask for 4 to 10 tanks to be taken out of their latrines. The pit emptiers earn about 2,000 to 5,000 shilling which they share among themselves. In order to make a living of the MAPET pit emptyings they should have at least one customer per day.

The process of MAPET introduction

The following points of view have guided the development of MAPET:

First, pit emptying is a service consisting of several components, of which the equipment is only one element. Other components are e.g. training to operate the equipment, repair facilities, the capacity to find customers, economic and financial aspects of the service organisation, and facilities for sludge disposal. All these components of the MAPET service have subsequently been addressed during the pilot project. Project experience has confirmed the importance of appropriate and locally constructed equipment. It has also confirmed the notion that a service can only be performed satisfactorily if all other components function properly.

Secondly, the introduction of new equipment, even more so of a whole new service, requires a step-by-step approach. This allows the innovations to be adjusted to local conditions at the appropriate time. This entailed e.g. that the basic MAPET equipment was constructed as a prototype in a few months' time, but that serious adjustments were made in response to the experiences of the immediate users, i.e. the pit emptiers, over a period of 3 years. Similarly, training of the mechanics took place over a number of years, as they carried out the improvements in the MAPET equipment in the DSSD's own workshop. A step-by-step approach also implied that other components of the MAPET service were developed only when the need arose. For example, when the pit emptiers found it difficult to generate a regular demand from customers, a system of informing and motivating customers and community leaders was developed.

Thirdly, the new service, including the equipment, should be based on the most appropriate elements of the existing pit emptying methods. That is, building upon what exists, on what is known and familiar to people and organisations. In this way MAPET is not a strange element, as it combines e.g. the modern vacuum technology of the cesspit tankers with the traditional system of on-site sludge disposal by manual labour. It also strengthens the so-called traditional element of personal interaction between pit emptiers and customers, which is an important feature of modern small-scale, informal business contacts.

Fourthly, a form of public-private cooperation was envisaged between the DSSD and the informal sector. The public authorities have ultimate responsibility for sanitation services as they concern public health. It was also recognised that the demand for employment is tremendous. In times of structural adjustment programmes, MAPET *could not generate new* employment opportunities in DSSD, a government institution, but only in the private, informal sector. The solution adopted was that the DSSD would be the owner of the MAPET equipment and lease it to the pit emptiers. The DSSD provides essential support services, such as performing large repairs, promotion of MAPET in new neighbourhoods, and training and supervision, while the pit emptiers are self-employed workers, responsible for earning their own income. They do not receive a basic salary from DSSD. In this cooperation DSSD has a position to control irregular sludge disposal by private emptiers.

Different forms of organisation and management are conceivable, with a different balance between public and private responsibilities. Several options are being tried out in Tanzania.

The resulting MAPET service has both advantages and disadvantages. Some of the advantages are that:

- The MAPET equipment can reach the most inaccessible houses.
- The service can be performed almost immediately, while the vacuum tanker service requires a long waiting time.
- And the possibility of regular social contact between residents and emptiers, which enables community influence and supervision.
- MAPET can offer 'service to size': small volumes suiting the customer's household budget.

Some of the disadvantages are that:

- The MAPET service is expensive per unit of volume (m^3) compared with that of the vacuum tankers.
- The method of sludge disposal (burying on the plot) is not suitable for areas with a high ground water table and very densely populated areas.
- Cash flows between the DSSD and the private pit emptiers are difficult to control in practice.

MAPET service as part of a city-wide system

The pilot project has shown that MAPET can function satisfactorily in local communities. The emptiers can identify their customers and earn a low but steady income, informal mechanics in the neighbourhood carry out minor repairs, a certain amount of sludge disposal takes place within the community, and in a general sense MAPET enjoys social acceptance in those communities where it is already working. Leaders in other areas that came to know about MAPET are eager to bring it into their neighbourhood as a solution to the public health problems. Some NGO community initiatives have identified MAPET as a first priority to start a neighbourhood improvement campaign. On the other hand, residents and leaders would like to have more influence on the MAPET service, as they observe the potential for integration within the economic and health service system of the local community. Also they see the potential for income generation by the community.

However, MAPET is not an independent alternative to the tanker service. The size of the population requires the volume and hauling capacity of pit emptying as performed by the DSSD vacuum tankers[3]. In addition, MAPET should be operationally linked to the DSSD regarding sludge disposal. In areas with a high ground water table, MAPET cannot operate at present because of the absence of disposal facilities. Sludge must be removed from these areas and transported to central dumping stations of the city. The DSSD is the most likely organisation to use its vacuum tankers for this purpose. The aim is to combine the advantages of a community based service with the advantages of a strong organisation able to haul sludge through the city for final disposal. The required institutional arrangements (technical, financial, and operational) between the DSSD as a bureaucratic, government controlled organisation, the independently operating MAPET pit emptiers, and local communities are quite complicated. This is a formidable task, not less than the first introduction of MAPET.

The next phase of the MAPET project will include the development of an institutional framework for a neighbourhood based service, as well as the development of a sludge transfer system. The sludge transfer will initially be directed towards locally manufactured transfer stations as well as options for sludge treatment at neighbourhood level.

As in the first stage of the project, progress will be directed by the problems experienced by the organizations and operators directly involved at the city-wide and at the neighbourhood level. Solutions will be reached through a unique combination of the potential of these organizations in the public, private and community sectors.

References

1 Comparative Study on Pit Emptying Technologies, draft Final Report, WASTE Consultants, Gouda, The Netherlands, 1993

2 MAPET Progress Report 2, WASTE Consultants, Gouda, The Netherlands, 1988

3 The COMPET study has recommended to separate urban areas with pit latrines into typical large tanker, mini tanker and MAPET areas. The typical MAPET areas are those where even mini tankers do not have access. Large tankers appear to be the most economic (if adequately managed, which is often not the case) for hauling sludge to sludge disposal stations over distances more than 5 km from the pit.

APPENDIX 5

IRC - Occasional Paper 16

On-Site Sanitation: Building on Local Practice