Sanitation in Developing Countries

Proceedings of a workshop held in Lobatse, Botswana, 12-15 August 1980
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Sanitation in Developing Countries

Proceedings of a workshop on training held in Lobatse, Botswana, 14–20 August 1980

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On-Site Excreta Disposal Technologies

E.K. Simbye

Human wastes can be both dangerous and useful. Proper disposal of faeces will minimize the spread of many diseases transmitted through contact with the skin or through food and drink contaminated with excreta. Such diseases include hookworm, ascariasis, schistosomiasis, typhoid fever, dysentery, amoebiasis, cholera, and other worm diseases. Well-prepared and well-treated excreta will make good manure, which could be an asset to small farmers.

For many years people in developing countries of the world have regarded sewerage systems as the best method of dealing with excreta. Indeed, it is the most sophisticated and hygienic method but it is also the most expensive technology. A lot of water is required for this type of system to perform well, yet water is both scarce and expensive. The gravity of the situation is more evident in rural areas.

As the world gets poorer, people are now turning to conventional, but simple and relatively cheap, technologies. Many low-cost technologies have been developed and are being tried. Improved pit latrines, compost latrines, pour flush aqua privies, and septic tank latrines are among the low-cost technologies.

This paper will discuss on-site disposal systems. These are the systems that do not require transportation. Three types of on-site dry latrines (vented improved latrines) will be discussed: the direct vented pit; offset vented pit; and compost latrines.

Vented Pit Latrines

The pit can either be circular or square in shape. A round pit is normally preferred. The pit is about 240 cm deep and 90–110 cm in diameter. It can be lined or unlined depending upon the soil structure. In weak soils (loam or sandy soils) it must be lined. This will guard against cave-in and will also minimize the chances of fouling the ground-water. The lining can be cement blocks, burnt bricks, stabilized earth blocks, concrete rings, or metal sheeting.

In digging the pit it has been found that it is advantageous to start by providing a collar around the pit. The vented pit latrines experimented with in Tanzania were square in shape, 100 cm × 100 cm × 240 cm. The collar helped in getting the sides straight and prevented the top portion of the pit from falling in. These pits were unlined.

The collar was reinforced with two iron bars 6 mm in diameter. One layer of brick was built on top of the collar to make a plinth on which the stance would stand. The pit stance can be made of wood (plywood), reinforced concrete, or ferro-cement. The platform must be durable and easily cleaned. In our experiment we used both marine plywood (1.8 cm thick) and ferro-cement (1.8 cm). Ferro-cement, besides being cheap and easily made locally, was found to be durable and strong. It requires a weight of 340 kg to break the slab. The slab must fit tightly to prevent passage of flies. In the vented pit, the slab (platform) has two holes: one of them for squatting (defecation) and the second hole, which is 20 cm in diameter, is fitted with a vent pipe 15 cm in diameter.
and about 250 cm high. The top of the vent pipe is belled outwards to about 30 cm and the aperture so made is covered with wire gauze to prevent the escape of flies and mosquitoes. Aluminum wire mesh has been found to be more durable because it does not corrode quickly. Fiberglass mesh could be another alternative.

The superstructure provides privacy and protects the user from the sun and rain. It can be made of any material: mud bricks, burnt bricks, or wooden poles, with a thatched roof or corrugated metal sheet roof. The superstructure must be high enough to permit the user to perform the function comfortably. Low and short superstructures should be discouraged. A door opening inwards must be provided as well.

The vented pit latrine operates anaerobically. The foul gases produced during decomposition are vented away through the flue provided. This type of latrine is odour free and if properly maintained can be free of flies. Normally, only excreta enters the pit. To perform well, the contents of the pit should not be too dry.

The vented pit latrine is designed for a single operation, i.e., it is a discontinuous system. Once filled, it has to be abandoned and a new one constructed. It can be emptied but after a long time of rest. Various designs have been developed recently to facilitate easy emptying of the contents and also to facilitate reuse of the latrine.

Because it is practically odour free, it should be safe to locate the offset pit latrine close to the house, but preferably at least 8 m away in townships, depending upon the plot size, and at least 20 m away in rural areas. The latrines should not be too far as this will deter their use by small children or at night by adults, which will defeat the purpose of the latrine.

Pit latrines are normally not sealed at the bottom and infiltration is likely, particularly in permeable soils. If they are located close (less than 50 m) to wells, they become potential health hazards because the water will become polluted. Alternatively, they should be placed downstream of any water source.

Pit latrines are the most common features in developing countries. This is true of Tanzania. In the past, people have been held back from using latrines due to tribal customs and taboos. This problem is now decreasing and in urban centres it is almost nonexistent. With health education, people accept pit latrines very readily. Because of their simplicity, pit latrines are easy and less costly to maintain. The small area of the squatting slab renders it easy to clean. The superstructure, if made of durable materials, will also require very little care. The door hinges may get loose quickly and these would require extra care. This is also true with the wooden hole cover, especially the handle. Pit latrines are best if provided on an individual household basis. Communal latrines pose problems in their upkeep. No one feels responsible to clean it and it may remain dirty for long periods of time. It then becomes a nuisance and a health hazard to the users.

**The Offset Vented Pit (Reid Odourless Earth Closet, ROEC)**

This consists of two separate units, the defecation unit and the holding (receiving) unit, connected by a short length of piping, the chute, set at an angle of between 50° and 60° to the horizontal. The defecation unit forms the shelter or the superstructure. Here again, this can be constructed with any suitable material. A door is also essential. The floor, cast in situ, is made of concrete, with a keyhole shaped defecation aperture. A room 90 cm long and 80 cm wide is quite adequate.

The holding unit can either be a lined tank or lined on the sides with an unsealed bottom. Again, this will depend upon the nature of the soil and the groundwater level. Lined pits should have weep holes for seepage. The tank is 200 cm long, 100 cm wide, and has a minimum depth of 240 cm. The depth is measured from the bottom of the chute to the pit floor. Heavy-duty concrete covers are required for the top of the tank. A vent pipe 15 cm in diameter is fitted on the fixed slab. The other slabs are lip-jointed and are provided with metal handles for easy removal. The top of the vent pipe is covered with
suitable mosquito gauze. This will prevent flies and mosquitoes from escaping when they are drawn up by the draught of air through the chute.

The ROEC works like a vented pit latrine. It is anaerobic in action and gases are vented away through the vent pipe. It is, therefore, odourless as its name implies. The unit can withstand some abuses in usage. It can tolerate the addition of water. Care, however, should be taken not to have too much water. The unit is acceptable to many people and was most liked by people who use water for anal cleansing. People have tended to use the enclosure as a bathroom but because of its small space, it has managed to discourage users from taking baths in them.

The floor of the ROEC is fixed and very easily kept clean. Most ROECs tested in Tanzania were always found very clean. The only problem arose with the chute. It gets fouled and if neglected can be a nuisance. By using a long-handled brush or by pushing small bundles of grass, the chute's surface can be kept clean. Like the vented pit, extra care is required for the door and its hinges. It will be of interest to note that of the 16 ROECs built and tested in Tanzania, 5 collapsed after being in use for between 6 and 16 months. One unit collapsed because of faulty construction and this was replaced with a better constructed unit. The others collapsed as a result of heavy rains and high groundwater tables. They were constructed in unstable soil. One probable reason for the collapse is the size of the walls of the receptacles. The units were constructed with blocks measuring 390 mm x 190 mm x 50 mm. The 50 mm thick wall does not appear to be strong enough to withstand the soil pressure. It is suggested that for the ROEC, bricks or blocks with a thickness of between 150 mm and 230 mm should be used.

Improved ROEC

Experience has shown here and elsewhere that the chute of the ROEC is subject to fouling by excreta. This fouling tends to undermine the hygienic properties of the ROEC. To eliminate such fouling, the design of the ROEC has been modified. In the revised design, the chute is omitted. Instead, the near end of the pit has been extended just below the superstructure so that excreta from the pedestal seat or squatting slab can drop directly into the pit. This modified ROEC has been named the vented indirect pit latrine (VIP). Another modification of the ROEC is the alternating VIP latrine. Here, the pedestal seat or squatting plate in each toilet room or cubical has two openings. Each opening leads to one of two adjacent indirect pits. Thus, behind the latrine are two adjacent pits, each with a corresponding toilet seat or squatting plate opening within the same toilet room.

During operation, only one pit is used at a time. When the first pit becomes full, the second pit is brought into use. When the second pit becomes full, the decomposed contents of the first pit are removed for possible use in agriculture, and the emptied pit is returned to use again. The size of the pits should be such that the contents in them should remain for at least 2 years before being removed. In this way, the destruction of pathogens will be ensured. The alternating VIP should be regarded as a permanent latrine. It is, however, more costly to construct than the ROEC and the VIP latrine. It can be observed that communal use is also applicable. In this case, the number of pits is one more than the number of toilet cubicles. If the pits are numbered sequentially from one end they can be divided into two sets, namely, odd-numbered pits and even-numbered pits. In operation, either the odd-numbered or the even-numbered pits are used at any given time. When a member of one set of pits becomes full, all members are put off use, and the other set is brought into use. Hence, these two sets of pits are used alternately. These modified alternatives are currently being tried in Ghana and Botswana.

Composting Toilets

There are two basic types of composting toilets: continuous and batch (alternating). Continuous composters are developments of a Swedish design known as the “mult-
rum. The composting chamber, which is situated immediately below the toilet seat or squatting plate, has a sloping floor above which are suspended inverted "U" or "V" shaped channels. In some cases these channels are omitted for ventilation purposes.

The multrum is a two-chambered unit. The two chambers are separated by a baffle wall which is built a few centimetres clear of the floor, thus providing a passage for the accumulating and decomposing compost in the upper chamber to slide down through into the lower, humus chamber. The floor is laid at an angle of between 25 and 30° with the horizontal. It has been found that with a slope less than 25° the compost does not slide fast enough, whereas above 30°, the compost slides too fast, to the extent that the humus nearly always contains fresh excreta. The humus is supposed to be the end product of decomposition of the compost and if properly managed should resemble black soil. The construction of the slanting floor at the required angle requires an expert artisan who may not be easily available in rural areas. The floor can be either concrete or brick lined. The walls of the multrum may also be constructed with adobe, burnt bricks, cement blocks, or stabilized earth blocks. The little spaces left between the joints would form weeping holes for seepage of excess liquid. The two chambers mentioned above have covers placed on top. The top chamber has a squatting plate with a defecation hole. The lower chamber has a solid (without hole) cover. These covers can be made of plywood, reinforced concrete, or stabilized ferro-cement. In our test units, plywood (1–8 cm thick) and ferro-cement (1.8 cm thick) were used.

Ventilation of the multrum is achieved by a flue inserted on the side of a wall below the squatting stance. The metal vent pipe has a right-angle bend fitted into the wall and a vertical pipe is extended above the roof. The belled top end is covered with mosquito wire gauze to stop insects from escaping. In addition to the vertical flue, one or two small vents are inserted in the wall above the ground level. These vents are also screened. It has been observed that metal screens get rusted too quickly, whereas nylon wire is eaten by cockroaches. Perhaps the best screening material would be aluminum gauze or fiberglass. The problem with vent holes is that they are easily tampered with by small children and also they tend to be blocked by fly pupae. It is advisable that vents be omitted; ventilation could be achieved through the hole in the squatting slab.

The Utafiti Latrine

This is a modified multrum that is currently being tested in Tanzania. Structurally the Utafiti latrine is basically the same as the multrum. There is no difference in its performance compared with the multrum; although the Utafiti latrine may be a little larger. Two special features that make the Utafiti different from the multrum are (1) the squatting slab incorporates a flap-trapped pan or chute and (2) "U" or "V" shaped conduits are provided. The floor of the Utafiti can be open or sealed. The absorption trench provided for the disposal of excess liquid is optional. It is not required for people who use toilet paper (as opposed to water) for anal cleaning. One thing worth noting is the problem of keeping the flap-trapped pan or chute clean. In the first instance, the pan is too small and easily fouled. The chute has the same drawback as that in the ROEC. It requires a lot of health education for users. The best cleaning material for the fouled chute is refuse and particularly a hip of grass pushed into the pit.

Continuous composting latrines work aerobically. Because of the presence of the vent pipe, the latrine is virtually odourless. For the latrine to work efficiently a lot of organic materials, e.g., grass, peelings (fruits), husks of grain, sawdust, and ashes must be added to the latrine. The compost latrine will not function well if it is too watery. Of course, the contents should not be too dry either. It is recommended that the moisture content should be between 40 and 60%. With the right moisture content and a lot of decomposable materials (a large hip), bacterial activity in the compost can raise the compost temperature to a level (50–60°C) that will eliminate pathogens in the
compost. The performance of the multrums in Tanzania was not very encouraging. In many cases, the compost was too wet and the humus was actually sludge. This excessive water content was due to water that was used to clean the anal parts and sometimes to water used to clean the squatting stance. Very little refuse was added. The temperatures in most units were just ambient.

Because of the sloping nature of the floor of the multrum or Utafiti latrine, the composters must be constructed below ground level (usually 1 m). However, because it is lined and has a sealed floor, the chances of groundwater being contaminated are small. If the pit must be unlined and open on the bottom, particularly in impermeable soils, the normal and recommended precautions, insofar as sitting in relation to wells, should be adhered to. Composting latrines are practically odour free but should, nevertheless, be sited as far as possible from the kitchen and the house to minimize the possibility of cockroaches finding their way from the receptacle to food and kitchen utensils.

Composting latrines are relatively new to the African people and particularly to Tanzanians. In operating the composter, a lot of organic materials (grass, straw, sawdust) are required. These may be lacking in urban areas. In some cases, because of taboos, people are not happy with the need to “keep on adding grass” into the pit. Again, humus has to be removed periodically. Many people loathe the idea of touching faeces and it, therefore, becomes a problem in removing the humus, particularly if it is “sludge.” Participants in our test units in the country have managed to remove the humus, but this has not been without prolonged health education and persuasion. They have also used the humus as fertilizer in their gardens with great enthusiasm. For people who use water for anal cleaning, compost latrines are not cherished. If given the choice, they prefer VIP or ROEC type latrines. If a composter is to be used properly, it is recommended that a bath place (room) should be provided adjacent to the latrine (with a door leading to it).

As pointed out with regard to the VIP and the ROEC, the main problem is the maintenance of the vent pipe. This corrodes very quickly. It has to be replaced many times which is costly. It has been suggested that to tackle this problem it would be advisable to use things such as cast iron, PVC piping, or bricks. These items, of course, are durable but very costly. One observation of misuse of the latrines, and this is true of the batch system (modified Gopuri), is the tipping of refuse or organic matter into the humus chamber. This defeats the purpose of the composting toilet. It is suggested that covers for the humus chamber should be fixed with cement mortar, because lime mortar is rather weak for this purpose.

**Batch (Alternating/Double-Vault) Composters**

Double-vault composting (DVC) toilets are the most common type of batch composting latrines. There are many designs but all have common features: (1) They have two adjacent vaults: one is used until it is about three-quarters full, covered with grass, filled with earth, and then sealed; the other vault is then used. When the second vault becomes full, the contents of first vault are removed and the vault used again. The vaults are, thus, used alternately. (2) They have vent pipes that extend above the roof and remove foul gases from the latrine. (3) Organic refuse, including ashes, must be added into the vault.

There are no standard designs and the sizes of the vaults are not well specified. Compost latrines are shallow and are designed to serve households. The vaults are, therefore, just adequate to accommodate excreta for 6–8 people for 6–8 months. The size of the vaults could range between 0.3 and 0.9 m³.

The construction materials are the same as those for continuous composting latrines, i.e., bricks, concrete blocks, or stones can be used. Double-vault latrines may either be lined and sealed at the bottom or may be lined and left open at the bottom. Decomposition in the sealed vaults takes much longer than in the open vault. Whereas in the sealed vault the liquid (urine plus excess water for anal cleaning and slab cleaning) is retained much longer, in the open pit the
liquid infiltrates into the soil. The moisture content in such open vaults is more conducive to bacterial activities than in the sealed vaults.

The squatting slab can be made from wood (plywood is best), reinforced concrete, or ferro-cement. Cement slabs are preferred because they discourage growth of hookworm larvae. The slab must have a hole large enough to avoid fouling of the sides but small enough to prevent children from falling into the vault. The DVC toilet works anaerobically and produces foul gases.

It is essential that the gases are removed. The problem with the metal vent pipes currently being used is that they rust very fast, particularly at the bend. The gases from the latrine are very corrosive.

Alternating or double-vault latrines are the most versatile types. They can be used under difficult soil and groundwater conditions. In this case, they may be the only choice. Where the groundwater table is high or the soil is impermeable or unsuitable, the double-vault latrine is recommended. The latrine can virtually be built above the ground (for a sealed unit) or just a few centimetres below ground (for an unsealed unit). The location of the latrine in relation to the house is the same as for the continuous composting toilet.

Batch composters perform well when the moisture content of the compost is between 40 and 60% and the carbon/nitrogen ratio between 15:1 and 30:1. It is essential, therefore, that very little water is put into the vault and a lot of easily biodegradable organic wastes, such as sawdust, grass, and vegetable wastes, are regularly added into the vault to maintain a suitable carbon/nitrogen ratio in the compost pile. If these two conditions are followed, the maintenance problems are minimal, i.e., only the vent pipe and screening material need to be cared for.

Composting toilets are comparatively new innovations in many African countries including Tanzania. The conditions required to enable the latrine to produce compost are not easily followed and many people loathe working with composted humus, which many people still regard as faeces. The acceptability of the composters by people is, therefore, still questionable. It is suggested that households that participated in our trial units accepted the latrine because they wanted a latrine. After all, they were going to get the services free. More time is needed to be able to evaluate this aspect.

Health Aspect of Composting and Refuse

Ventilation of vaults reduces odours and fly nuisances considerably, and if the squatting plate is kept clean, double-vault composting toilets do not pose significant risks to health. Provided each vault can store excreta for 1 year, the composted humus can be safely handled and used on the land. Microbiological studies carried out in Tanzania on the compost have shown that there is considerable reduction in the coliform bacteria. Thus, the humus in the compost latrine contains no more pathogenic organisms than the soil on the ground around the households. A triple-vault composter (TVC) would make the humus much safer. With regard to reuse of the humus, only three households were surveyed. They used the humus in their gardens and they have made very favourable remarks.

General Remarks on Compost Latrines as Experienced in Tanzania

As indicated, compost latrines are a very new technology in this country. People are more familiar with pit latrines. There are only 57 compost latrines in the country; of these, 44 are continuous and 13 are double-vault latrines. All of these were experimental units. No new ones have been built. The performance of continuous composters was not satisfactory. Poor operational maintenance was the main cause of failure. People used too much water for anal cleansing and also for cleaning the stance (if they had to). Therefore, the compost was too wet and so was the humus. Temperatures in the compost heap were just ambient, so that many pathogenic bacteria could not be eliminated. Perhaps the reduction of the coliforms was
due to the length of time the humus remained in the vault. Many users considered it as an unnecessary bother to keep putting organic matter in the latrine vaults. There was, therefore, very little material to provide the carbon and nitrogen necessary for bacterial activity. The double-vault composters, however, did work out well. Four of the composters produced good dry humus. With these composters, the removal of the humus was not a problem, but the people had to be educated and persuaded. The people did accept the composters but the acceptance could well be due to the fact that they did not have to pay for the latrines and they needed them anyway. Nonetheless, with the passage of time and continual health education, many households will probably opt for the compost latrine. A compost latrine, in addition to being an excreta disposal unit, is also a refuse (garbage) disposal unit. If used well, household refuse collection and disposal would be very much facilitated. Furthermore, a compost latrine has the advantage over a pit latrine of being shallow and in this respect things, including children, falling into them can easily be retrieved.

Conclusions

Pit latrines (VIP) and composting toilets are low-cost technologies that are cheap to construct and to maintain. Many people can afford to own them. Furthermore, people are accepting their use. It is a pity that in the past more emphasis was put on the supply of water than on sanitation. Water alone cannot improve the health of the people. Both water and excreta disposal systems must be provided together if the health of the people is to be significantly improved.