Ecological Toilets

Start simple and upgrade

from Arborloo to VIP

Peter Morgan

Pre-Production Draft

Ecological Toilets
Start simple and upgrade from Arborloo to VIP

by
Peter Morgan
Aquamor: Harare, Zimbabwe

Stockholm Environment Institute
EcoSanRes Programme
2009

Pre-Production Draft

EcoSanRes Programme
Stockholm Environment Institute
Kräftriket 2B
10691 Stockholm
SWEDEN
Tel: +46 8 674 7070
Fax: +46 8 674 7020
Email: ian.caldwell@sei.se
Layout and Editing: Ian Caldwell
Research and Communications Manager: Arno Rosemarin
www.ecosanres.org, www.sei.se

Photo Credits: Peter Morgan

ISBN

Table of Contents

Table of Figures

Acknowledgements

For support in Zimbabwe I thank Christine Dean and Baidon Matambura of the Friend Foundation, Maxwell Jonga and supporting staff and of UNICEF, John Mutisi (Headmaster) and staff of the Chisungu Primary School, Tedious Chanyowedza and supporting staff of Christian Care, Terry Quinlan and Rod Charters (GRM & TLC), John Mwenda (National Institute of Health Research) and Cleophas Musara and supporting staff of Mvuramanzi Trust. I also thank Annie Shangwa for her dedication and skills at training the teachers and pupils at Chisungu Primary School, Epworth and also the staff and trainees at Kufunda Training Centre, Ruwa. From Malawi and Mozambique I thank Ned Breslin, Steven Sugden, Twitty Mukundia, Jim McGill, Gary Holm and Elias Chimulambe.

Many thanks also to Gunilla Brattberg, Arno Rosemarin, Håkan Jönsson, Madeleine Fogde and supporting staff of the EcoSanRes Project at the Stockholm Environment Institute, Sweden for much encouragement and support. I also wish to thank Linus Dagerskog for carefully reading the text of this book and making many excellent suggestions for improvement. I am constantly indebted to Ingvar Andersson, Rolf Winberg and Bengt Johansson for their constant support and personal encouragement over the years. I also offer thanks to Sida for their support which has made this work possible. Most importantly, I thank my wife Linda, for your patience, encouragement and every other possible support.

Peter Morgan
Harare, February 2009

1. An introduction

Where the VIP (ventilated improved pit) toilet is used in national programmes and is seen as a standard to aim for, but where local families cannot afford the expense, or where donors may be reluctant to provide sufficient material assistance, there comes a need to provide a step by step process of upgrading simpler toilets to VIP toilets over time.

VIP toilets are ventilated pit toilets which help to control odours and flies. Being pit toilets, pit filling is inevitable – the pit must either be emptied or the toilet rebuilt when the pit is full.

In Zimbabwe, the VIP toilet is known as the Blair VIP (after Dr Dyson Blair, whose name was also given to the Blair Institute where the VIP was first researched in the early 1970's). Most Blair VIP toilet pits are dug 3m deep. In earlier years the pit diameter was 1.5m, and some built in the mid 1970's are still being used 30 years later. But in later models pit diameter was reduced, at first to 1.2m, then to 1.1m to save on cost. These had an expected life of only 10-12 years. Thus most of the toilets built during the years 1980 to 2000 are now full or nearly full.

For most African countries toilet systems using large quantities of cement (e.g. 5 bags) to build family toilets are never likely to achieve wide coverage. This is particularly pertinent now. Millennium Development Goals cannot be achieved on a large scale with costly technology, when the recipient community is so poor.

Neither can sanitation programmes in Africa be entirely dependent on donor aid because this makes them unsustainable. In Zimbabwe for instance, very few self-financed VIP toilets have ever been built. If the program had been founded on a more modest and sustainable approach the percentage of the rural population having access to improved sanitation would have been rising, not falling over time. These facts and the history of the Zimbabwe programme make it very obvious that a new approach to the provision of improved sanitation for the rural areas is now required.

Given the popularity and benefits of the VIP, such an approach should retain the possibility of achieving VIP status, if that is what the family chooses, but a more modest approach is required to begin with. In this way far more families can be served with basic but improved sanitation. The concept of an upgradeable toilet, moving from simpler, cost effective technology to more advanced technology in a step by step process is clearly what is required.

This book describes a step by step approach to the construction of improved sanitation technology which may be suitable for several countries on the sub-continent. The concept of start simple and upgrade later is central to this theme.

Toilets become ecological if they protect the environment and in addition serve their families not only as units which isolate excreta, but also where recycling of the excreta is possible for the benefit of the family. That is where the excreta, either toilet compost or urine, or both, can be used to enhance food production or provide valuable commodities such valuable trees.

The upgrading concept is based on the construction of basic building units like a simple concrete slab, which is designed in such a way that it can be used on a series of upgradeable toilet designs. This slab may at first be placed on a “ring beam” made of concrete or bricks over a shallow unlined pit with a simple traditional structure placed on top. In a later upgrade, the same slab may be mounted over a brick lined pit of much greater capacity.

The simplest ecological toilet in this range, known as the "*Arborloo*" (tree toilet) uses a basic concrete slab and a "ring beam" of bricks or concrete. The shallow pit (1m deep) is dug within the ring beam. Being shallow, the pit is easily excavated by the family and there is no pit lining. Also, at the beginning of this series, there will be no vent pipe fitted. Odour and fly control can be partly achieved by regularly adding soil and wood ash to the pit. Soil and ash also accelerate the rate at which the human excreta turns into compost. This is an important property of these shallow pit ecological toilets. A large range of light weight and portable "toilet houses" can be used with this basic simple unit. The *Arborloo* is the starting point along a road of sanitary options which increase in cost and complexity.

This *"Arborloo"* has a movable slab, ring beam and superstructure and these are relocated periodically as the pits fill up. Once the pit is nearly full, the exposed pit contents are levelled off and covered with a generous layer of topsoil and left to compost. At a convenient time, often at the start of the rains, but at any time if water is available, a young tree is planted in the topsoil, protected from animals and watered. This pit of organic contents can be a great asset to any family, particularly where the local soils are poor and devoid of nutrients. It serves like an "organic oasis" where plants may thrive in an otherwise hostile environment where the soils are poor.

In an alternative approach, a young tree can be planted in a smaller pit dug to the side of the main pit and filled with more fertile soil, so the tree starts to grow as the toilet is being used.

This tree toilet moves around in the garden or homestead, with trees or vegetables being planted in or near each "station." Trees can provide fruit, fuel, shade and timber for construction. Vegetables like pumpkin and tomato can also be grown in the topsoil added to the compost pit. If a tree or vegetables are not planted, the pit contents, once turned into compost, can easily be dug out and used elsewhere in the garden. This process usually takes one year. The same pit can then be used again if the side walls of the pit are firm.

In stable soils a ring beam may be unnecessary with the *"Arborloo"* with the concrete slab being placed directly over a smaller hole dug in the ground. In this case soil taken from the pit is built up around the rim of the pit and the slab placed on top. Further soil is then rammed around the slab to stabilise the unit and reduce soil erosion during the rains. Pits dug in this way have a reduced diameter and capacity compared to pits dug within ring beams. They are also less stable. A ring beam is desirable.

This single pit (*Arborloo*) design can be upgraded in several ways, with the same concrete slab being used as the basis of an extended range of toilet options. In this series the slab is made with a vent pipe hole made in it from the start. Upgrading to VIP then becomes possible.

Where longer pit life is required and where bricks are available for use, it is desirable to dig the pit deeper and wider and line it with bricks. The same slab can be fitted on top of the pit lining and a "toilet house" built over or around this. Such a unit can operate like a pit toilet, but it is wise to use the unit in an ecological way – in other words by adding soil and ash regularly to the pit and not garbage. The pit contents then turn more efficiently into compost and at a later date can be more easily excavated or recycled in other ways.

In a system known as the "*Fossa alterna*" ("alternating shallow pit compost toilet") two pits are used alternately at 12 month intervals. These can be lined with bricks or unlined and are dug about 1.5m deep. The compost is dug out every year and used on the garden. The slab and structure are moved from one pit to the other – and then back again! Two pits can be dug within a single "house" if desired. If the filling rate is fast, a third or fourth pit can be dug and the slab used on a rotating basis on all pits. If the soil is moderately firm a ring beam at the head of the pit is sufficient. In less stable soil, the pits should be lined with bricks.

If the pits are lined with bricks it pays to enlarge the diameter of the pit and to step in the brickwork at the top so that the smaller slab will fit on the larger pit. This brick construction method is known as corbelling. Larger pits take longer to fill and this can be an advantage. Another advantage of lining pits with bricks is that the "house" on top can also be built with bricks. Bricks are commonly available in many parts of Zimbabwe and in other countries.

Both the *Arborloo* and *Fossa alterna* can be upgraded further by adding a vent pipe. The pipe will draw out odours from the pit and reduce odours in the toilet. If the pipe is fitted with a fly screen and the superstructure provides semi darkness, it will also help to control flies. A spiral door-less structure with roof or a structure with self closing door and roof are essential in this case. In this way both systems can be upgraded into variants of the VIP toilet. They can also be improved by adding a hand washing facility and a pedestal for sitting. It is also possible to place plastic containers fitted with funnels into these toilets for urine collection.

Each system can be further upgraded to a urine diverting toilet, where the faeces and urine are separated. These use urine diverting pedestals or squat plates where the urine and faeces are separated. The urine, which contains a lot of nitrogen, is useful as a fertiliser. It is piped to a plastic container, and can be used to accelerate the growth of green vegetables, maize and other foods. Alternatively it can be piped directly to a nitrogen loving tree like a banana. Urine diverting pedestals or squat plates can be used either over shallow pits (such as the *Fossa alterna*), medium depth pits like the VIP or mounted over vaults above ground level. These can be single vaults or alternating vaults. Vents can also be fitted to urine diverting toilets. The vent takes away moisture in the vault which helps the dehydration process.

This book uses evidence derived from programmes based in Zimbabwe and elsewhere which shows that simple basic sanitation can be achieved without the need to built expensive toilets. It also reveals that the basic principles of the VIP toilet can be achieved at relatively low cost and do not demand construction in bricks. A screened vent pipe is required and a superstructure providing semi-darkness. Many simple and traditionally built structures work well as VIP toilets. It is possible, for instance, to hand-make vent pipes at relatively low cost. Indeed some of the best Blair VIP toilets ever built were not made with bricks at all. Generally low cost structures built with traditional materials require more maintenance. That is one advantage of the brick structure – they cannot be attacked by ants! Termite attack is a problem where wood and grass are used. Each system has its advantages and disadvantages.

The aims of this book

This book describes how to construct a series of low cost and upgradeable toilets for use in the rural and peri-urban areas which may have application in Southern, Eastern and West Africa. It also describes how to use recycled human excreta (compost and urine) in the garden and how to make hand washing devices, low cost vent pipes and pedestals etc. The aims of this series can be listed as follows:

1. To make the toilets simple, with a high content of local materials, where families can play an important part in construction.

2. To make the simplest units so low in cost that village folk may be able to afford them, or where, if donor support is available, the unit cost will be low enough to ensure that large numbers of beneficiaries can be served.

3. To design the toilets in such a way that simpler units can be built at first, but that the same building components can be used to build more sophisticated units later.

4. To design toilets so that parts (both structural and biological) can be recycled.

5. To form links between conventional sanitation technology (such as the deep pit toilet) and ecological toilets (such as the shallow pit composting toilet).

6. To form strong links between the world of sanitation and the important worlds of agriculture and forestry.

7. To design toilets in such a way that the human excreta can be recycled into compost for use in the garden.

8. To demonstrate that both compost made from human excreta and also urine can be valuable sources of plant food.

9. To link the toilet to hygiene improvement in a practical way and describe how to make simple hand washing devices.

10. To make the toilet system harmonise with Nature, so that it becomes part of the surrounding ecology.

This series starts with details of how to build a low cost single pit compost toilet, followed by a method of upgrading using pits lined with bricks and where the toilet becomes a ventilated improved pit toilet. Methods of alternating pits are also described. Methods of using the human compost and urine are also described in later chapters. The importance of making a toilet more than just a disposal system is central to the theme of this book.

This series of upgradeable toilets offers a wide range of units serving the wide range of environments characteristic of the African sub continent. No single technical option can serve all. The technical options described here may be most useful for use in rural areas or in peri-urban settlements where there is some space available for reusing recycled materials. But the methods are also being tried in low and medium density urban settlements. Time will tell how successful each method is for a specific environment.

Figure 1-1: Proud villagers next to a banana growing on Arborloo pit in Malawi

2. Basic principles

Most of the toilets described in this book turn excreta into compost which is useful in the vegetable garden and can also be used for growing trees. The simplest are low cost shallow pit toilets where an artisan or builder may not be required once the householder has learned the basic methods of construction (concrete slab, ring beam and traditional structure). The slightly more complex toilets may use a method known as urine diversion and a builder will be required to construct this type. In each case a vent pipe can be fitted to reduce flies and smells.

In the VIP toilet a screened vent pipe is used to reduced flies and odours, but fly and odour problems can also be reduced by regularly adding soil, wood ash and leaves to the excreta in the pit. The regular addition of soil and leaves to excreta in a shallow pit helps the composting process considerably. The more soil and ash is added to pit the better, with a greater the degree of fly and odour control. But this must be offset against filling the pit too fast. When a vent is fitted, flies and odours are reduced without the need to add lots of soil and ash and this can extend the life of the pit considerably. So there are advantages in fitting a vent, over and above the control of flies and odours.

It is possible to grow a valuable tree directly in the filled toilet pit if it is planted in a layer of soil placed above the compost (*Arborloo*). It is also possible to plant a tree in a narrower hole placed to one side of the *Arborloo* and filled with good soil. In this way the young tree grows to one side of the toilet, at the same time as the pit fills up. The roots of the tree will eventually invade the pit contents and take nutrients from it. It is also possible to dig out the compost after a suitable time (12 months) and use this to fertilise the vegetable garden or plant trees. So the simple toilet can have many valuable uses, in addition to being a safe way to isolate excreta. This is the new approach to pit sanitation.

The pits are shallower and the contents encouraged to compost. Recycling of the pit contents is encouraged, either by growing trees in or near the composting pits, or digging out the composted contents after a period of a year or more.

2.1 Basic principles of the toilets

The *Arborloo* (Single pit composting toilet)

In this concept the pit is shallow (1m deep) and the toilet site temporary. A ring beam of bricks or concrete is made and the pit dug down inside this. A concrete slab is mounted on the ring beam. A portable structure is mounted around the slab and ring beam. Excreta, anal cleansing materials, soil and ash are added to the pit every day and preferably after every visit to defecate. Thus the pit fills up not with raw excreta alone, but a mix of these various ingredients.

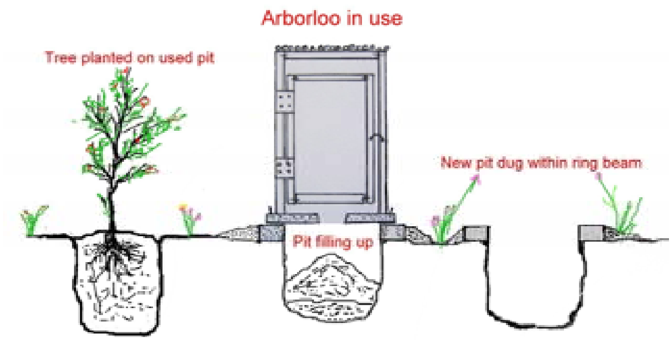


Figure 2-1: The Arborloo – dig the pit, use the pit, top up the pit, plant a tree – move on!

Leaves can also be added and this helps the composting process further. Even organic kitchen scraps can be added in limited quantities. Once the pit is nearly full, the toilet (ring beam, slab and structure) are moved to a new site nearby. This movement takes place at between 6 and 12 months intervals or even longer if the pit is larger. The used pit is topped up with a thick layer of good soil (if it can be found) and left to compost. The added soil depth is around 15cm. A young tree is then planted in the topsoil. It is also possible to plant a tree in a small pit to the side of the main toilet pit, so that as the tree grows its roots start to invade the filling compost pit.

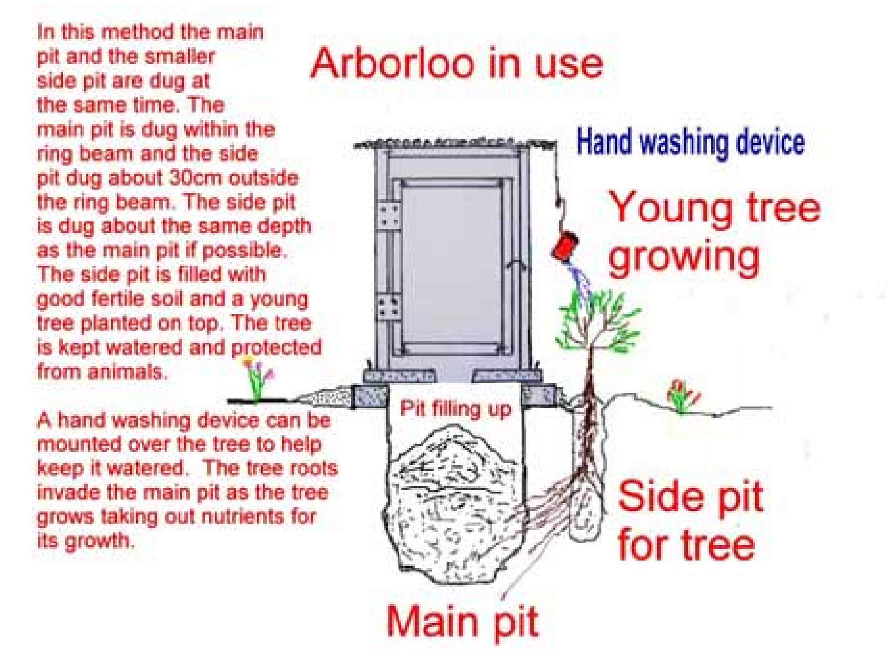


Figure 2-2: An Arborloo where the tree is planted at the same time as the toilet is put to use

Trees are best planted at the onset of the rains, but if water is available the tree can be planted at any convenient time. Young trees should be protected against goats and other animals. Also vegetables can be planted in this soil to make a small compact garden. The organic pit and soil covering is known as a "compost pit." It can also form a "ring beam garden." This can be used as a valuable asset to the users, providing a source of vegetables etc. If a tree or vegetables are not planted the contents of the compost pit can be dug out after 12 months and the pit used again for a toilet if the side walls are strong enough.

The "*Fossa alterna*" (alternating shallow pit compost toilet)

In this concept there are two permanently sited shallow pits (1.5m deep) close to each other which are used alternately. As with the *Arborloo*, soil and ash are added regularly to the pit contents in addition to the excreta. The addition of leaves also helps. These additions accelerate the rate of composting of excreta in the pit. In most soils which are moderately stable twin ring beams can be used with a single concrete slab.

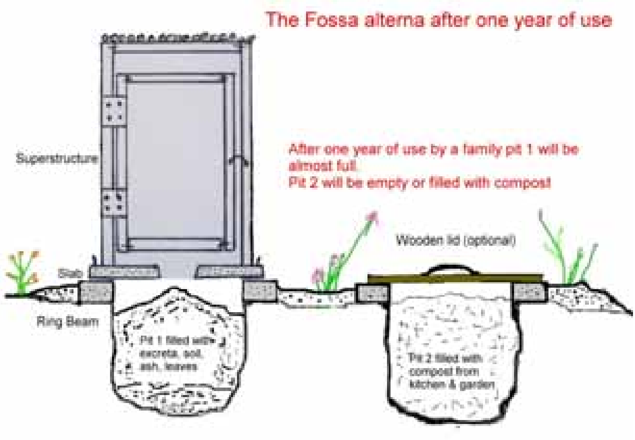


Figure 2-3: Basic design of the Fossa alterna

The slab and superstructure are moved from one pit to the other at around 12 month intervals. The pit should have a large enough capacity to accept the combination of excreta, soil and ash for a medium sized family over a 12 month period. This same period (12 months) allows sufficient time for the mix of excreta, soil, ash and leaves to form compost which can be excavated. Every year one pit is excavated whilst the other becomes full. If the pits remain stable this process can continue for many years on one site. If the pits show signs of collapse, then they can be lined with bricks or new pits dug. Both pits can be enclosed in a single larger permanent structure if desired. If the pit filling rate is fast, a third or fourth pit can be dug and used. Then a portable structure can rotate around the three or four pits.

Ventilated Improved Pit Toilets (VIP Toilets)

Pit toilets that have a screened ventilation pipe and a superstructure with semi dark interior are commonly called VIP toilets. They are usually not composting toilets. VIP toilets use the vent pipe and semi-dark interior to control both flies and odours.

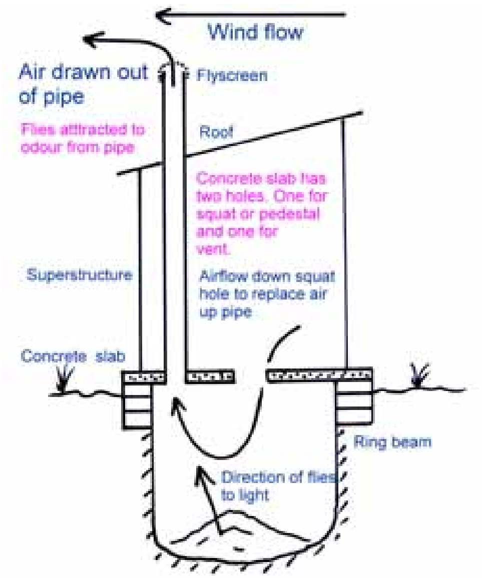


Figure 2-4: Effect of venting a pit toilet

How it works

Visualise a concrete slab fitted over a sealed pit. The slab has two holes made in it, one for the vent pipe and one for the squat or pedestal hole. As soon as the pipe is fitted air will start to move up the pipe and this escaping air draws fresh air down the squat or pedestal hole. The air flow is caused by air flowing across the top of the pipe. This has the effect of drawing air out of the pipe. Also if the pipe is exposed to the sun it will warm up and this will also make air rise in the pipe. Also the direction of the opening of the cabin or superstructure will have an influence. Wind blowing into the entrance to the toilet house will push air through the system. In the toilets described in this book the vent will normally be mounted within the toilet house, but the venting action will still take place. If the interface between the slab and the pit is sealed, air will be sucked down the squat hole to replace air passing up the pipe. When fresh air passes down the squat hole, odours from the pit cannot pass into the toilet itself. The toilet thus becomes odourless. During the day and night there may be variations in air flow depending on local conditions, but the overall effect is positive and a great improvement on the unventilated system.

Flies are attracted to odour when they enter a pit and attracted to light when they leave the pit. This is a behaviour found in Nature. If pit odours are leaving the toilet through the pipe, flies will be attracted to the pipe and enter the pit mostly via this route. If a corrosion resistant fly-screen (like aluminium or stainless steel) is fitted to the head of the pipe, the flies will not be able to pass into the pit through the pipe. Some flies may enter through the squat hole, especially if the toilet slab is not clean. If flies do breed in pits they will leave by moving towards the brightest light source. If the structure is semi-dark (that is shaded, not very dark) the flies will tend to pass up the pipe towards the light. They will be trapped and will die if the vent pipe is screened. However, if the VIP has a door which is left open, the flies will exit the pit via the squat or pedestal hole. There will be little fly control. If a pedestal with a black or dark coloured seat cover is used and the cover is in the down position when not in use, then more flies will be attracted to the vent pipe which acts like a fly trap. Also if the fly screen is not corrosion resistant, it will disintegrate quite quickly, and fly control will be lost.

So the Blair VIP, unlike many other VIPs, has a structure which provides guaranteed semi darkness. But this does not mean it must very dark. It must have a roof and an entrance which is in the form of a spiral (square or round). If a door is fitted it should be self closing. A door hinge made of a car tyre works well. Nearly all Blair VIPs use door-less spiral structures. It should be possible to read a book inside a VIP toilet.

2.2 Parts of the VIP toilet

The pit

In most VIPs the pit is dug down into the ground about 3 metres deep. If a heavy structure built with bricks or concrete is to be built, the pit must be lined with bricks. In moderately stable soils and where a lighter structure is to be built, a ring beam at the head of the pit may suffice. But ring beams are best used on shallower rather than deeper pits. The VIP principle works on both shallow and deep pits. There is no specification on pit depth. Normally VIP pits are brick lined. The width of the pit has varied over the years. Formerly 1.5m was a maximum and 1m a minimum. The greater the volume of the pit the longer the unit lasts. Some units built in the 1970’s with pits 1.5m in diameter and 3m deep are still in use, 30 years later.

The slab

This is made of concrete with two holes cast in it, one for the squat hole (or hole for pedestal) and one for the vent pipe (normal minimum size 110mm for tubular pipes). This slab sits on the brick pit lining (or ring beam) at the head of the pit. A good diameter for a round slab in which both vent and squat holes are made is 1.1m. But it is possible to squeeze both vent and squat holes on smaller diameter slabs. A good airtight seal is essential between pit lining and slab if the vent pipe is to be effective. Thus the slab is sealed to the pit masonry with low strength cement mortar or traditional anthill mortar. If air can pass between slab and pit, the aerodynamics of the ventilation system is spoiled. The result is that fly breeding commences and a smell will be noticed.

The superstructure

VIPs can be made with many types of superstructure. The most commonly used are made from bricks or cement blocks, but this is not essential to the functioning of the VIP. Brick superstructures demand brick substructures – a brick lined pit. The structure should provide semi darkness to provide fly control. That means fitting a roof. And if a door is used it should be self closing. If no door is used a square or round shaped spiral door-less structure is built. Structures in the Zimbabwe programme are mostly built with bricks, but this is not an essential feature of the VIP toilet.

The vent pipe

The most efficient vent pipes are made of smooth walled tubes like PVC and asbestos. PVC pipes work well, but are prone to damage and may have a limited life. The first Blair VIP vent pipes had a diameter of 150mm and were made of asbestos. These were virtually everlasting and very effective. But later they proved to be too expensive. Later pipes were made of PVC, but these are not as durable as asbestos pipes. The minimum diameter for a tubular pipe is 110mm, although on ecological VIP's in which soil and ash are added to the pit, this diameter can be reduced to 90mm. The vent pipe length ranges from 2.1m to 2.5 metres – the longer the better. Pipes can also be made with bricks, and most in the Zimbabwe National Sanitation Programme were made in this way. But brick pipes, with their rough internal walls are not very efficient at drawing air as smooth walled pipes – but they work well enough. Pipes can also be made with ferro-cement or cement slurry. There are several ways of making low cost home made vent pipes. An excellent technique exists for making vent pipes from news print paper and PC15 cement diluted with water to make paint. The construction of home made pipes is described in this book.

The fly-screen must be corrosion resistant. The best are made from aluminium or stainless steel, the latter lasting almost indefinitely if undamaged. PVC coated fibreglass screens may last for 5 years. Normal metal screens are useless as they corrode within a year. The pit gas is corrosive. Fly control is lost if the screen is missing or damaged. Aluminium fly screens are the best as they are relatively cheap and long lasting. Stainless steel screens are expensive, although probably worth the cost as they are virtually ever lasting.

The vent pipe must be fitted over the vent hole made in the slab and this must be fitted directly over the pit, so that light falling down the pipe will enter the pit. The pipe can be fitted both inside and outside the structure. The pipe does not have to be painted black to work. It is inevitable that spiders will weave their webs inside the pipe. After all, the pipe is a fly trap and spiders are looking for food in the form of flies. Vent pipes with spider webs inside them do not ventilate well. In fact ventilation may almost stop. To retain the efficiency of ventilation, and odour as well as fly control the inside of the pipe must be washed down with water periodically.

To get the best effect of the VIP the interior should be cleaned down regularly. Soiled toilet slabs smell and attract flies. The standard Blair VIP has been frequently used as a washroom and this is a popular feature. However when a lot of water is added to a pit, the contents will not compost, but they will degrade through a process of aerobic and anaerobic digestion. Thus pit composting during the filling stage is almost impossible if the toilet is used as a bathroom. However the popularity of the Blair toilet is partly related to its multi-purpose functioning as a toilet, washroom and a dumping ground for unwanted disposal material. This is a factor which must be considered in the choice of toilet system. There are those who may consider the use of a toilet as a bathroom more important than being able to recycle compost. In fact both options can be accomplished, by adding some soil to the pit and planting a tree next to the toilet, so it grows and derives nutrients from the pit whilst the toilet is in use. This possibility is described later.

Variants of the VIP

There are many variants of the VIP toilet: If an *Arborloo* or *Fossa alterna* is fitted with vent pipe and a suitable structure offering semi-darkness is built - it becomes a variant of the VIP. The pit depth and construction is not specified in the VIP concept. Pits can be shallower (1m) or deeper (3m) or of medium depth (2m).

Shallow pit composting

In the standard pit toilet, faeces and urine are added together with a variety of anal cleansing materials and garbage like rags, plastic and even glass. The pit is an easy dumping ground for all sorts of garbage and rubbish. Sanitary pads and rubber items also find their way down pits.

In the new generation of shallow pit composting toilets, especially those where pit emptying is envisaged, no garbage should be added to the pit. Thus rags, plastic, bottles, rubber, glass and other garbage should not enter the pit. These items will make pit emptying more difficult and possibly embarrassing later. The additions should be faeces, urine, anal cleansing materials, soil, ash and leaves. Neither should too much water be added. If water is added, it should be in relatively small amounts.

When soil, ash and leaves enter the pit together with the excreta, the composting process is accelerated. Normally the composting rate in a deep pit to which excreta alone is added is slow as conditions are not ideal. Air and composting microbes are essential. If sufficient soil and ash are added together with other composting materials like leaves an aerobic process starts and this converts the materials into compost more effectively and at a faster rate. Composting can be achieved within 12 months, rather than in years. In fact a well composted pit is easy to excavate, although the pit fills up more quickly.

Thus the way in which the pit toilet is used determines whether it will be a composting pit toilet or not. The users of standard pit toilets often add garbage and water as well as excreta. These pits are both difficult and unpleasant to empty. In the rural programme it may be easier to build another toilet and abandon the old one. In contrast composting pit toilets have very little garbage and water added and much more soil, ash and leaves. This slight change in the way the pit toilet is used makes a huge difference to the way the pit operates under the ground and what can be done with the pit contents later.

Pits of intermediate depth

Pit composting can also be made to work in pits of intermediate depth – say 2 metres if the pit contents are a mix of ingredients. Using a brick laying technique known as “corbelling” it is possible to construct a brick lined pit with a wider diameter but reduced in depth compared to a normal deep pit. In the corbelling technique, the brickwork is stepped a little in each of the upper courses. Thus a pit 2m deep and 1.4m in diameter (internal) will have a slightly larger capacity than a pit 3m deep and 1.1m in diameter (used on later Blair VIP toilets). Shallow alternating pits (*Fossa alterna*) are normally dug down to a maximum of 1.5 metres. But this can be extended to 2 metres in longer life brick lined pits. At this depth composting of the ingredients (excreta, ash, soil etc) can still take place, and at 2 metres the pit is not excessively deep and dangerous to dig. To gain the capacity the pit must be dug wider. Experiments have shown that a pit dug 2m deep and 1.6m wide (internal brick diameter of 1.3m) can be lined with fired bricks using a 16:1 sand and masonry cement mix as mortar. This leaves sufficient cement to make a concrete slab with a diameter of 1.0m or 1.1m to fit over pit on the brickwork. Thus a pit of reasonable working life (internal diameter 1.3m) can be brick lined and capped by a strong small economy concrete slab using a single 50kg bag of masonry cement. If high grade PC15 Portland cement is used the pit diameter could be increased to 1.5m using a 20:1 mix of sand and cement for the brick mortar. This is good value for money.

If a pit of this type is used in an ecological way (ie no garbage, little water and plenty of ash, soil and leaves) it becomes easier to excavate than a normal pit toilet. Also brick superstructures can also be dismantled and rebuilt if the bricks are of moderately high quality and bonded with weak cement mortar (16 parts pit sand to 1 part cement). Also by planting trees with soft wood, like paw paw, in the filled pit (planted in a layer of soil), the tree itself can be removed later when the time for pit excavation comes. The roots will have taken up nutrients and the paw paw provided fruit. But after a few years the tree can be dug out. This would not be possible with trees which establish themselves more permanently. The pit compost can then be dug out to gain access to the original pit and the compost used on the garden.

It is also possible to plant a tree in a special tree pit filled with fertile soil close to any pit toilet in such a way that the tree will eventually benefit from its close proximity to the pit and it's digesting contents. Thus the contents of even abandoned traditional pit toilets and VIP toilets can be recycled by planting suitable trees close by. Tree roots are remarkably invasive and will be able to penetrate pit linings of all sorts in the search for nutrients. A filled and abandoned family Blair VIP pit holds nearly 3 cubic metres of semi digested material turning slowly into compost which sooner or later can be utilised by trees to provide extra fruit or wood fuel etc. The material need not be wasted although it is underground and invariably difficult or unpleasant to excavate. The tree itself will perform the task. That is Nature's way.

By simple calculation, over a million cubic metres of valuable tree food in the making is waiting in Zimbabwe's abandoned Blair VIPs!

Thus pit toilets can become a long lasting asset and not just a useful facility with a limited life span. The recycled products like urine in combination with pit compost can be used to grow trees even if the material is not excavated. When the compost is excavated or the urine is tapped off separately, the products can enhance the growth of vegetables, maize, herbs and other useful plants.

The parts of the toilet can be made in such a way that they are also recyclable. Using weak cement mortar in superstructure brick work, fired brick walls can remain stable, but can be taken apart easily. The bricks can be cleaned and used again. Roofs, vents, slabs, pedestals etc can be taken away and reassembled to make new toilets. So many parts of the toilet structure above ground can be recycled. Below the ground other miracles happen. If the pit contents turn into compost, then even that part can be used again. If poor quality farm bricks are used to line the pits, they may eventually disintegrate. But the lattice work of cement mortar will remain to uphold the structure and retain the valuable compost. The lattice work is easily penetrated by the invasive roots of trees. What is below ground goes back into Nature and is recycled by the tree.

So perhaps a new generation of VIP toilets can enter the realm of ecological toilets where most of the parts and products can be recycled and are thought of in this way right from the start. It is in this context that the modern VIP toilets are described in this book. The new toilets have become ecological and have gained the property of being useful far beyond the life of the pit.

Urine diverting toilets

The urine diverting toilet uses a special pedestal or squat plate which separates the urine from the faeces – they do not mix. In this case, the urine is fed through a pipe to a plastic container. Alternatively the urine can be led through a pipe to a tree which is nitrogen loving like banana. The faeces fall into either a pit below ground or into a vault or even a plastic bucket or sack held in a brick vault above ground. Soil and ash are added to the pit, vault or bucket after every deposit is made. If a bucket (or sack) is used the contents of the bucket can be removed regularly and deposited for further processing in another site (secondary compost site) to make compost. This process takes between 6 – 12 months. If a vault is used the semi dry contents are removed periodically. This material can be added to shallow pits or into compost heaps. Many urine diverting toilets use two vaults where the faeces are drying out in one whilst the other is filling up. Most urine diverting toilets are built above ground and therefore are useful if the ground water is high or if the ground is rocky.

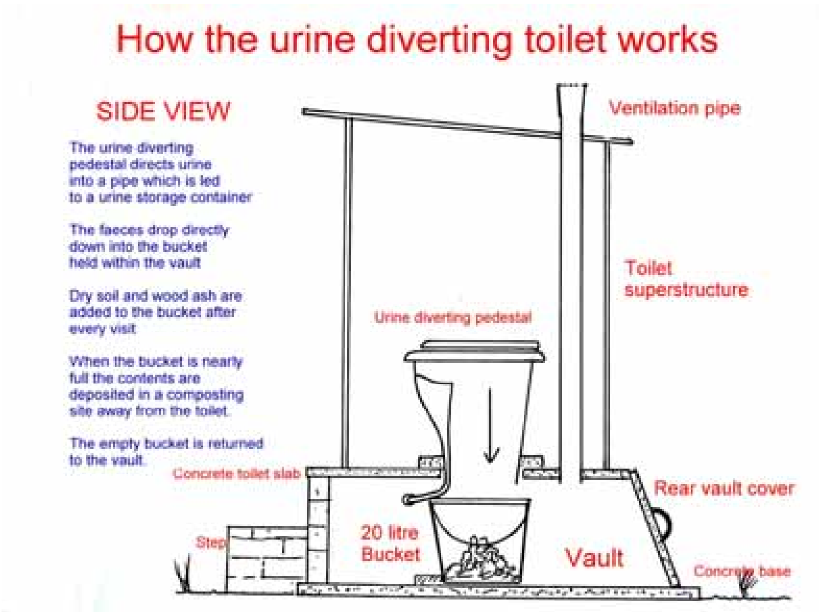


Figure 2-5: Urine diverting system
Urine and faeces are separated in a specialised pedestal or squat plate. Faeces fall into a bucket or vault with ash and soil being added on top. Urine passes through a plastic pipe to a container on the side.

The advantage of the urine diverting principle is that the valuable urine is tapped off directly and is a valuable source of nitrogen for plants. The second advantage is that faeces are easier to handle if they are not mixed with urine, especially in vaults built above ground. By adding ash or dry soil, the faeces dry out over time and become far easier to move and process. Vaults can be emptied relatively easily. Thus toilet structures can become permanent. Urine diverting toilets also have fewer problems with odours and flies – and one can therefore permit more light into the superstructure, they can even be built inside the main house.

Urine diverting pedestals and squat plates can also be added to pit toilets. Here the solids (faeces) fall into the pit whilst the urine is fed through a plastic pipe into a plastic container placed on one side or to a tree. Urine diverting pedestals or squat plates with a urine off-take above slab level are best for use on pits. Collected urine can be used to enhance the growth of maize, green vegetables etc. Urine diverting pedestals and squat plates can be home made. Several methods are possible.

So starting simple we can take several paths forward up the sanitary ladder. Very often the simplest things work best. Where wide coverage is required things must be simple, effective and cheap to build. As one enlightened designer once said….

"The designer knows he has reached perfection, not when there is no longer anything to add, but when there is no longer anything to take away!"

3. How to build an upgradeable *Arborloo*

This simple pit toilet is made up of 4 parts

1. The pit (one metre deep)
2. The “ring beam” to protect the pit
3. The concrete slab which sits on the ring beam
4. The toilet house which provides privacy.

The shallow pit fills up with a mix of excreta, soil, wood ash and leaves. Leaves are put in the base of the pit before use and every day some soil and wood ash are added to the pit. Dry leaves are also added to the pit from time to time. Organic kitchen scraps can also be added in smaller quantities. But garbage like plastic, rags, bottles, tin cans etc should be placed in a separate garbage pit dug for this purpose. When soil, ash, leaves and other organic materials are regularly added to excreta, the conversion into compost takes place at a faster rate compared to excreta to which nothing has been added. These extra additions, especially plant material also helps produce a more humus-like compost in the pit. The addition of soil, ash and leaves also helps to reduce flies and smells. If ash or leaves are not available add soil alone – it helps!

What is unique about the *Arborloo* is that the toilet is linked to a tree. The word *Arbor* in Latin means tree. The organic ingredients which are formed in the pit provide a valuable source of nutrients for the tree which can aid its growth considerably. In one sense this is what makes this toilet ecological.

The *Arborloo* is the simplest of pit toilets. It is easily constructed at low cost. But it has the potential to be upgraded. The concrete toilet slabs described in this book are made with holes not only for the squat (or pedestal hole) but also for a ventilation pipe. These means the toilet can be upgraded to a VIP (Ventilated Improved Pit) toilet later. The *Arborloo* represents the first step up the sanitation ladder.

Figure 3-1: Planting young tree. Fruit trees can grow very well on these organic pits

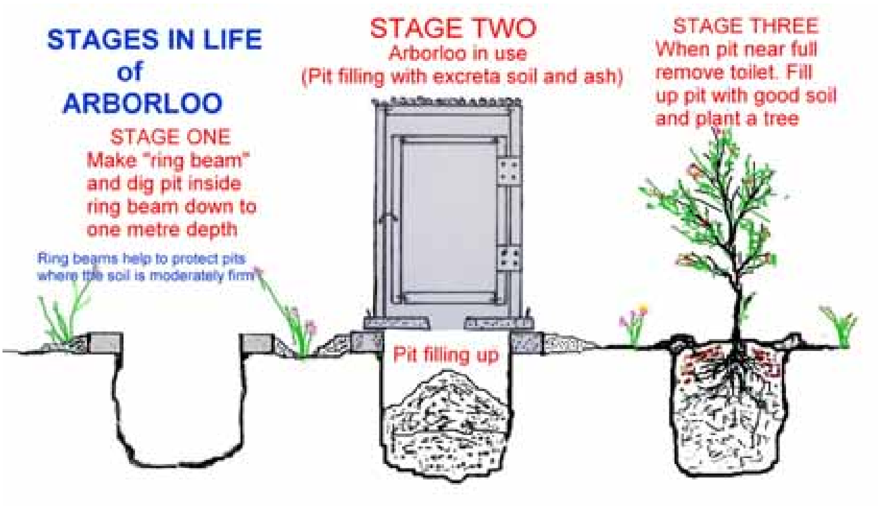


Figure 3-2: Stages in the life of an *Arborloo*

Planting trees

There are two methods of planting trees linked to *Arborloo* toilets. The established method is to wait for the pit to fill up with excreta, soil, ash and leaves, cover it with a thick layer of soil and plant a tree in the soil. The young tree roots first grow in the soil and invade the compost deeper down inside the pit later.

A second method involves planting the tree in a narrow pit dug next to the toilet at the same time as the *Arborloo* built and put to use. This narrow pit is filled with fertile soil. The tree roots will grow down into the fertile soil and later locate the organic matter in the pit, although they are not placed directly above it. This later method greatly reduces the time interval between building the toilet and the utilisation of valuable products produced by the tree like fruit, timber and fuel which result from the recycling of pit nutrients. The young tree is watered and protected from animals. The tree roots are encouraged to grow rapidly through the tubular "tree pit" and will grow deeper as the pit fills up. Eventually the tree roots will invade the main pit and tap off nutrients from it.

Figure 3-3: Young trees being planted to side of *Arborloo* pits

Moving *Arborloo* site

When the *Arborloo* pit is nearly full, the parts of the toilet (ring beam, slab, structure) are moved to another convenient place, rebuilt and put to use in the same way again. A thick layer of soil is placed over the filled pit. If a tree has not already been planted to the side of the toilet, a young tree is planted in this topsoil and is watered, protected from animals and cared for. It is often best to allow the pit contents to compost for a while, top up with soil again and then plant the young tree at the start of the rainy season.

The growing tree will require extra nutrients to make it grow at its best over a period of years. The growth of several trees (eg banana, mango and mulberry for instance) can be accelerated by the application of diluted urine (100mls urine diluted with 300mls of water) applied weekly. Compost and leaf mulch can be added to the soil around the tree to retain moisture, add extra nutrients and thus help the growth of the tree. Once the tree is established, animal manure can be dug into the soil surrounding the tree. After some years a large mature tree will be growing where the toilet was before. An organic plug is formed in the soil at each *Arborloo* site. An orchard of fruit trees or a woodlot of gum trees will grow, using nutrients derived from the compost formed from excreta.

In fact most trees will grow on an *Arborloo* pit if well cared for, including ornamental, shade and indigenous trees. In trials made in various countries a wide variety of tree species can thrive on such organic pits. By using this simple principle, the nutrients in our excreta can be recycled into something valuable – without any handling of the excreta or resulting compost at all.

Trees are good to look at, and they can provide food, shade, medicine, fuel and building materials and also consolidate the soil. They improve the environment and our world enormously.

Examples of *Arborloo* toilets

Figure 3-4: Simple *Arborloo* toilets built from traditional materials

3.1 Stages of construction

In this series the basic *Arborloo* toilet is upgradeable to a VIP system which uses a screened vent pipe. This means that the concrete slab is made with two holes, one for the squat (or pedestal) and another for the ventilation pipe. The vent pipe may not be fitted at first, in which case the vent hole is filled in with a plug of weak cement mortar.

The ventilation pipe can be fitted later as part of the upgrading process. At first, regular additions of ash and soil to the pit will help to reduce odours and flies, but it will not control them completely. These ingredients should be added after each defecation. Obviously the addition of these extra materials hastens the filling of the pit. After the pipe is added odour will be controlled far better and if a fly screen and suitable structure, which provides semi-darkness is added, fly control will also be enhanced.

The concrete slab – what size?

Concrete slabs for the *Arborloo* can be made in several sizes. The smaller the slab the easier it is to move, but less room is available for fitting the squat hole and vent pipe hole at comfortable distances apart. It is technically possible to make a concrete slab which is 0.9 metres in diameter with both a vent hole and squat hole. Slabs with diameters of 1.0m, 1.1m and 1.2m in diameter can also be made. The larger the slab and matching ring beam (which supports the slab), the larger the pit size will be, thus extending the life of the pit.

A 1.0m diameter concrete slab is a convenient size to use if made off-site and must be transported by road, as it can be made very strong and is not too heavy. If the slab is made on-site, that is at the site where the toilet is to be built then the 1.1m diameter slab is a better size to use as it provides a little more space between vent and squat hole. 0.9m, 1.0m, 1.1m and 1.2m slabs can be used on upgraded *Arborloo* toilets which may be made of bricks mounted over brick lined pits. Slab weight, strength and portability are important factors with the *Arborloo* concept. Larger slabs use more cement and are heavier to lift and move about.

How to make a concrete slab

The concrete slab is ideally made with a mixture of Portland (PC15) cement and good quality river sand (sharp feel and clean) with some wire reinforcing (2.5mm - 3mm wire or barbed wire). The quantities used depend on the size of the slab. Obviously the larger the slab the more cement, sand and wire it will use. If Portland cement is not available then masonry cement must be used. This will mean using a higher ratio of cement to sand – about 5:1 for Portland and about 3:1 for Masonry cement. The final slab strength also depends on the curing process - where the concrete is kept wet (after hardening) for at least a week. Concrete that is allowed to dry out after it has set never gains strength. The curing process where the slab is covered and kept wet is essential is slab strength is to be assured.

Mixes of cement and river sand for different slab sizes

For PC 15 (Portland) cement

Slab diameter	Cement	River sand
0.9 metres	6.5 litres	32 litres
1.0 metres (Medium strength – 5:1)	8 litres	40 litres
1.0 metres (High strength – 3.5:1)	10 litres	35 litres
1.1 metres	10 litres	50 litres
1.2 metres	12 litres	60 litres

For Masonry cement

Slab diameter	Cement	River sand
0.9 metres	10 litres	30 litres
1.0 metres	12 litres	36 litres
1.1 metres	15 litres	45 litres
1.2 metres	17 litres	50 litres

A 50kg bag of cement contains about 40 litres of cement. This means that 4 or 5 slabs can be made with a single 50kg bag of Portland cement depending on the mixture and size of slab made.

Making the mould in which to caste the slab

The mould for the concrete slab can be made from a ring of bricks laid on levelled ground. The bricks are laid around a circle 1.0m (or 1.1 metres (or chosen size) in diameter (radius 50cm or 55.5cm). The bricks can be laid on a plastic sheet placed on the ground, or a plastic sheet placed within the brick circle. Alternatively the ground can be levelled off and river sand laid down and levelled off and the bricks laid on the sand. The sand should be moistened. Using a centre mark, bricks are laid around in a circle. A string radiating from a nail placed in the ground is ideal. Or a length of 3mm wire bent at both ends at a right angle to form a 1m circle. A mould which has been made for the squat hole is then laid 30cm from the rear end of the slab. This can be made from a 15 litre plastic bucket, with a wire to make the shape (see photos). The hole can also be made from shaped bricks or from wood or steel. The vent hole is ideally 110mm, but to reduce cost a 90mm hole (for PVC or other pipes) will still ventilate quite well. The vent hole is made using a 75mm length of 110mm or 90mm PVC pipe. This is laid to one side of the squat hole, so the lower edge of the pipe hole and the squat hole are at the same level. The vent hole is made 12cm in from the edge of the slab. The distance between the vent hole and squat hole should be 20cm.

Note where the toilet is to be used in an ecological way (eg where soil ands ash are added to the pit) part of the odour and fly control is undertaken by the soil and ash and the vent pipe can be slightly smaller. Under these conditions a 90mm diameter pipe is acceptable.

Making the concrete

The concrete mix can be made by mixing 10 litres of PC 15 (Portland) cement with 35 litres sharp clean river sand (for high strength 1.0m slab). Or 8 litres PC15 cement and 40 litres river sand for standard strength 1.0m slab. Mix thoroughly in the dry state and then add water to make a thick slurry and mix again. Add half of this mix to the mould, adding first around the squat and vent hole moulds to secure their position and then adding further concrete over the entire area and levelling off. The reinforcing wire is added next and then the remaining concrete.

The wire reinforcing

3mm steel wire or barbed wire can be used for reinforcing. For the 1.0m slab 4 pieces 0.9m long and 4 pieces 0.7m long are used. For the 1.1m slab 4 pieces 1m and 4 pieces 0.8m are used. The wires are laid on the concrete as shown in the photos.

Finishing off

The second half of the concrete mix is then added and levelled off flat with a wooden float and then a steel trowel. After two hours carefully remove the squat hole and vent hole moulds and smooth off the edges of the squat hole. Lay some thin poles over the slab and cover with plastic sheet and leave overnight. Once the concrete is hard the following morning add water and cover again with plastic sheet. If a ventilation pipe is not going to be used immediately the vent hole can be filled with a small weak mix of sand and cement (15:1). Place a ring of plastic sheet in the hole first and then fill with concrete. This forms a plug which can be knocked out later when the pipe is fitted.

Curing

The slab is left to cure for at least 7 days. It is kept wet under plastic sheet or paper all the time. It can also be covered with sand which is kept wet. The curing process (where the slab is kept wet all the time and not allowed to dry out) is very important. Slabs only develop strength when cured properly. If they are allowed to dry out once made, they never develop strength. Curing is essential for a long life concrete slab. The longer the slab cures the stronger it will become.

Making a 1.0m diameter concrete slab

This concrete slab is 1.0m in diameter and caste within a ring of bricks. Moulds for the squat and vent pipe holes are laid within the bricks. In this case a steel mould (former) is used for the squat hole. Shaped plastic buckets can also be used. The vent pipe hole is formed around a length of PVC pipe (90mm in this case). The squat hole is positioned 30cm from the rear of the slab and the vent hole 12cm in from the edge. The vent and squat holes are 20cm apart. Eight 3mm wires (steel or barbed wire) are cut : 4 X 0.9m and 4 X 0.7m. These are laid down first to check on size and removed. The concrete is then made up and laid inside the mould on a plastic sheet or on sand.

A concrete mix of 10 litres cement (PC15) and 35 litres clean river sand is prepared mixing thoroughly in the dry state first and then with water added. The consistency should be like a stiff slurry. Half the full concrete mix is added within the mould first. The concrete is laid first around the vent and squat moulds to ensure they do not move. Then the first half of the mix is laid level within the bricks. The reinforcing wires are then added as shown.

The second half of the concrete mix is then added and smoothed down level. The moulds for the squat hole and vent are removed after 2 or 3 hours and the holes are neatened up with a trowel. The slab is covered with plastic sheet and left to cure overnight. The following morning the slab is watered down and left to cure for at least 7 days before moving. Note the positions of vent and slab holes – their rear side lies along the same line.

Top view showing positions of vent and squat holes. If a vent pipe is not fitted at first the vent hole can be plugged with weak cement mortar (15:1) 2 days after the concrete slab is made.

The slab is the most important part of the toilet and the part which can be used for many years. It is an excellent investment in money and labour. It is very important to use the cement provided wisely and ensure that the concrete work is made strongly, and cured correctly. Once a concrete slab has been well made and cured it will last almost indefinitely and can be used on a whole range of toilet designs from the simplest to more sophisticated models.

NOTE : A 50kg bag of cement contains about 40 litres cement – enough for 4 or 5 slabs (depending on mix) of diameter 1.0m if fresh PC 15 cement is used. If there is doubt about the quality of the cement or sand use a stronger mix.

3.2 How to make matching concrete ring beam

The ring beam is a ring of bricks or concrete which is caste on the ground at the top of the future pit. The ring beam is made first then the hole dug inside later. The concrete slab is laid on the ring beam. The ring beam helps to keep the top of the pit from falling in. It also supports the concrete slab, which is raised above the ground level. The ring beam also diverts rainwater away from toilet site. The pit is dug down inside the ring beam once it has been laid. The soil taken from the pit is rammed in place around the ring beam to make the toilet safer and raise the ground level around the toilet. The ring beam can be made of bricks and anthill mortar or it can be made from wire reinforced concrete using a mix of cement and clean river sand. It is important to raise the toilet base above ground level to avoid flooding during the rainy season. The ring beam is made on slightly raised ground where the toilet is to be built. The ring beam works if the soil is moderately firm, but will not work on looser sandy soils. Before the method is put to widespread use in an area the technique should be tested first. Normally the ring beam method will be used on *Arborloo's* or *Fossa alterna* or VIP toilets in moderately firm ground. The maximum pit depth is normally 1.0m.

Making the concrete ring beam

Locate the site for the toilet and level the ground. The site should be well away (30m) from wells. Make two circles of bricks on levelled ground. The concrete for the ring beam will be laid within the two circles of bricks. The size of the ring beam will depend on the size of the slab. The slab should overlap the ring beam by at least 50mm all round. In firmer soils the width of the ring beam is 150mm.

Slab size	ring beam size (internal)	ring beam size (external)
0.9m	0.75m	1.05m
1.0m	0.85m	1.15m
1.1m	1m	1.3m
1.2m	1m	1.3m

For the 1.0m diameter slab, lay the bricks so the inner diameter of the ring beam is 0.85 metre and the outer diameter 1.15metres. Thus the width of the ring beam is 15cm all round. The slab will overlay the ring beam by 75mm all round. This will use about 10 litres of cement and 40 litres of river sand (for PC 15 cement). Use a mix of 12 litres cement and 36 litres river sand if masonry cement is used. Two rings of 3mm wire are laid on the concrete after half the total mix has been added to the mould. These wires are about 3.5 m long each. The remaining half concrete mix is added on top of the wires. The procedure of mixing and adding the concrete is the same as for the slab. If ordinary bricks are used for the inner ring mould the spaces between the bricks must be filled with wet river sand to get a smooth wall all around. Specially shaped bricks can also be used for the inner ring of bricks. Alternatively a mould can be made of steel.

Cover the final ring beam with plastic sheet and leave for several days to cure before digging the hole inside. Keep wet during this curing period.

In the photo above special bricks have been used for the inner brick mould. This ring beam was made for a 1.1m slab. Lay on ground with 1 metre for internal diameter of ring beam and 1.3m for external diameter. This makes the beam 150mm wide. If Portland (PC15) cement is used 10 litres of cement are mixed with 50 litres of river sand. The brick mould is half filled with the concrete mix. Then two lengths of 3mm wire is laid centrally on the concrete between the inner and outer bricks. The remaining concrete is added and levelled off. It is levelled with a wooden float and left to cure, being kept wet for several days after hardening.

Making a concrete ring beam with a width of 225mm

In areas with slightly softer soil a ring beam with a width of 225mm may be more stable than one with 150mm. In this case the internal diameter can be 750mm (0.75m) and the external diameter 1200mm (1.2m). The width of the ring beam is then 22.5cm, the same as a brick. This ring beam can be made with a mix of 10 litres Portland cement and 50 litres river sand.




The method is the same as other concrete ring beams. Wire handles have been added.

3.3 Making ring beam with masonry cement

As with the slab, the ring beam can be made with masonry cement if PC 15 cement is not available. The mix is strengthened and for a 1.1m diameter slab requires 15 litres of cement and about 50 litres of river sand. A suitable site is found and the ground levelled off. Two circles of bricks are laid on the ground for the inner and outer moulds. Specially made half bricks are very suitable for the inner brick mould. The photos below were taken at Hopley farm under a UNICEF/Christian Care project.

For a 1.1m diameter slab, a circle is marked on the ground 1m in diameter. Special half bricks are laid around this. Another circle of bricks is laid 15cm away from the inner circle, making the ring beam 15cm wide.

The concrete mix is made up (50 litres river sand and 15 litres masonry cement) and half this is added to the mould. Two rings of barbed wire are then added on the concrete midway between the inner and outer bricks. The rest of the concrete is then added and levelled off. It is left to harden and cure and kept wet for 7 days. The bricks should be left in place for a day.

3.4 Using special steel moulds

In a project where large numbers of units are to be built, special steel moulds are useful. Commercially made steel moulds (or shuttering) are available in Zimbabwe. The ring beam shuttering provides an internal diameter of 1m and an external diameter of 1.3m. Slab moulds are available for various diameter units.

Steel ring beam shuttering in use. Two ring beams are caste and a slab

Shuttering for the slab. The squat and vent holes also have special moulds. This is a 1.2m slab which uses 12li PC15 or 15li masonry cement with 50litres river sand. 2.5mm or 3mm wire is used for reinforcing.

3.5 Brick ring beams

It is also possible to make a round ring beam in fired bricks and cement mortar or traditional termite mortar. Mark the circle on the ground (about 80cm internal diameter for bricks) and add the bricks in a circle. Using a trowel, add the termite mortar between and above the bricks which are laid in a circle. Add a second layer of bricks on the first layer. The upper layer of bricks should sit on the joint between bricks of the first course. Use the anthill mortar to hold all the bricks together. Bed the slab down in this same mortar.

Lay the ring of fired bricks in a circle. Bond with termite mortar. Then add a second layer of bricks.

No ring beam

In very stable soil a ring beam may be unnecessary, but it is wise to raise the slab above ground level. A hole can be dug in the ground about 0.75m deep and 0.7m in diameter (for a 1m slab).. It is wise to lay a ring of termite mortar around the head of the pit and bed the slab in this. The slab should be levelled and bedded tin to the mortar carefully. Soil from the excavated pit can be rammed hard around the slab to help reduce erosion and pit collapse during the rainy season. This provides less effective pit protection than a ring beam, but may be suitable in many situations. It is certainly cost effective since neither bricks or cement are required. The slab itself is the most important part of the structure and can be reused many times.

Digging the pit

The pit is dug down inside the ring beam, the extracted soil being placed around the ring beam and rammed hard in place. The pit rim is thus raised above ground level. The pit is dug down one metre in depth. For firm soils it can be dug down 1.5 metres. The deeper the pit the longer it will last. Ring beams are suitable only for light weight structures. Also in looser soils there is a possibility of side wall erosion by fluids contained in the pit, where these erode the soil and widen the base diameter of the pit. This may also happen in looser soils if too little soil and ash are added to the pit. Fortunately the subsidence is slow and easily detected.

Digging pit inside brick ring beam. On the right a pit has been dug inside a concrete ring beam. Ram removed soil around the beam to stabilise. The pit should be dug vertically downwards or preferably tapered inwards slightly so the base is narrower than the top.

Group of trainees at Kufunda village (Ruwa, Zimbabwe) being taught how to build a simple "compost toilet." Adding leaves to the pit.

Building the toilet house (superstructure)

Superstructures ("toilet houses") are used to add privacy to the toilet. There are many ways of making the superstructure from simple low cost materials. It is best to make a roof to fit over the structure for shade and to keep the rain out. This also helps control flies. *Arborloo* structures should be made in such a way that they can be moved easily or dismantled easily for movement from one location to the next. The structures are generally light and made of traditional materials. The toilet house is built around or on top of the ring beam and slab with local materials like poles and grass. Where a ring beam is used the structure should be light. Where wooden poles are used and penetrate the ground it is important to put some form of ant and termite protection in the holes around the wood. This can be in the form of wood ash or old engine oil.

Shape of structure

Some structures may be fitted with simple doors and others built in a spiral (round or square) shape so that a door is not required. Wooden poles are usually used as the frame of the structure. Wood ash can be placed in the holes made for the poles to reduce termite attack.

Engine oil placed in the soil around the pole can also reduce termite attack.

Use of poles and grass is a traditional method – some without roof some with a roof. A roofed structure is preferred.

Types of superstructure

Most simple structures are built with poles and grass. Even these simple building materials can be used to make a functional and attractive structure

A huge range of home built structures can be built with simple building materials. These photos were taken in Malawi and Ethiopia.

Portable structures can be built over a frame of poles (left). Grass, reeds or plastic bags and other materials can be used for walling. The roof can be made of thin corrugated iron or even plastic sheet laid over reeds and mounted on a frame and covered with grass. Grass roofs make the structures look more traditional with many types of local materials like reeds for the walls. Traditional structures can look very smart.

Adding a vent pipe to an *Arborloo*

Arborloo toilets can be upgraded on site to become simple versions of the VIP toilet. With the vent hole already in place, this upgrade is easy if a vent pipe is available. Later in this book several methods of making vent pipes will be described.

The addition of a vent pipe to a slab fitted over a sealed pit will draw odours from the pit up the pipe. Thus foul gases from the pit will be much reduced inside the toilet itself. This immediately makes it more pleasant to use. If the vent is screened, it also becomes a fly trap if the interior of the toilet is semi dark. If the toilet is fairly light inside, fitting a plate over the squat hole will also help to divert flies up the pipe, where they become trapped.

Ventilated *Arborloo* toilets at Chisungu school and Epworth

Fitting a screened 90mm PVC pipe to an *Arborloo*. By lighting a smoky fire in the pit, the effect of venting can be seen. Smoke comes up the chimney revealing the air currents. Fresh air is drawn down the squat hole.

How to use the single pit compost toilet

When using a simple compost toilet regularly add dry soil, wood ash and leaves to the pit as well as excreta. This mix of excreta, soil, ash and leaves helps to make good compost in the pit. Add soil and ash after every visit to deposit faeces, about a small cup full of soil and some ash, but not after every visit to add urine. Sometimes add extra leaves from time to time. If ash and leaves are not available the addition of soil alone helps. The more ash is added the greater the fly and odour control. Keep the toilet clean. Do not put rubbish down the pit like plastic and rags, as this makes the pit fill up more quickly. Use the toilet until the pit is nearly full. Keep fly breeding under control by adding plenty of soil and ash if possible. A vent pipe can be added later to help fly and odour control further.

When the pit is nearly full it is time to move the single pit compost toilet to a new location.

Remove the superstructure or take it apart. Remove the concrete slab and ring beam. If it is a brick ring beam, take the bricks apart and re-use them in the new site. Level off the contents of the pit and cover with a thick layer (150mm deep) of good soil. This is ready for tree planting. Now rebuild the brick ring beam in a new site. If a concrete ring beam is used it just needs to be moved to the new site. Dig a new pit inside the ring beam and surround the ring beam with soil and ram hard. Add a sack of leaves to the bottom of the pit. Place the slab on the new ring beam and rebuild or refit the superstructure. Then start to use the new toilet.

What to do with the filled pit

1. Leave this pit to settle. Add more soil and compost and wait for the rains before planting a new young tree. OR
2. Plant a young tree immediately in the added soil and look after it. It will require protection from animals and frequent watering. OR
3. Allow the pit contents to turn into compost and dig the compost out later (after 6 – 12 months) for use on the garden or for trees.

Photos of method 2

A series *of Arborloo’s* at a school site. Slab being removed from full pit.


Ring being removed from pit. Pit being topped up with soil.


Hole dug in centre for new tree. This is filled with a mix of soil and compost.


Banana being planted in compost/soil mix. The ring beam located on new site and dug down with soil being rammed around it. The slab can be fitted and the structure fitted on top. The site of a future tree in about one year.

Planting trees in organic pits

Planting a mulberry tree on an *Arborloo* pit in Ruwa, Zimbabwe

Many types of tree will grow on the compost formed in the *Arborloo* pit. These include mulberry, avocado, guava, mango, paw paw and banana. But many other types of tree including citrus, eucalyptus, indigenous and ornamental trees have been tried and are known to respond well. Plant the young tree in a thick layer (15cm) of topsoil placed above the compost. The young trees must be cared for. They must be protected from animals and must be watered often. If the tree dies, plant another. Trees are best planted just before or during the rainy season. In time the tree will provide many fruits, or provide shade or fuel etc. All growing trees require additional feeding and benefit from the application of leaf compost as a mulch and also garden compost or manure, periodically dug into the topsoil surrounding the tree. A mug full of wood ash every week or two provides potash which helps fruiting. Nitrogen loving trees like banana also benefit from the addition of urine diluted with water (2 litres urine + 10 litres water, once a week.

The *Arborloo* will move about in the garden and will help to make many new trees of various types over the years. The time to fill the *Arborloo* pit depends on the depth of the pit and the number of users. It will normally be between 6 and 12 months for small to medium sized families. Space the tree sites to suit the type of tree.

Examples of trees growing on *Arborloo* pits

Luxuriant growth of a banana and paw paw on *Arborloo* pits in Malawi

Banana in Malawi and Mulberry and banana in Zimbabwe

Avocado tree and variety of other trees growing on Arborloo pits in Ethiopia

Growing vegetables on *Arborloo* pits.

Practical experience has shown that vegetables are also grown on *Arborloo* pits. Sometimes a tree like banana is planted together with pumpkin on the same pit. These valuable techniques are also being used in Zimbabwe, where tomato plants are also grown. In fact when several *Arborloo* pits are fully composted or in a stage of composting they can be regarded as "organic oases" with increased fertility and looseness of soil. This is particularly valuable when the surrounding parent soil is poor and contains no humus. Organic fertilisers, compost and manure can also be dug into the organic pit to increase production if desired. Even conventional fertilisers can be added if they are available and affordable to increase the food output of the pit. As experience is gained, the value of these "compost-pits" may prove to be very useful in the production of a wide range of trees, vegetables and herbs etc. Their safety lies in the fact that the composting material lies beneath a generous layer of topsoil in which the plants start to grow.

Left: Young pumpkin growing on *Arborloo* pit. Right: Tomato plants growing on *Arborloo* pit in Zvimba, Zimbabwe.

Left: passion fruit growing on *Arborloo* pit in Malawi. Right: Spinach growing within ring beam in Zimbabwe.

Hand washing

If health benefits are to be gained from a sanitation programme the inclusion of a hygiene and hand washing component is essential. Hand washers of many types are easy to make and cost almost nothing. They should be fitted to every low cost (or high cost) toilet made. Hand washers can be made from plastic bottles and tin cans as the following pictures show.

Making a simple hand washer from plastic bottle

There are several types of simple hand washer. This one uses a plastic bottle. Cut the bottom off about one third up. Make a hole in one corner of the base.

Wrap some thin wire around the bottle and hook up to part of the toilet. To use the washer it can be dipped into a container of water on the ground or some water from another bottle can be added to the washer. The water comes out slowly, but it is sufficient to wash the hands. It uses water economically. Tin cans can also be used

Making a simple hand washer from metal can


The top is taken off the metal can with a cap opener. A hole is pierced near the lower rim with a nail.


Two further holes are made with the nail at the top of the can. These are made at right angles to the single hole made in the base of the can. A wire is passed through the holes and tightened up at the back of the can. Then a loop is made at the top of the wire.


The can and wire are suspended from a wire held from the roof. Wash water can drain over a tree planted at the rear of the toilet or into a basin filled with herbs or flowers. It is best to use soap or wood ash to wash the hands.

Summary

This chapter has described how to build and manage a simple shallow pit composting toilet and grow trees and vegetables on soil placed over the filled pit. In this case the pit is shallow and will last from 6 to 24 months before filling and it is moved to another location. The filling time depends on the pit volume, number of users and the amount of soil/ash and other materials added to the pit.

At first odours and flies are controlled by the liberal addition of wood ash and soil. The more ash is added, the better the control of flies and odours. The soil also helps promote composting. Soil bacteria promote the composting process and turn the excreta into compost. Adding leaves to the mix also helps. They add air and also special fungi and bacteria which also help composting. The ecological shallow pit fills up with a mix of ingredients. Water should only be added to shallow pit composting toilets in small amounts. Odours and flies can be controlled further by adding a vent pipe to the simple toilet. Vent pipes can be home made at relatively low cost.

The same concrete slab with its existing squat hole and vent can be used to construct a larger pit lined with bricks. This can be fitted with an improved structure made from traditional materials or also bricks.

These more permanent improved structures (built on pits which last longer) can also be fitted with vent pipes which can also control odours. If the vents are fitted with corrosion resistant fly screens (stainless steel or aluminium), together with superstructures which are semi dark inside the unit becomes a VIP (Ventilated Improved Pit) toilet. Vent pipes and well made structures can also be fitted on shallower pits. The VIP principle still works even on a shallow unlined pit.

The deeper brick lined pits will fill up more slowly, but in this series the usefulness of composting is emphasised. Compost is valuable on the garden, but it also has another important property. It is much easier to dig out of pits than excreta. Composting also takes place more efficiency in shallower pits with less compaction of the materials.

A compromise is to make the pits shallower rather than deeper (2m rather than 3m). The capacity can be maintained by making the pits wider. They have the volume but not the depth. Thus the advantages of composting can be fulfilled together with the advantages of longer pit life. This combination of effects is possible when a method of lining pits with bricks known as “corbelling” is used. In this process the brick lining is wide lower down in the pit, but nearer the top, each course of brickwork is stepped in. The result is a reduced diameter at the upper end of the brickwork. This means that smaller and lower cost slabs can be made on pits of wider base diameter. Thus the 1.1m diameter slab can be fitted on pits which are 1.3metres to 1.5metres diameter. Thus several benefits are gained. Longer life yet composting is still possible with ease of excavation. Such a semi-deep (2m) may last a family for 10 years or more.

Interestingly a 2m deep brick lined pit with a 1.3m diameter internal base diameter together with a 1.1m slab can be made with a single 50kg bag of masonry cement. Once the pit is lined and the slab made and fitted a wide range of structures can be built. These include the simple traditional structures described in this manual. They also include higher quality traditional structures and also brick structures. Brick structures can be built because the pit is itself lined with bricks. There are also several ways of making vent pipes rather than buying commercially made pipes which can be expensive.

When these methods are combined an interesting phenomenon takes place. We have pits which last longer, but pits which can also be dug out easily. The period of composting in these semi-deep pits may be 5 years. But the pit may last 5 – 10 years.

In these cases it pays to build a second pit. The use of pits can alternate. This period of alternation may be 12 months in shallower pits (known as the *Fossa alterna*). But in larger and slightly deeper (2m) composting pits the period may be 5 – 10 years. If the toilet is designed so its parts are recyclable, the only expense at the time of first filling is a new lined pit, which uses less than a bag of cement. It is also possible the concept of alternate the use of a single larger pit with a series of smaller shallow pits *(Arborloo*). Thus the following chapters in this book describe:

1. How to build a semi-deep pit of 2m and line it with bricks using a corbelling technique. This is fitted with a concrete slab with vent pipe and squat hole. Many types of superstructure can be fitted to this pit including those made with bricks.

2. How to alternate pits of various sizes. This includes the smaller shallower pits (1.5m deep max with max diameter of 1.0m). Also the larger and slightly deeper eco- pits will be described.

3. The usefulness of the toilet compost and human urine

This book describes how to build low cost and upgradeable toilets and also how to use the recycled materials in agriculture and tree planting.

Trees growing on Arborloo pits

4. Upgrading the *Arborloo* to a VIP toilet

The previous chapter described how to build a low cost upgradeable shallow pit compost toilet *(Arborloo)*. The main component of this toilet was a 1.0m (or 1.1m) diameter concrete slab with holes for squat hole and vent pipe. In its simplest form this toilet is mounted on a ring beam over an unlined pit, with a simple traditional superstructure mounted on top. Flies and odours are partly controlled by the liberal addition of soil and wood ash and composting is also accelerated by the regular additions of these ingredients. Composting is also improved by adding leaves and other organic vegetable matter to the pit contents. A screened ventilation pipe can also be added to the simple *Arborloo*, which can improve both odour and fly control.

This unit can be used effectively for several years if the slab and structure are moved from one site to another at periods ranging from 6 – 24 months, depending on pit size and number of users etc. This requires space and a willingness of the owners to perform the task of moving from one site to the other. Trees can be planted in each site left by the toilet, which become “organic islands” within the soil. These are ideal places to start the growth of trees, shrubs and even vegetables. They are particularly effective in areas where the soil is barren and depleted of nutrients and tree cover.

However inevitably there comes a time when a more permanent toilet installation is required. This will mean digging a pit of greater capacity which takes longer to fill up. In order to maintain the ecological status of the toilet system, the pit must not be too deep and yet it requires an increased capacity to extend the period between emptying or planting trees etc. This can be achieved by changing the shape of the pit from narrow and deep (as in the Blair VIP) to wider and shallower. Larger pits will also require lining with bricks. These requirements can be achieved by using a brick work technique known as “corbelling” where the upper courses of brickwork are stepped in, so the top of the brick lined pit is narrower than the base and able to accept the smaller more economical slab made for the original low cost toilet. Once a pit has been lined with bricks a far greater range of superstructures can be built, including those made from bricks. Brick structures are too heavy to be placed on unlined pits.

The upgrading process can go further than lining the pit alone and building a brick structure. The toilet system can be fitted with a screened ventilation pipe, if one has not already been fitted, which draws odours out of the pit. If the slab is well sealed to the pit, this suction of air will draw air down the squat hole and the interior of the toilet become almost odourless. If the pipe is fitted with a fly screen and the toilet structure is fitted with a roof and some means of reducing light within, the principles of the VIP are attained. Flies can be trapped in the pipe.

Various other means of upgrading are possible. Fitting simple pedestals is one such improvement. Also a urine diverting pedestal or squat plate can be fitted, which diverts the urine into a container. Urine can be used to enhance the growth of vegetables and maize. Also the pit under a urine diverting device becomes drier and less smelly and fly ridden. Urine is a valuable fertilizer – but there are many ways of collecting urine, other than using a urine diverting pedestal.

This chapter describes how to build a brick lined pit (substructure) using the corbelling technique, and also how to fit the slab and make more permanent structures of various types from brick. These are more costly than the simpler *Arborloo* toilet but they will last longer and require less maintenance. A range of systems becomes possible which allows for choice to fit to the user’s financial means.

Using the corbelling technique, it is possible to brick up a pit which is dug quite wide, but not so deep as a normal Blair VIP toilet. Shallow alternating pits (*Fossa alterna*) are normally dug down to 1.5 metres. This is extended to 2 metres in the longer life brick lined VIP pits. At this depth composting of the ingredients (excreta, ash, soil, leaves etc) can still take place if sufficient soil, ash and leaves are added. And at 2 metres the pit is not excessively deep and dangerous to dig. In fact it is much easier to line than a 3m pit.

Whilst no standard has yet been finalised, the width and depth of such a pit can be made by judged from what can be constructed from a single 50kg bag of low grade (masonry) cement. Experiments have shown that a pit dug 2m deep and 1.6m wide (internal brick diameter of 1.3m) can be constructed using a 16:1 pit sand and cement mixture for brick mortar together with the construction of a 1.0m concrete slab to fit over the top. Thus a pit of reasonable capacity capped by a strong slab can be made with a single bag of low grade masonry cement. If high grade Portland cement is used the pit diameter and pit volume can be increased. Using Portland cement and a 20:1 mix for brick mortar the internal diameter of the pit base can be increased from 1.3m to 1.5m. A strong concrete slab can also be made from the same bag of Portland cement.

Once the substructure (pit and lining) has been built and capped with the concrete slab, a wide range of superstructures can be fitted. At first this may be the simple traditional structure from poles and grass. But upgrading to fully brick now becomes possible. Several styles of brick structure can be built from round or square spiral (door-less) to structures fitted with doors. These should all be fitted with roofs. Vent pipes of various types can also be fitted - PVC to home made.

Once the toilet has been completed, it can be used in a conventional way, by adding excreta only. But there are advantages to adding soil and ash regularly, although the addition of these extra ingredients

decreases the life of the pit. The added fly and odour control together with enhanced composting make the pit contents more valuable and more easily emptied in the future. The choice of how to use and manage the VIP will rest with the family using the toilet.
Once the larger pit is filled with a mix of excreta, soil and ash (and leaves), it can be covered with soil and left to compost in the same way as smaller shallower composting pits. This period may be for 5 years or more. After this time it will be far easier to excavate than a normal deep toilet pit. Soft wooded trees like paw paw might also be planted in topsoil added on top of the pit contents. These will produce fruit for a few years and then be chopped down easily and the pit excavated since the wood is soft. In the meantime another longer life pit may have been dug and used.

By using strong fired bricks and weaker mortar (16:1 with pit sand or traditional mortars made with termite soil), it is possible to make durable brick superstructures which can easily be taken apart and reused years later. Roofing materials can be detachable and upgradeable over time. Tin, asbestos, and concrete roofing materials can be used as well as the more traditional grass roofs.

Extending pit life

As described earlier, the life of a toilet pit can be extended by building a pit which is wider but not necessarily deeper using the corbelling technique. For instance, using Portland cement it is possible to mount a 1.0m or 1.1m diameter slab over a pit which has an internal diameter of 1.5m and depth of 2m. This has a greater pit volume than a pit which is 1.1m wide and 3m deep (used in later VIP toilets in Zimbabwe). This technique must be used on round pits fitted with round slabs. The roundness provides the structural strength. It is wise to put the main investment into the pit and lining. Then pit volume can be increased and pit life can be extended considerably. By making pits wider and shallower (compared to the earlier deep pits), they are easier to dig, more suitable for composting and easier to excavate. The superstructure constructed over brick lined pits can be made simple and low cost at first, and can be upgraded with brick later. The pit filling time increases (and pit life decreases) if soil and other materials are added regularly. However the family may choose to use the Blair VIP in the conventional way.

Pit life in relation to depth and diameter

(Estimated with small additions of soil and ash)

Pit diameter (m)	*pit depth (m)*	*vol. cu.m.*	*life (yrs)*
1.5	3	5.3	17.6+
1.5	2	3.5	11.6+
1.3	3	4.0	13.3+
1.3	2	2.6	8.6+
1.1	3	2.8	9.3
1.1	2	1.9	6.3
1.0	3	2.3	7.6
1.0	2	1.5	5.0
1.0	1.5	1.1	3.6

Digging and lining the pit

In the example described below a hole has been dug and lined with standard Zimbabwe bricks (approx 75mm X 110mm X 225mm). The hole is dug down with a diameter of 1.75m to the required depth which is 2 metres. This pit is then lined with bricks so the internal diameter is 1.5 metres. At this diameter about 19 -20 standard bricks are required per course and 12 courses are required for each metre of depth. Thus approximately 240 bricks are required to line each metre of pit depth. The internal diameter of the pit lining is maintained at 1.5m up to 1.3m from the base of the pit. Then the corbelling begins. The diameter is reduced as extra courses are added. Corbelling from an external diameter of 1.75m to and external diameter of 1.1m takes about 10 courses to achieve which is around 0.85 m of height. 0.7m of this is below ground level and an extra 0.15m can be above ground level. Each course of bricks is stepped in by around 25mm.

About 500 brick should be allowed for this type of lining. Using a 20:1 mix of pit sand and Portland cement mix, a single 50kg bag of cement should be sufficient to make cement mortar (30 litres) to line the entire pit and also make a 1.1m diameter slab (10 litres). Smaller (1.3m ID) pits will use fewer bricks and can be built with masonry cement. Fired bricks should always be used to line toilet pits.

Stages of construction

The hole for the Blair VIP is dug 1.75m in diameter as a deep as possible. If one bag of Portland cement is to be used for making mortar for bonding the bricks in the pit lining and making the slab, the pit is dug down to 2m depth.

The pit is lined with cement mortared fired bricks using a mortar mix of 20 parts pit sand to 1 part cement. The cement can be mixed inside the pit.


The diameter of 1.5m internal is maintained until the brickwork is 0.7m from ground level. Then the brickwork is stepped in about 25mm per course so the diameter is reduced as the pit lining gets higher.


The corbelling continues until the brickwork is above ground level and reduced in diameter so it can support the concrete slab. Where the 1.1m diameter slab is used the external diameter of the brickwork should be 1.1m. The number of bricks used is reduced by about half a brick per course.


The space between the brickwork and pit wall is backfilled with soil from the excavation. A very weak cement mortar can be used for brick work mortaring in this case because the conditions for mortar curing are ideal. The slab is fitted on top of the brickwork as soon as the backfilling has been completed. The slab is mounted on a bed of very weak cement mortar placed on top of the upper ring of bricks. Thus the mortar is not exposed to the direct sun and cures slowly under ground level. This curing process is also aided by wetting the bricks before they are used for building the brick wall.

Some practice may be required with the corbelling technique. And some calculation is required to get the right point of starting the “stepping in” process. The upper course of brickwork should have an outer diameter the same as the slab, which is 1.0m or 1.1m in diameter. When the ring beam is available after the upgrade, the owner may prefer to keep the ring beam for use on another toilet.


Views of the corbelling from inside the pit. This is a valuable technique which has been seldom used to line toilet pits but has several advantages. The pits and their linings must be round to provide the structural strength using this technique.


The brick work should rise at least one brick course above ground level. In this case it rose several courses above ground level with soil excavated from the pit being used to backfill the annular space between brickwork and original pit excavation and also to build up soil around the raised brick work. The concrete slab is fitted directly to the brick pit lining. However because the slabs are rarely completely flat, they are placed in a bed of weak mortar placed on top of the brickwork. This also ensures an airtight fit between slab and pit brickwork which is essential for the aerodynamics of ventilation in VIP toilets. There must be no air leaks at the joint.

Example of making a lined pit and slab with a single bag of masonry cement.

It is possible to line a 2m deep pit with bricks using cement mortar and make a 1metre diameter concrete slab with a single 50kg bag of cement. This can be the starting point for many types of VIP toilets.


In this case the pit was dug 1.6m in diameter and 2 metres deep. The internal diameter of the brickwork was 1.3m. The pit was lined with fired bricks using a 16:1 mortar mix of pit sand and masonry cement. A 5 litre bucket was used for measuring – 5 litres of cement and 80 litres of sand per mix. Each mix was able to mortar 4 courses of 16 bricks. 24 courses were built and corbelling began on the 17th course. At 2 metres deep the builder could access bricks laid on the rim of the pit.


30 litres of cement were used to bond 24 courses of bricks. 8 courses were required to corbel in from an external diameter of 1.5m to 1.0m. 12 bricks were used in the uppermost course which was one course above ground level. Slightly less than 370 bricks were used to line the pit. The remaining 10+ litres of cement was sufficient to make a concrete slab of 1.0m in diameter. Also to make a bed of weak cement mortar in which to place the concrete slab over the upper ring of bricks.

Making the 1.0m diameter concrete slab


Some river sand was laid on the ground and levelled. A 3mm wire was used to mark a 1m diameter circle which was surrounded by bricks. The vent pipe and squat hole moulds were laid in place. The squat hole being 30cm from the rear wall and the vent hole being 12cm from the edge with a space of 20cm between squat and vent holes.


10 litres of masonry cement was mixed with 35 litres of river sand to make the slab concrete and 4 X 0.9m + 4 X 0.7m of 3mm wire used for reinforcing. Half the mix was added first, then the wire followed by the rest of the mix.

The slab was smoothed down and left to cure for a week and then placed on the lined pit in a bed of weak mortar made from the same 50kg cement bag.

Adding the superstructure

Once the pit is lined and slab is fitted, excavated soil is used to backfill the space between brickwork and pit wall. This is rammed hard into the annular space. This backfilling is extended above ground level around the elevated brickwork which should lie at least one or two courses above ground level. This raises the toilet structure above the surrounding area, which helps to reduce erosion during the rains.

Once the slab has been fitted in place the superstructure can be built, or placed on top if it is a portable unit. There are many variations. With the VIP toilet it is essential that the structure provides semi darkness and is fitted with a screened vent pipe. Simple structures made with grass and poles can work well and be attractive if well made. These have been described in the previous chapter. Also steel framed structures lined with grass, reeds and other materials can be built. If the pit has been lined with bricks, then the option of building a brick structure is also possible. It is unwise to build brick structures on pits which are not brick lined. This will lead to collapse.

Smart structures made from poles and grass can be fitted over a brick lined pit. Also portable structures made from steel frame with grass walls and roofing material (underlain by plastic) can also be used. The steel frame unit is fitted with a 90mm PVC screened vent pipe.

Brick structures for the upgraded (Blair VIP) toilet

1. Round brick structure with door

It is possible to build an economical round brick superstructure with bricks on edge on top of the ring beam supporting the 1.1m diameter slab. Alternatively this can be built directly on top of a 1.2m diameter slab with bricks laid normally or on edge. Brick structures must be built on brick lined pits, not on ring beams, otherwise the structure will collapse. In this case a gum pole door frame has been used with 150mm or 125mm nails used as “sprags” which are embedded in the cement mortar between brickwork. They link the door frame to the brick structure.

The gum pole frame is mounted on the ring beam outside the slab. 125mm or 150mm nails have been knocked into the poles on either side. These will act as sprags to secure the door frame to the brickwork. One nail every other course has been used here. The bricks are bonded together on edge.

The round configuration allows greater strength of the structure allowing the bricks to be built on edge. This economises on the use of bricks.

Brick construction half way to the top.


A door frame has been added and door hinges made of car tyres. The door then becomes self closing. The vent hole is inside the structure and works well.


On the left a wooden roof frame has been added. This is covered with chicken wire, plastic sheet and grass or tin or asbestos sheet. This round structure uses around 180 bricks. On the right a brick built round structure with thatched roof and door. This traditional method is attractive and long lasting.

4.1 Building a Blair VIP (with door) at Chisungu Primary School

In work undertaken at the Chisungu Primary School, Epworth (under the supervision of Mrs Annie Shangwa), primary school children have Blair VIP toilets mounted over fully lined (corbelled) pits. The following photos show the sequence.

The pit is lined with bricks and corbelled at the top

The slab is mounted over the pit and a round brick structure is built attached to a wooden door frame.

Roof, door frame and vent are added to complete the Blair VIP

2. Spiral (door-less) structures

It is also possible to construct a standard square spiral brick structure on the 1.0 or 1.1m diameter round slab. This requires the construction of a foundation for the brick wall which will lie outside the area of the slab. This unit will use about twice as many bricks as the simpler round structure (with door) built directly on the slab.

Configuration of the square spiral structure. Brick foundations are laid.

Brick walls are built up. In this case the pipe is made of a concrete panel mounted on interior wall over vent hole.

The walls are built up and roofing panels added. A short length of tubular pipe is mounted through the roof on a concrete plate (see detail elsewhere)

4.2 Building a Blair VIP (with spiral door-less structure) at Chisungu Primary School.

The following photos show a much abbreviated sequence of primary school children building a brick spiral structure over a corbelled brick lined pit. In this particular model windows are cement bonded into the superstructure to allow a little more light in.

The pit is lined with bricks and the slab fitted. Space between bricks and pit wall backfilled with soil and rammed hard.

Foundations laid outside the slab and walls built on top.

Roof, and pipe fitted and a floor at the entrance to complete.

3. Steel frame structure and brick combination

Using a steel door frame as shown below and around 170 bricks laid on edge, a rectangular brick superstructure can be built using about 9 kgs of cement for the brick mortar and 12.5 kg cement for the 2 roof panels. This means that 50 kg bag of cement is enough to make a concrete slab (12.5 kg)), a cement slurry vent pipe (4 kg), two concrete roof panels (12.5 kg), a pedestal if required and the mortar for brickwork (9 kg). With another bag of cement a 2.5m deep pit can be lined with bricks. Enough for a complete brick VIP toilet.

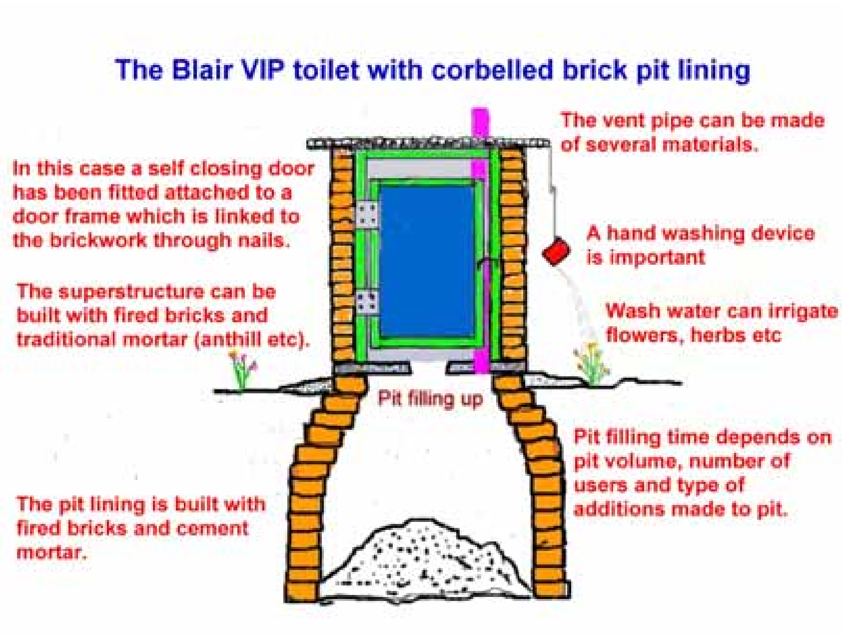
With the 1.1m diameter slab small extensions are made of the slab on the ring beam. The steel doorframe is erected and held in place by a pole. The first course of bricks is laid using a mix of 16 parts of pit sand and 1 part cement.

The brickwork is extended upwards, about 14 courses of 12- 13 bricks built in a rectangular shape. The 6 sprags welded to the steel door frame are immersed in the mortar bonding the brickwork. PC 15 used.

The nearly completed brickwork has used around 170 bricks built on edge.

The roof is now made with a mix of 1 part PC 15 cement (10 litres or 12.5 kg) with 3 parts river (30 litres). This is enough to make 2 panels measuring 0.5m X 1.3m. at least 2 X 2.5mm wires are laid down the length for reinforcing. In one panel a hole (diameter 0.2m) is made for the vent pipe. These are left to cure for a week under plastic sheet and kept wet at all times.

The 2 roofing sheets are added to the structure. The joint being filled with cement mortar. Extra cement is added to the rear brickwork to support the roof. On the left a PVC vent has been fitted. On the right a home made cement slurry pipe has been added, being held in place with cement mortar added to the base and also within the roof panel. The door panel is fitted with a light weight screen for privacy.



Interiors


Left: Round slab fitted with rectangular grass walled steel frame structure and PVC pipe. Right: brick structure fitted with cement pipe.


The interior can be fitted with a standard squat hole or upgraded with a pedestal. There are many ways of making a home made pedestal using cement, a bucket and a seat.


Pedestal made from concrete and a plastic bucket inside brick structure with PVC pipe. On right urine diverting pedestal fitted over pit toilet.

Vent pipes – home made

The vent pipe is an important part of a VIP toilet. Commercially made pipes can be used but are expensive and pipes made in the earlier national sanitation programme (in Zimbabwe) were made of bricks. Whilst PVC pipes work well, attempts must be made to reduced cost. There are several methods of making lower cost vent pipes. Vent pipes can be made with reeds attached to tin cans, wire loops or short sections of plastic pipe. The pipe can be covered with cloth soaked in cement slurry to strengthen it. Cement slurry can also be added to material laid over plastic bottles laid end to end. Excellent pipes can also be made by painting newsprint paper with cement paint and laying over a tubular mould covered with plastic sheet. These methods are described below but are not suitable for mass production. In ecological Blair VIP toilets a 90mm pipe is acceptable being reduced from the standard 110mm specified size.

Cement slurry on a plastic bottle mould

In this method a series old plastic bottles (used mainly to hold fruit juice) have their bottoms and top removed with a pair of scissors. One end should be cut so it passes around the taper of the bottle and the other end cut at the part near the base which has the maximum diameter. In this way one bottle can fit into the next. About 14 of these are put together and held with adhesive tape. The pipe should be fairly rigid, but it will not be strong enough to last in a toilet if made of plastic alone. It must be covered and protected with a cloth soaked in cement slurry (mix of Portland cement and fine sand). The series of bottles is then mounted over a wooden pole supported on bricks at each end. Cement slurry is then mixed (1 part fine sand - pit sand, 1 part course sand - river sand and 1 part Portland cement (1:1:1) and applied to cloth wrapped around the pipe. Alternatively 2 parts road sand (rain washed sand deposited on the road side) can be mixed with one part cement. The various layers are allowed to cure, being kept wet after the mix has hardened for at least a week. Once thoroughly cured a corrosion resistant fly screen (eg aluminium) is fitted to one end of the pipe.


Plastic bottles linked together after bases and tops have been cut off. They are supported on a pole. Cement slurry is made up using a strong mix of Portland cement and sand and prepared into a slurry. Suitable cloth or sacking is cut up into manageable pieces and immersed in the slurry.


It is then wrapped around the plastic tube and bound with string. Additional layers are added. A paint brush can be used to thicken up the slurry on the pipe. Once the final layer has been applied the pipe is surrounded by a plastic sheet and is left to cure. It is kept wet for at least 7 days. An aluminium fly screen 20cm square is mounted on one end of the pipe with wire or string.


Additional slurry soaked cloth is wrapped around the top of the pipe which is left to cure thoroughly. The pipe can then be fitted to the VIP toilet. Batches of slurry can be made up using a litre of cement mixed with 2 litres of sand.

Method with reeds, wire rings and cement slurry

This method uses a series of wire rings which support cut lengths of reeds or bamboo about 2.1m long. The reeds are laid on the ground and drilled with 4mm holes. These holes are drilled 7cm from each end and in the middle of each reed. The holes should all face in the same direction. Each wire ring is threaded through the holes in the reeds so a tube is made. The ends of each wire loop are bent at right angles. The two reeds nearest the right angle are brought together and bound with string. Then the remaining reeds are distributed evenly around the wire ring and bound also with string. This forms a rigid reed tube about 120mm in diameter over which cement slurry soaked fabric can be laid around the pipe frame. Alternatively if no cement is available a plastic sheet can be wrapped around the tube and protected with more reeds, as described earlier. Suitable material is thin absorbent cotton (shirts, sheets etc or hessian). The cement slurry can be made from 1 part Portland cement and 2 parts road sand or a mix of one part cement and one part pit sand and one part river sand. The cement is mixed with water to make a slurry which can be applied by brush. The method works better if the sections of cloth can be soaked in the slurry first and then placed around the tube. It is often best to place smaller section of slurry filled cloth down the tube. The initial slurry filled material is allowed to harden overnight and then several additional application of a similar slurry mix can be applied by brush. The thickness of the slurry can then be built up to form a very hard and rigid pipe once the concrete has cured. The cement work should be well cured if final strength is to be assured. Finally an aluminium fly screen is wrapped around the end of the pipe and tied with wire. Then an extra band of slurry filled material can be wrapped around the pipe over the screen to make it neat. The cement pipe is placed over the hole in the slab which should be around 110mm in diameter. It may help to place a short length of

PVC pipe into the hole first and then fit the cement pipe over and around the PVC pipe, which can be cement mortared in position.

Photos of method

3 loops of 3mm wire bent into a circle. The 7 reeds are drilled with 4mm holes at three points along the length (middle and 7cm from each end) and the wire is threaded through the holes.

The ends of the wire loops are bent over at right angles and the two reeds closest to the bend brought together and bound with string. The other reeds are distributed evenly around the loop and also bound with string.

A suitable material is wrapped around the tube and cement slurry is applied. The more layers of slurry are applied the greater the strength of the pipe.

Making vent pipes from paper and cement paint.

This is an excellent method of making strong vent pipes, but the method must be followed very exactly. The pipe is best made over a rigid class 16 PVC pipe, 90mm in diameter. The vent is made 2.1m long. The PVC mould pipe is supported on timbers or chairs and covered with plastic sheet. In order to make pipe extraction easier, a folded length of plastic sheet is first laid down the length of the PVC and held with tape. Then the main plastic sheet is wrapped around the pipe and also held with tape.

The best paper to use is newsprint which absorbs water and also the cement paint very well. A4 newsprint is ideal. The cement paint is made up by taking 2 litres of PC15 cement and mixing with water into a thin paint like slurry. Using broad paint brush each sheet of paper is laid on a sheet of plastic and painted with the cement paint on one side. Then it is added to the pipe mould at one end with the cement paint beneath. Using the brush, a further layer of cement paint is added on top. This process is repeated, with the next sheet of paper being added and overlapping the first. The sheets are paper are applied up the pipe from one side. Then the pipe is rotated and the cement filled sheets are applied and repainted coming down the pipe again from the other side. The pipe is then rotated again and the same process is followed with overlapping sheets being applied up the pipe and down again. At least four complete layers are applied, using 4 to 6 litres of cement. These are best made in 2 litre batches. Additional cement paint is added on the final application of paper.

The cement filled papers are then carefully covered with a thin plastic sheet and left overnight. The following morning the plastic is carefully removed and the cement pipe is watered and covered again with the plastic sheet. It is essential that the pipe be allowed to cure thoroughly for at least a week before it is carefully removed from the mould and transferred to a place where it can be covered and kept wet for at east another week. The removal of the cement pipe from the mould is made easier by first removing the folded plastic beneath the main plastic sheet. A well cured cement pipe made in this way is then capped with a suitable screen (as described earlier) and fitted to the vent hole. Once again it is best to fit a short length of PVC pipe into the hole in the slab and fit the cement pipe over this. A hole is made in the roof, through which the pipe passes.

PHOTOS OF METHOD


The cement paint is made in a bowl by mixing PC15 cement and water. The newspaper or A4 newsprint paper is painted on one side and applied to the pipe mould, cement side down. The paper is painted again on the outside.

The next sheet is added and overlapped with the one before it. The sheets are applied up the pipe and down again on the other side after the mould is rotated. Several layers of papers are added (4 – 6 layers) using 4 – 6 litres of cement paint. Once the application of treated papers is complete, the pipe is covered with plastic sheet and left to cure overnight. The following morning the plastic is removed, the pipe watered and then covered again with sheet. The pipe must be kept damp for at least a week before it is removed. It is best to carefully remove the pipe and store it for an additional 2 weeks under plastic to develop fully strength. It must be kept damp at all times. The screen can be added when the pipe is cured.

Making a simple pedestal

Very effective pedestals for sitting on toilets can be made with standard plastic buckets and concrete. If Portland cement is available the mix is one part cement to 3 parts sand. If masonry cement is available it may be best to make a 1:1mix. It is possible to make both a standard pedestal and a urine diverting pedestal using a 10litres bucket and concrete. The bucket provides the inside of the pedestal with a smooth wall which can be cleaned down. The outer shell of concrete (with some wire reinforcing) offers strength and durability. The unit can be painted in bright enamel paint colours once the concrete has been allowed to thoroughly cure and dry off.


A 10 litre plastic bucket is used and the base sawn off. The bucket is placed base down on a piece of clear plastic and a mark drawn 75cm around the bucket. To keep it secure a weight is placed on top of the bucket.


A mix of cement and river sand is now made up. If Portland cement is used the mix is 1 part cement and 3 parts river sand. If masonry cement is used a 1:1 mix is used. The concrete can be mixed in small lots with a litre of cement being mixed with the sand at any one time. The concrete is made into a neat round shape with a trowel. A ring of 3mm wire is placed inside the concrete.


This ring of concrete will become the seat of the pedestal. Additional concrete is then added half way up the side wall of the bucket. This is covered with a plastic sheet and allowed to cure for 1-2 days. The following morning the concrete is wetted down and a ring of 3mm wire prepared and wound around the middle of the bucket. The bucket is then carefully turned over.


The base of the pedestal is then built up in the same way using the same mark on the plastic sheet. A 3mm wire ring is placed in the concrete. The concrete is shaped neatly so that upper and lower layers meet to form a strong shell around the bucket. The pedestal is then covered with plastic sheet. The next day it is watered and kept wet for at least 7 days to cure.


After this period it is allowed to dry out in the sun. The seat section is then filed and sanded down to make it smooth. It can then be coated with enamel paint. Bright colours are best!

4.3 Use and maintenance of the upgraded VIP Toilet

Standard method of using a Blair VIP toilet

The standard Blair VIP toilet built over a 3 metre deep brick lined pit is a versatile system which not only controls flies and odours but can also be used as a bathroom, a garbage disposal system (including sanitary pads and rubbers). This has been the conventional way of using the toilet in the past. However pit life is reduced if a lot of garbage is added. It is far better to put garbage into a garbage pit and keep the VIP toilet pit for excreta. It does pay to build a pit with large capacity for long life. This can be achieved by the brick corbelling method described earlier. It is possible to use this new Blair VIP in the same way – that is as a bathroom as well as a toilet. It is possible that most lower cost Blair VIPs will still be used in this way in the future. Certainly convenience and privacy count for a lot.

Ecological method of using the Blair VIP toilet

If it is intended that the pit is going to be excavated later, then the method of using the VIP toilet should change. In this new generation of VIP toilets the addition of wood ash, soil and leaves is increased and the addition of water decreased significantly. This means the toilet can no longer be used as a bathroom. This is because composting is encouraged by the ash, soil and leaves, but discouraged in very wet conditions. Also plastic, cloth, glass, rubber and other garbage should not be thrown down the pit. The greater the amount of soil and ash added, the better the composting will be. The pit will fill up more quickly with the additional ash, soil and leaves, but it will be far easier to excavate later. The pits of intermediate depth may last for 5 years or more before they fill. During the period when the pit is composting, smaller pits like the *Arborloo* can be used. Alternatively a second pit can be dug and lined with bricks in the same way as the first, and the brickwork superstructure taken apart and rebuilt on the second pit. This concept is certainly worth considering. It is a new way of thinking about pit toilets! This method means that both the physical structure as well as the processed excreta can be recycled.

Recycling potential of the new Blair VIP toilet

The new recyclable Blair VIP differs in many ways from the original design. Whilst the concept of odour and fly control remains the same, using a screened vent pipe, many things have changed. The version of the brick superstructure using a door is built directly on top of the slab and is much easier to dismantle and rebuild or replace. The bricks are fired, but can be bonded together with traditional material like anthill mortar. Such walls can last for many years, especially if well protected by an overhanging roof. In fact many earlier Blair VIP toilets were bonded with traditional mortar. The new vent is a tube of some suitable stable material and can be replaced or upgraded. The roof is also upgradeable and replaceable. It can start as poles and grass and be upgraded to ferro-cement, tin or asbestos sheet. The door and its frame can be upgraded from wood to steel if required. Or a combination of wood and steel. Hinges made of car tyre are self closing and long lasting if well attached to the door and frame. All these new features make variants of the new Blair VIP easier to dismantle and rebuild when the pit is full. However there is also great merit in building a Blair VIP in a spiral shape without moving parts.

The brick built superstructure

Experiments carried out in Epworth show that bricks bonded with traditional mortar and used to build a static spiral Blair toilet and can last for a decade or two with little maintenance. And thousands of house structures built in the rural areas confirm this. Such structures could be carefully dismantled when the pit is full and the bricks reused. However, in areas where brick making is common, new bricks may be preferred, or the old brick material reconstituted to make new bricks. There is still great merit in the spiral structure.

The door or door-less superstructure?

Door frames can be made of wood or steel. There is the outer door frame and the inner door frame which forms part of the door itself. Outer door frames of wood can be fitted to inner door frames of steel or the other way round. But both inner and outer frames can be made of steel or wood. Obviously steel door frames last longer, for if they are protected with red oxide paint they may last for generations and offer a good investment. Outer doorframes welded with “sprags” which can link into superstructure brickwork and linked to inner door frames through car tyre hinges offer an interesting option.

However there is no doubt that the static spiral structure which guarantees semi darkness is still the ideal design for the Blair VIP toilet. More recent designs include placing glass bottles as windows in the upper walling to let in more light.

The brick built pit lining

The bricks of the pit lining are bonded with cement mortar. The bricks come into contact with the pit contents which are moist and often wet in standard Blair toilets. The cement bonding helps to stabilise the fired bricks especially if they are of low grade. In fact most Blair VIP toilets built in the rural areas are constructed from "farm" or locally made bricks which can degrade over time. Unless the brick quality is high, they may well partly dissolve back into the soil, being supported by the cement bonding which can form a lattice work, keeping the pit lining in shape. It is very probable that the pit linings of many Blair VIP toilets are actually permeable with spaces being formed between the cement bonded layers as the liquids of the pit slowly dissolve the brick wall. If this is the case, the brick lining of a Blair VIP toilet must be considered as recyclable in a difference sense. That is it is recycled back into the soil but is unusable for reconstruction. In fact it is very unlikely that the bricks in the pit could never be salvaged to reconstruct new toilets. Perhaps this is the advantage of using high quality bricks or cement blocks in the pit and superstructure. They can be recycled as bricks.

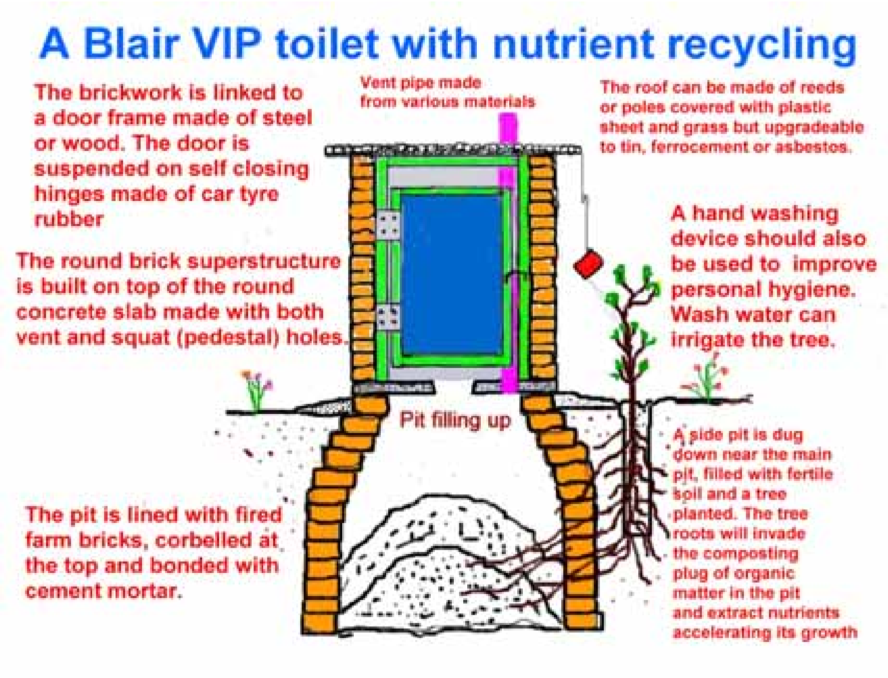
Recycling potential of the pit contents

Where the brickwork of the pit lining is sound and sufficient time has been allowed for composting, then the possibility of pit excavation exists. But the Blair toilets built during the era 1980 to the present were not built with this in mind. Most Blair pits will be filled with a variety of materials and garbage and the organic contents may take ten years or more to fully compost. The Blair VIP toilet has been popular partly because it can be used as a wash house as well as a garbage dump. In Zimbabwe this trend is likely to continue.

However there are other ways of recycling the nutrients contained in these pits, especially if the pit linings are made of lower quality farm bricks. Such bricks are not as durable as higher quality bricks and may have a limited life span under pit conditions. Under these conditions it may be undesirable to excavate the pit contents and planting trees near the pits may be a more practical method of recycling the pit nutrients. The growing tree roots search for nutrients in the soil and will invade the pit, even penetrating the pit lining to do so. Thus a simpler and more user-friendly way of recycling nutrients from lined deeper pits is to excavate or auger a smaller tree pit (or pits) near the old toilet pit down to a depth of a metre or more and filling with good soil mixed with compost and planting with a tree. The growth of the tree is enhanced by planting in good soil and even applying diluted urine to the tree once it has been established. The mulberry tree is a good example.

Planting trees near filling or old disused pits.

This concept of planting trees on top of used pits or nearby filled or filling pits can also apply to existing Blair VIP toilets. A huge volume of untapped pit compost lies within these pits. This material can be put to good use by planting trees, a method which will find favour particularly when compost extraction by hand is considered unacceptable or impossible to carry out by the family.



In this case a suitable tree is planted in a side pit filled with fertile soil. The tree performs the recycling. Tree root growth is encouraged by planting the tree in good soil and feeding the tree. The tree itself will decide at what time the organic pit contents are suitable for invasion. The roots will invade the soil around the pit first. After the tree roots have invaded the pit contents, nutrient extraction will accelerate. Toilet pits contain a large amount of valuable nutrient material which normally remains unused and therefore wasted. In this concept they are tapped by the tree itself and can therefore be utilised in the form of fruit, timber, fuel and medicine, depending on the choice of tree chosen. Because the exchange of nutrients takes place underground, the valuable recycling process takes place safely out of site and out of mind. This method can be used on both old filled pits and new pits because the decision to start root invasion is a biological one made by the tree itself!

The ecological Blair VIP

The main aim of an ecological toilet is to make it possible to recycle the contents for the benefit of the users. Safety, comfort and convenience are also important as well as the protection of the environment. The new configuration of the Blair VIP may make these aims possible. The pit is shallower (2m) and wider (1.3 +m) at the base. The corbelling technique makes this possible. Pit composting is accelerated by adding soil periodically, but in the longer cycle concept being promoted here on larger brick lined pits, the soil ash and leaves may be added less frequently as the control of flies and odours is achieved by adding the screened vent pipe. Thus the daily application of ash and soil will not be necessary to control flies and odours and this change of use will prolong the life of the pit.

The basic concept here is to be able to build a corbelled brick lined pit of a large capacity with farm bricks, which have sufficient strength to support the brick structure. A single bag of masonry cement is required to line such a pit and make a 1.0m diameter slab on a 2m deep pit with an internal diameter of 1.3m. However if Portland (PC 15) cement is chosen the cement can be used to line a wider pit since the mortar mix can be reduced from 16:1 to 20:1. In this case the pit base diameter can increase from 1.3m to 1.5m with a significant increase in capacity. The 1.0m slab can be increased to 1.1m and made from the same bag of PC 15 cement. This pit (2m deep and 1.5m internal diameter at base) may last for at least 10 years if the additions of soil and ash (to aid composting) are added weekly rather than daily. Since the composting process can now take up to 10 years (the life of the pit) the amount of soil/ash required will be less.

Recycling the superstructure

Recycling of the superstructure is easier if the unit is built on the slab rather than both on the slab and to the side of the slab on a foundation (as in conventional Blair VIP). Thus the round doored structure built on top of the slab is more easily dismantled and rebuilt. In this concept the slab itself acts as the floor. Both the structure and the roof are upgradeable over time. The structure and roof may start as a grass and pole unit, but the structure can be upgraded to brick and bonded with well chosen traditional mortar (anthill mortar). The roof can be upgraded to a higher quality thatch or to tin sheet or thin ferro-cement or asbestos.

If the bricks used in this unit are low cost burnt farm bricks it is very unlikely they will be usable after 10 years of lining the pit. This may also be the case also for the superstructure. After the ten year period the owner may choose to build a new unit with freshly made bricks.

In this case, both the structural and organic components of the substructure (pit) can be considered disposable and recyclable. The farm bricks will dissolve back into the soil leaving a plug of organic material of valuable nutritional content which can be tapped by useful trees which are planted close by. Such trees may be mango, avocado, mulberry, banana, paw paw and many others. Tree roots will invade the organic plug and withdraw the nutrients turning them into valuable fruit, shade, or fuel and building materials. The pit contents therefore will not have been wasted. The tree may have been planted at the time of toilet construction or at any other time during the use of the toilet. And even after the pit has filled up!

If the bricks of the superstructure are still usable when the pit is full, they can be taken apart, cleaned up and reused. Taking bricks apart is easier if the mortar used to bond them is weak or if traditional mortar is used. The concrete slab will certainly be re-useable after 10 years.
The re-usability of the door and frame and the roof will depend on what materials they have been made from. If no door is used, then this problem does not enter the equation.

Once the first pit is full (after about 10+ years), the toilet above ground can be taken apart and the re-usable parts, which will include the slab, some bricks, and possibly the roof may be suitable for incorporating into a reconstituted structure placed on top of a new pit. The construction of a new toilet will involve digging and lining a newly lined pit and fitting the original slab on top. So the cost of the second construction will be less than the first since the important slab has already been built. And it is possible that some of the other components may be re-usable.

This new generation of Blair VIP toilets is far more ecologically sound and recyclable than the old. The parts made of soil (bricks) are recycled back into the earth. The biological component is also recyclable, as the nutrients in the “plug” of pit compost are also recycled back into a useful form by the trees planted close by. Even the earth (termite) mortar used to bond the bricks on the superstructure can be returned to the earth. Many of these concepts use traditional methods which are well tested and work in the real world. The materials can be recycled back into Nature, as Mother Earth intended. And the so called waste products (excreta) are reused for the benefit of the family for generations.


From Arborloo to Blair VIP!

5. Alternating or rotating between pits

This subject can be divided into two sections. Alternating between shallow pits and alternating between deeper pits. The simpler toilets use shallow pits. These may be lined or unlined depending on soil conditions. Where the soil is moderately stable (or where the *Arborloo* is used) the pit will not be lined, but protected with a ring beam. Lining with bricks is essential is unstable soil.

1. Method for shallow pits

The basic shallow pit compost toilet is made with a single slab and ring beam and a simple structure. The pit is usually 1m deep. Odours and flies are partly controlled by the regular addition of soil and wood ash. These extra materials also help to accelerate composting in the shallow pit. Once the toilet pit is nearly full, the structure, slab and ring beam are moved to another site where a new pit is dug. The near full pit is leveled off and topped up with soil (about 15 cm deep) and trees or shrubs or even vegetables are planted in this layer.

The next stage of development of the shallow pit composting toilet is to add an extra ring beam. In this case two pits are dug and one is used during the first year, whilst the second pit remains unused – or is filled with leaves and other compost. The pits are dug deeper preferably 1.5m deep. This will provide extra filling time. After a year of use the slab and structure are moved over from the first pit to the second pit (which has been emptied of compost) and soil is added on top of the used pit. Trees are not planted in the pits as they will grow and occupy the pit space. However vegetables can be planted in the topsoil. So the first upgrade consists of:

1. Two pits (or 3 or 4 pits if the demand on the toilet is great)

2. Two (or 3 or 4) “ring beams” to protect these pits
3. A single concrete slab which sits on one of the ring beams
4. A single toilet house which provides privacy.

Like the earlier systems, each pit fills up with a mix of excreta, soil, wood ash and leaves. Leaves are put in the base of the pit before use and every day some soil and wood ash are added to the pit. Dry leaves are also added to the pit. Good humus formation required the addition of some vegetable matter. **No garbage (plastic, rags, bottles etc) is put down the pit.** One pit fills up first. During the first season the second pit is unused or is filled with leaves or composting material which is dug out later.

Examples of alternating compost pit systems

Both rectangular and round pits can be used with the alternating compost pit system (*Fossa alterna*) with both unlined pits and pits lined with bricks. Unlined pits are protected with a ring beam of concrete, and both rectangular and round ring beams can be used.


Concrete ring beams can be cast inside a brick mould or within specially made steel moulds. In this case the ring beam has an ID of 1m.


The same applies to the concrete slab. Slab diameter here is 1.2m.


Two ring beams and a single slab are caste for the alternating pit system

If PC 15 cement is used a mix of 10 litres cement and 50litres river sand are used for each ring beam (ID 1m, OD 1.3m for the 1.1m slab and ID 0.9m, OD 1.2m for 1m slab). See description of ring beams in earlier chapter. If masonry cement is used 12 litres of cement are used with 50 litres of river sand. If the slab diameter is increased to 1.2m, 15 litres of masonry cement is used. Once the ring beams and slab are caste they are left to cure, being kept wet for a week.

The pits are then excavated within each ring beam. In a programme being conducted at Hopley Farm near to Harare, the pit which will be used for the toilet is dug down 1.5m whilst the second pit is dug down to 0.3m and filled with fertile topsoil used as a garden, whilst the first pit is filling with excreta soil and ash. With alternating pits the pits can be lined with bricks as they remain in one location.

First pit being dug down to 1.5m depth. The concrete slab is then fitted and sealed with weak cement mortar.

A suitable superstructure is then mounted on the slab and the toilet can be put to use. The soil within the second ring beam is planted with suitable vegetables and kept watered.

Alternating pits

When the first pit is full, the toilet slab and structure are moved on to the second pit and top soil 15cm deep is placed over the contents of the first pit which is then left to compost. It is best to level off the contents of the pit first. The second pit is then dug down to 1.5m and put to use as the toilet pit whilst the contents of the first pit are composting. The composting pit can be topped up with soil to the rim of the ring beam and then used as a miniature vegetable garden ("ring beam garden" – see later).

After a year or more of use (for a small to medium sized family) the second pit will be full (with excreta, soil, ash and leaves) and the first pit will be ready to empty of its compost. After the original pit is emptied the toilet slab and structure can be placed back again over the empty pit and the recently filled pit covered with soil and left to compost for a further year. This ritual of changing pits every 12 months can continue for many years in the same site if the soil remains firm. Otherwise the pit can be lined with bricks.

If the pit filling rate is faster, it is possible to remove pit compost after 6 or 9 months and carefully transfer to a “tree pit” and plant a tree rather than use on the vegetable garden (see later). In this case the pit compost will not be fully processed and a transfer from one pit to another pit (tree pit) is important to avoid exposure and a possible health threat.

If the pit filling rate is fast due to heavy use, it is possible to build a third pit (or even 4^{th} pit) and rotate the slab and structure around the three or more pits, which are all placed in semi-permanent locations. It is important to regularly add soil, ash and leaves to the pit to accelerate breakdown of the excreta and to allow a period of 12 months for the process to take place before excavation.

These composting pits can be used just to contain the composting ingredients during processing or as miniature vegetable gardens (see later chapter). Additional soil, compost and even some urine, manure or fertiliser can be added to these miniature vegetable gardens to increase production. Green vegetable and pumpkin for instance respond very well to the application of diluted urine. A variety of vegetables can be grown such as onion, rape, tsunga, spinach, tomato, pumpkin, squash and various herbs etc.

Lined or unlined pits

A pit lined with bricks is more stable than an unlined pit unless the soil is firm, in which case the stability of both may be similar. However there are certain advantages in having an unlined pit capped with a ring beam. Decomposing excreta has greater access to the soil and its organisms in unlined pits, compared to lined pits. This will lead to an enhanced rate of processing in the pit. Also the seepage of fluids into the surrounding soil is faster in unlined pits, so the pit can cope with additional urine or water. Pits lined with bricks may fill up with fluids faster if the base of the pit becomes clogged with sludge. Wet pits do not compost properly. Also unlined pits cost less to build than lined pits. But there are situations where brick lining is essential. If the soil is unstable then a lining is essential to avoid pit collapse. If bricks are used to make the superstructure, then the pit must always be lined with bricks. In general fluid additions to composting pits should be kept to a minimum. That is urine and a little washing water.

It is possible that after a few years the side walls of unlined pits capped with ring beams may begin to erode. These can be repaired after the pit has been emptied with a mix of firm soil and cement mortar, or even termite mortar. This can also be done if the eroded section lies above the compost level.

Photos showing eroded section of pit wall under ring beam. This has been filled with a mix of red soil and cement to stabilise.

In the series of toilet designs described here the slab diameter is relatively small (1.0m or 1.1m). So it is important to use the corbelling technique of pit lining to gain a meaningful pit volume, especially when the standard pit or VIP concepts are used. This even applies to the *Fossa alterna* concept. The larger the pit, the longer the pit takes to fill and the more time becomes available in the pits for complete composting. As described earlier, round pits suit the corbelling technique best, as the small economic slab can be placed over quite large pits if required. The roundness of the structure helps to provide strength.

Adding vegetable matter to the pit makes better compost. This can come from the kitchen. The pit becomes an underground composter. Urine added to the pit and its contents also aids for the formation of compost. A balance must be struck between filling time and time to compost. That is why in some cases more than 2 pits will be required.

2. Method for semi-deep pits (max 2m)

The bricked lined pit using corbelling technique can be used on an alternating pit system if a second pit is made. It requires two pits 2m deep with an internal lower pit diameter of between 1.3 and 1.5m. The second pit can be constructed at the same time as the first pit is made or later when the first pit is about to fill up. Like the *Fossa alterna* system, only one pit should be used at one time. One slab and one structure alternating between two pits.

To be successful as an ecological toilet where pit compost is to be extracted, this system with brick lined pits must be used as an ecological toilet and not like a normal pit toilet. In other words soil, ash and leaves must be added to the pit contents regularly and not garbage. Neither must an excess of water be added to the pit. If the pit fills up with raw excreta and garbage in wet conditions it will not compost well and the contents may take some years to turn into compost once the pit is abandoned. This is particularly true for lined pits, where there is little contact with the soil. Also pits filled with all manner of garbage are difficult and unpleasant to excavate. By comparison, pits filled with well composted excreta are easy to excavate. This must be considered carefully before the owner puts the system to use. The use of two larger ecological pits can be called a “long cycle alternating pit system” as opposed to the “short cycle alternating pit system” such as the *Fossa alterna* currently in use.

Rotating use between several smaller pits

If the demand for toilet use is high and there is space in the garden or homestead a single concrete slab and portable toilet house can be used on a series of shallow pits in rotation. These pits can be protected with ring beams which are left in place. As before, soil and ash etc are added to the pit during use. When the first pit is full, the slab and structure are moved to the second pit, then to the third and fourth. Trees can be planted, but the pit contents can be left to compost. After a year, compost can be dug out of the first pit and this pit used again for the second time. So pits can be used in rotation. This method does require the use of a simple and easily portable and durable toilet house. But once such a house has been made the process is simple. In practice the family may choose to plant trees on some pits, vegetables on others and make compost for later excavation in others.

Alternating between pits of different sizes.

So far the method of alternating pits of the same or similar sizes has been described. However pits can be alternated between pits of different sizes. An example uses the larger brick lined pit (corbelled) described earlier. This can be alternated with a series of smaller pits and different sizes and depths (eg *Arborloo's*).

One large and one small (Earth and Moon)

This method involves the construction of a large brick lined corbelled pit with a diameter of between 1.3m and 1.5m and a depth of 2m. This is filled over a period of 5 – 10 years with a mix of excreta, soil, ash and leaves. Eventually it will fill up and must be left to compost. This composting may take 2 or more years depending on the composition of the ingredients. The time to compost will depend on many factors, but mainly how much compostable material like soil and leaves etc have been added. Wood ash will also help to make the pit contents more alkaline and add potash to the final compost.

During the period when the larger pit is composting, a smaller shallow pit or series of smaller pits are used (like the simple *Arborloo*). The same slab can be used. The slab can be removed from the larger pit (together with removing or dismantling the superstructure). If brick structures are used they can be designed in such a way that they can be easily dismantled. Using strong fired bricks, weak bonding mortar (20:1) and a removable roof helps to make the structure easier to dismantle. Portable structures can also be used. These can be made of well constructed traditional materials or steel or wooden framed structures, which can simply be removed and placed on another pit easily and at any time interval.

So in this case the primary toilet is made with the brick lined pit. During the time when the composting is taking place in the primary toilet, the secondary toilets can be used. This can be a toilet built on the ring beam and used like an *Arborloo*. The site of the second pit can be changed two or three times whilst the primary pit is composting.

In this way a versatile system can be achieved based on the alternating shallow pit system. The primary lined pit can be 1.5m deep (or even 2m deep). The secondary pits can each be 1m deep and unlined. After say 2 (or more) years composting in the larger lined pit the contents can be dug out and used on the garden and the large pit put back into use. It is important that plastic and other garbage is not added to the larger pit and that soil and ash and leaves are added regularly. This makes the pit much easier to excavate.

Managing the larger alternating double pit compost toilets

These concepts, especially those using deeper larger lined pits are still on trial. Like the earlier single pit system each pit fills up with a mix of excreta, soil, wood ash and leaves etc. Leaves are put in the base of the pit before use and every day some soil and wood ash are added to the pit. Dry leaves are also added to the pit. **No garbage (plastic, rags, bottles etc) is put down the pit.** Also excessive water must not be placed down the pit.

These methods of using ecological VIP toilets differ from earlier experience. The Blair VIP toilet is well liked for its ability to act as a garbage disposal unit and also a washroom. Ecological pits designed to make compost for later excavation do not cope with this system of use. If the toilet is to be used for later pit excavation then it must be used in n ecological way. If the user chooses to use the VIP as a washroom and place for garbage disposal, it is unlikely the pit contents will be fit for later excavation. The pit lining must be sacrificed, although pit nutrients can be drawn out by planting a tree nearby. It is a choice that must be made by the user.

Examples of double pit composting toilets

The portable structure

Two rectangular concrete ring beams and slabs and portable structure made of poles and reeds (left) or a steel frame (right). The structure itself moves with the slab at yearly intervals in this design.

Examples of simple *Fossa alterna* compost toilets in Mozambique and Malawi. In Malawi and Mozambique, the most popular method of building the *Fossa alterna* is to house both pits within a single superstructure.

Some *Fossa alterna* toilets built in Malawi are made from bricks (left). On the right a *Fossa alterna* near Harare with portable structure.

Pit emptying and use of the compost

Digging out compost from a double pit compost toilet in Hatcliffe and Epworth both near Harare.

Pit contents that are not fully composted (e.g. at 6 months) can be excavated from a shallow composting pit and added to a second pit (tree pit). This is topped up with soil and a tree is planted. In this way the semi-composted material is exposed for a limited amount of time under controlled conditions.

Compost from composting pit in Hopley Farm being is transferred to a "tree pit" where a mulberry tree was planted. On the right some months later the mulberry tree is thriving.

Safety of the pit compost

If the recommendations have been followed on adding soil, ash and leaves, then the compost should be relatively safe for reuse after 12 months. The bacteria which cause disease should have died out within a few months, but the soil bacteria which are part of Nature's method of recycling organic matter should be thriving. If there is doubt about the safety (from a health point of view) of the pit compost extracted from the *Fossa alterna* or if the pit compost is dug out before it is fully composted, it is best to transfer the compost immediately into another shallow pit and cover with soil. This can be planted with a tree ("tree pit") or left to compost further in the pit before planting or later excavation. Once the compost is covered with a good layer of soil (15cm) any threat from parasitic worms (such as *Ascaris)* will be overcome. The time it takes to excavate a pit full of compost to another pit or pits is relatively short and any threat of exposure of the compost is short lived.

This also applies to areas where worm infections like *Ascaris* and tapeworms are known to be transmitted. If worm infections are common in the area, a period of 12 months may not be long enough to destroy the eggs of *Ascaris* and some other parasitic worms. In this case care is required in reusing the compost. Under these conditions and if there is doubt about the safety of the compost it is best to transfer the compost directly from the toilet pit into a tree pit or compost pit and cover with soil. Extra soil and vegetable matter can be added to improve the humus content. The pit compost is covered with 150mm of soil and a tree, shrub or vegetable like pumpkin or tomato is planted. The worm eggs are then buried and not likely to be picked up by children. In fact the quality of pit compost can be improved considerably by further mixing it with garden or leaf composts and allowing a further period of composting. The best compost is made by mixing both animal and plant material into the mix. During this secondary composting stage a far more valuable material can be produced by adding more soil and plant material.

It is wise to assess the area for the prevalence of worm infections first. People living in hot and coastal areas may be heavily infected with parasitic worms and clearly spreading unsafe compost on the fields may be dangerous. However in other areas these worm infections may be light and not a great threat at all. In this case the pit compost may be used directly on the lands after the recommended 12 month period. So the simple rule is to assess the area first, use the method of recycling which is most appropriate for the area where the pit compost is being used. The same reasoning applies to the use of solid material formed in urine diverting toilets. This is described in the next chapter.

6. Using urine diversion

Urine diversion is a system where urine and faeces are separated either in a special pedestal or in a squat plate. The urine is fed off through a pipe to a plastic container and the faeces drop into a vault where soil or wood ash or both are added. This has the effect of partially dehydrating the faeces which makes them easier to handle.

The advantage of urine diversion is that urine can be collected separately and used to increase the production of green vegetables, maize, pumpkin and other valuable food items. Urine can also be collected in plastic bottles (for men) and potties. The “desert lily” (eco-lily) a funnel placed in a plastic container and enclosed in a structure for privacy, can also be used to collect urine. The second advantage to urine diversion is that the faeces are far more easily handled and dehydrated, as they are not mixed with urine.

Urine diversion systems generally cost more money than pit systems and greater care is required to keep them clean and functional. Urine pipes can get blocked with soil or ash etc and urine may find its way down into the vault intended for the faeces which should remain relatively dry. If a urine diversion system is placed over an ecological shallow pit rather than a vault, then problems of passing some urine down the dry side is overcome because the urine can seep into the soil. Also the system becomes much easier to clean down with water, since a little water added to a pit does little harm. Water added to a dry vault system can cause significant problems.

It is possible to convert any of the shallow pit toilet systems to urine diversion if required. Urine diversion pedestals or squat plates can be used. The exact method will depend on the type of urine diverter chosen. Also the VIP toilet can be converted to suit urine diversion. In each case the system becomes more complex to use and user education is required. The main benefits are that urine is collected automatically in plastic containers (20 litres) the contents of pit or vault become drier, easier to handle and smell less and generate fewer flies.

6.1 Converting a pit system to urine diversion.

The *Fossa alterna* is a semi permanent installation and converting this with a urine diverting device is possible. In those cases where a urine diverting pedestal is fitted to a shallow pit composting system like the *Fossa alterna*, it is best that the urine pipe is led off above the base of the pedestal and passes over and on top of the toilet slab. Piping placed under the slab is more complicated to fit to pit structures and the toilet slab must be raised above ground level to make this possible. The same urine diverter (often using the same concrete slab) can be fitted to a brick vault where the toilet is constructed entirely above ground level (see later).

1. Fitting the urine diverting pedestal at ground level

In this case a special urine diverting pedestal is used with a urine off-take above the base of the pedestal.

This urine diverting pedestal has been fitted to a *Fossa alterna* system. The urine off-take is fitted above the base of the pedestal so that the pipe can be led above the slab to the most suitable place – like a plastic container for urine

collection, compost-pit or tree. The 110mm vent pipe passes through a hole made in the slab and is fitted in this case inside the toilet house.


Details of the urine diverter. The base of the urine diverting shute is fitted to an offset pipe (to avoid plastic elbow) to divert urine through a short length of plastic pipe to the plastic container or seepage area. Ideally the urine should be able to take a clear route down the pipe without any bends!


The plastic pipe is taken through the side wall of the structure to a plastic container for urine collection. This container can be placed in the second pit (of a *Fossa alterna*) or in a hole dug in the ground. A plastic elbow is fitted and directs the urine down into the container.


Urine collects in the container. If the container overfills, excess urine can run into the pit or hole dug in the soil.

If the urine pipe becomes blocked it can be cleaned out by removing the plastic pipe which enters the pedestal and water can be used to flush out the piping and joints. The plastic pipe carrying the urine from the pedestal can be pulled out and refitted easily. It is almost certain the urine pipe will become blocked with soil or ash etc and maintenance should be made as simple as possible.

When a urine diverting toilet is fitted to a *Fossa alterna*, the pit contents start to become drier although they do not dry out completely. Water is used to wash down the pedestal from time to time. Odour and fly breeding are also reduced. Soil and ash should be added regularly.

The pedestal shown in these photos can be removed easily from the slab. The pipe is easily removed. When the pits are changed (as in *Fossa alterna* system), the pedestal and urine pipe are removed and also the urine container. The structure, including vent pipe is removed and the slab and structure refitted on the empty pit (which has been excavated). Then the urine diverting pedestal is fitted back. If an elbow is fitted to the urine pipe as it leaves the pedestal, then the direction in which the urine flows can be changed easily by turning the elbow. However elbows have a habit of getting blocked. Where the urine off-take is offset, as in the photos above, a hole must be dug to hold the 20li container.

Urine diverting slabs can also be made where the urine pipe lies above the toilet slab level as shown in these photos. The smaller slab with urine diverting arrangement is made first and then placed on top of the toilet slab.

6.2 Fitting a urine diversion system to a VIP toilet.

With the conventional VIP which is constructed with a brick substructure (pit) and superstructure made of bricks it will be necessary to use a urine diverting device with urine off-take above slab level. The urine diverting pedestal and urine diverting squat plate designed for this purpose have both been briefly described above.

The advantage of adding a urine diverter to a pit system is that the pit contents will become drier, with less potential for odour and fly breeding. Also the urine can be collected and used as a fertiliser. Urine can be led to a 20 litre plastic tank which can be housed in a hole dug in the ground (preferably brick lined). The urine can also be led to a banana tree which will provide extra fruit as a result of the urine application. This conversion can take place at any time during the use of the VIP. Some people may object to handling the faeces contained in a vault, but they may accept the idea if the urine diverting system is placed over a pit and the urine led by a pipe into a suitable tree.

The pit will fill with much drier additions of excreta, and water can be added to clean the facility down. But at the same time valuable urine can be collected for fertilizing many valuable food plants. Or it can be directed to a tree by the side of the toilet, like a banana or mulberry.

Normally standard pit toilets, including the VIP, are used also for refuse disposal and every conceivable type of garbage and waste is thrown down the pit (rags, glass, bottles, sanitary towels etc). Also VIP toilets are used as washrooms. These features are thought of as considerable assets and have made the Blair VIP popular since it can

be used as a multipurpose unit. These features are desirable and one reason why the Blair VIP still remains popular in Zimbabwe.
But ecological pit toilets, where compost formation and excavation, is desired cannot be used as washrooms. Thus for many the conventional method of using the VIP may be the chosen method of use.

However it is interesting that trees will grow in pits containing garbage, since the concept of planting trees in abandoned toilet pits is frequently used in many parts of Africa. The tree roots do not object to the garbage – they simply find their way around it in the compost formed in the pit. It is only when the pit contents must be excavated that garbage removal becomes a problem.

So in one sense, if one fits a ventilation pipe and light weight semi-dark superstructure to a ring beam and slab (an *Arborloo*), one has a fully functional low cost VIP toilet, in which excreta can be added together with soil and ash. The unit can also be used to dispose of garbage since the pit contents will not be removed. When the pit is nearly full and the ring beam, slab and portable structure moved are moved on to a new site, the pit contents will settle and during this stage extra soil can be added on top. At some suitable time a tree can be planted on the pit in the topsoil. As the tree grows it will start to use the nutrients available in the compost formed. So recycling is taking place.

Likewise, once a deeper pit VIP toilet is full, the slab and superstructure can be removed or taken apart and the pit contents levelled off and the pit filled with topsoil and left to settle. More soil can be added as the contents settle more. Then a tree can be planted in the old VIP pit (or to one side). Those bricks which were used for pit lining will be lost, but if the tree is well chosen the value of those bricks will be replaced by the value of the products produced by the tree, whether it provides fruit, fuel or building material. The 500 000 Blair VIP toilets units built during the 1980’s and 1990’s have an estimated combined pit volume of 1.5 million cubic metres. This may represent over a million cubic metres of valuable toilet compost.

Building a single vault urine diverting toilet above ground

If a urine diverting pedestal is used with urine off-take below slab level or a squat type urine diverting plate is used, the toilet must be raised above ground level. In this case the owners of the system must accept that the vault (or bucket) will fill with a mix of faeces, soil and ash and they must be prepared to handle this material – extract it and take it to a secondary compost site for further processing.

If two ring beams and a slab have been used in an earlier construction (as in the *Fossa alterna*) then these same components can be re-used to build a brick lined vault above ground level suitable for a urine diverting system. A brick wall is built up about 0.5m on top of the lower ring beam above ground level. The upper ring beam is placed on top of the brick work and the toilet slab is fitted back in position forming a vault above ground level. The hole in the slab is enlarged so it can accept the required urine diverting device.

In this way the brick enclosure becomes an above the ground vault. The circle of bricks laid on the ring beam is not complete and space is made for a door at the back to gain access to the vault. A thin walled concrete door is made to fit into this space. The urine pipe from the urine diverting device can be led through the wall of the vault to a container placed partly below ground level. The toilet is fitted with a suitable superstructure for privacy. A ventilation pipe also helps to take out odours from the vault and also helps to reduce the moisture content of the bucket or vault.

Most urine diverting vaults have a concrete floor, but in this case the vault floor is made of soil within the ring beam, allowing for some seepage of urine or water that may have found there way into an area which should be dry. Flooding of the vault is therefore avoided as any excess fluids can seep away.

Example of upgrading the toilet system using the 1.1 metre diameter round slab and matching ring beams.


The ring beam is laid on firm ground in the desired place. Three courses of bricks laid on edge are them built up on the ring beam on the outer edge. An opening is left for the vault access door. A second ring beam is made and added on top of the brickwork.


Photo on left showing rear access to vault. The floor of the vault is built up with soil levelled and rammed hard. The concrete slab is them mounted on the upper ring beam. This is made to suit the type of urine diverting pedestal or squat plate made. It can be made with the standard slab with the pedestal hole cut out larger with a hammer and chisel. In this case the slab has been made to suit the UD device being fitted which was a home made.


The vault access door is made to fit the opening in the vault. High strength concrete is used mixing one part cement with three parts river sand. Small bolts have been used as handles.

The home made urine diversion squat plate has been fitted. A 20mm garden hose is used to carry urine from the devise to the outside of the vault where a plastic container is fitted.

Urine diverting squat plate and vault door.

An alternative way of making the urine diverting squat plate with a plastic insert (cut 10 litre bucket) placed in the slab itself. The slab is caste first in the upside down position, cured and then turned over. The foot-rests can be added and the surface of the slab recoated with strong cement plaster. This method can be made to fit on rectangular or round slabs of different sizes.

Other examples of single vault urine diverting systems

Single vault urine diverting toilet built by Mvuramanzi Trust, Zimbabwe. Early single vault urine diverting toilet built in South Africa. South Africa has built the largest number of urine diverting systems in Africa.

Urine diverting toilets built in Kisumu, Kenya

Home made toilet and urine diverting pedestal in Kenya

The double vault (alternating) urine diverting systems.

Most urine diverting toilets around the world are built with two vaults. The first vault fills up with a mix of faeces and ash (or soil and ash). When this is full the second vault is used. By the time the second vault has filled the first vault can be emptied. This period may lie between 6 and 12 months depending on the volume of the vault and the number of users. Where pedestals are used these can be moved from one vault to the other with the urine pipe being repositioned. Where urine diverting slabs or squat plates are used two units may be used, one for each vault, and the urine piping arranged to deliver urine from which ever unit is in use.

In some other systems the urine collects in depressions made in the toilet slab itself, with urine being led into a recess where the pipe is fitted. In these systems the urine may seep into the concrete and smell but regular cleaning and even coating the slab with wax polish helps. There is much variation in the design of double vault urine diverting toilets around the world. Some double vault urine diverting toilets are built in combination with washrooms as the photos taken in Malawi show.

Double vault system being built in Lilongwe, Malawi. In this case the toilet is coupled with a washroom. Programme by CCODE Malawi.

Urine diverting slabs in use in Malawi (Photos from CCODE, Malawi).

The vault door is opened to reveal the vault contents. These require extra processing before they can be used. CCODE Malawi.

Double vault urine diverting toilet in rural Malawi (COMWASH)

Collecting and processing the faeces to make compost in above the ground vaults (single and double)

The urine diverting system directs faeces (together with soil and ash) into the vault where the material may accumulate in the vault itself or in a bag or bucket which is removed more regularly and the contents placed in a secondary composting site. If a bucket or container system is used this will be placed in a single vault system. In the case where a single vault is used and the faeces enter the vault itself, extra soil and ash are added and the vault and the pile is left to dry out for few days (an alternative toilet is required during this phase). The semi dry material is then raked out and placed into a pit to decompose further or placed into bags. In the double vault system, the use of the vaults alternates like the *Fossa alterna*. In most double vault systems a period of 6 months elapses for the vault contents to dry out. Then the contents are removed and either dug into the ground or placed in pits. Secondary processing of dehydrated vault material is very desirable to make it more suitable for agricultural purposes. This involves mixing with other organic composts and allowing time for a further period of processing.

Collecting the faeces in buckets, sacks and other containers.

When the faeces (together with soil and ash) are collected in a bucket or other suitable container or a sack, the contents can be removed and the vault can be cleaned out and even washed down with water. The contents of the bucket or container can then be moved to a secondary composting site, where they are mixed with soil, compost and other compostable plant materials and processed further. A shallow composting pit designed for the purpose is an ideal site. Soil, ash and leaves are added to these sites together with the contents of the bucket. The conversion of dried faeces into rich compost takes place within a few months.

A sack can be placed within a 20 litre bucket fitted in the vault to collect the combination of faeces, soil and ash. Or a free standing sack. The sack can be removed and the contents covered with soil. Comfrey can be planted in the topsoil. It will grow rampantly. Comfrey is a valuable garden plant. Specially designed containers can also be built to fit into the vault.

Routine maintenance of the urine diverting toilet.

Routine cleaning and maintenance of the urine diverting toilet is important for the best functioning of the unit. This is not an arduous task and can be carried out quickly once every month or two. Urine diverting pedestals have no means of flushing down the sidewalls and it is inevitable that some fouling will take place. Whilst the vent will carry any odours down into the vault and up the pipe, periodic cleansing of the pedestal is essential. During normal use, the dry soil/ash mix will cover any side wall fouling, dry it out, and make it less objectionable.

The advantage of the urine diverting described here, where the faeces are contained in a removable container and not a static vault, is that the container can be removed and the system washed down completely. It is desirable that the vent pipe, pedestal and urinal pipe are also washed down and cleaned from time to time. First the faeces container and urine container are removed and put to one side. The vent pipe (which will normally be made of PVC) is also pulled out. Cobwebs which may have developed in the vent can then be cleaned out with a small tree branch. The whole vent can then be thoroughly washed down and cleaned out with water. The pedestal is cleaned entirely from top to bottom including the side walls with water. The water will be flushed into the vault, but the bucket or other container holding the drying faecal matter has already been removed. The urine pipe is also flushed out with water. The toilets floors and vault can also be washed down with water. It is a thorough "spring clean."

It is important to thoroughly clean out the ventilation pipe from time to time to retain its efficiency. This is because spiders weave their webs inside the pipe and this seriously disrupts the air flow inside the pipe. Efficient ventilation is important and helps to reduce odours and also maintains a constant flow of air through the vault which reduces moisture.

The toilet and its parts are then allowed to dry out and are all put back together (put back faeces and urine containers and vent). The dry soil/ash container inside the toilet is constantly being recharged from a larger stored stock elsewhere.

In those cases where the urine diverting toilet is placed over a pit, the pit (shallow or deeper) will eventually fill up. But by this time a huge amount of benefit should have been gained from the use of urine, on maize, vegetables or on trees. When the pit is full the system must rest in order to compost. An alternative toilet system must be put in place like an *Arborloo.* If the original pit, which may be lined, is to be reused, it must eventually be excavated. In this case the upper structures must be removed to gain access to the pit.

Where above the ground single or double vault urine diverting systems are used and maintained properly, the unit will function well for decades. The writer has used a single vault urine diverting system for the last ten years in his garden (in Zimbabwe) and collected urine and composted faeces for use in growing vegetables. Similarly he has also used a Blair VIP pit system as an alternative in the garden. Both systems have merit. The urine diverting system needs more attention but the VIP will eventually fill up. But the writer may be 100 years old before this takes place!

7. Using toilet compost and urine in the garden

For the great majority of people this may seem like an unpleasant and unnecessary thing to do. But for rural farmers and those living in peri-urban settlements in Africa who grow vegetables and trees in their gardens, it makes more sense than meets the eye. In an era when commercial fertiliser may be too expensive to buy and where soils are poor and where cattle manure may be difficult to find, there may be great sense in considering the use of human compost and urine.

Urine contains a very large amount of nitrogen which green vegetable and maize and many other valuable plants respond to very positively. It is possible for instance to more than double the grain yield of maize on poor soils using urine alone. And the production of green vegetables can be multiplied several times using urine. The amount of the increased production varies according to the species of plant, the condition of the soil and the amount of urine used. When used on vegetables the urine is best diluted with water – one part urine to three parts water and applied around the plants. When used on maize urine can also be diluted with water or diluted by the rains.

The compost produced from human excreta is also valuable, especially if it has been processed with soil and plant material like leaves. It has considerably more nutrients than poor soil and when mixed with poor soil can enhance the production of vegetables. The compost contains less nitrogen than the urine, but contains valuable amounts of potassium and phosphorus. Potassium is useful for the fruiting of plants and phosphorus helps root growth. The compost also is more like humus than the soil it is mixed with. The ideal is to use the toilet compost and urine in combination. Each compliments the other in the provision of nutrients and humus.

Human compost can be derived from shallow pit composting toilets like the *Fossa alterna* (or *Arborloo* if the pit is dug out rather than planting a tree). It can also be derived from urine diverting toilets. The urine can be collected in many ways – in bottles, containers and from urine diverting pedestals or squat plates. A container with a plastic funnel attached, called a desert lily (eco-lily) is useful for collecting urine. An ideal method is to mix toilet compost with topsoil in equal proportions (especially if the local soil is poor and does not feed plants well) and then add measured amounts of diluted urine to the plants once they have become established. It is possible of course to plant the seedlings in normal topsoil and then feed the plants with diluted urine without using toilet compost at all.

As a general rule it is best to plant vegetable and other seedlings in the soil first and water until the young plants are established. Then the application of urine can begin. It is diluted with water at a rate of about 3 parts water to one of urine and added to the soil around the seedlings. The amount of diluted urine added depends on the area of application. It is best to apply the diluted urine in the evening, as the loss of nitrogen will be less. The urine takes about one week to have an effect on most green vegetables. Bacteria in the soil convert the urine nitrogen into a form which can be used by plants. The most obvious reaction of plants to urine is to make the leaves turn greener and more luxuriant. It also speeds the growth of the plants.

Three methods of growing various plants and vegetables are described here. The first is to grow vegetables in buckets or basins of about 10 litres capacity. The second is to grow them intensively within specified sites such as ring beams. When the ring beam lies above composting pit material, it can be topped up with soil and used as a miniature garden. This is known as a “ring beam garden.” The third method of growing vegetables is the most commonly practiced

– in vegetable beds in the garden. Several trials have been undertaken to reveal the effects of toilet compost and urine on valuable food plants. The effects are very positive and valuable, particularly in areas where alternative plants foods like fertiliser are difficult to buy because of cost or availability or where other means like compost or animal manure are not available.

7.1 How to use toilet compost in the garden

Toilet compost can be excavated from *Arborloo* or *Fossa alterna* pits or taken from secondary processing sites linked to urine diverting toilets. These sites may be jars, bags and shallow pits. In shallow pits the compost may take a year to process. Faeces (with soil and ash) taken from urine diverting toilets and processed in secondary compost sites takes less time to process. This is because the smaller amounts can be mixed with soil, ash and leaves as the compost site builds up. Bags can be used in the place of the vault or a bucket in a urine diverting toilet. In this case when the bag is getting full it can be withdrawn and the contents moved to a composting site where more soil is added together with ash and leaves and left to compost. If extra soil is added to the bag, herbs like comfrey can be planted directly in the bags containing the compost. They thrive well.

Toilet compost varies a great deal in texture and colour depending on the amount and type of soil added. The compost extracted from pits like the *Fossa alterna* has a slightly darker colour than the soil added. Its consistency also varies from one part of the pit to another. Regular additions of soil, ash or leaves are important as the soil bacteria work on the excreta close by and the greater the mix of the ingredients in the pile the more effective the conversion from excreta into compost becomes. The demonstration that human excreta can change into a pleasant smelling compost can be an important step in convincing people that something good can come out of recycling.

Toilet compost

Digging out the compost from shallow pits

Excavating pit compost in Mozambique and Malawi

Excavating pit compost in Epworth and Hatcliffe, Zimbabwe Harare.

Toilet compost from urine diverting vaults

Human faeces falls directly into a vault and ash is added to sanitise and dehydrate. Or faeces can fall into a bucket or sack together with soil and ash. The bucket/sack is removed when nearly full and placed in a secondary composter. Alternatively plants like comfrey can be planted in the sacks.

7.2 Ways of using toilet compost

1. Enhancing poor soil with toilet compost.

Very poor soils can be made more productive my mixing with toilet compost as the two examples below show. The increase in growth is very significant. Poor soils, such as those used in the trial are very common in Africa. By combining poor soil and pit compost, vegetable production can be enhanced significantly.

Mixing toilet compost with poor soil helps the vegetables to grow better. Using a 50/50 mix of poor soil and toilet compost the yield of both spinach and lettuce was increased 7 times.

2. Growing tomatoes in toilet compost

Tomatoes grow well in toilet compost either mixed with topsoil or unmixed. Often tomatoes will grow directly from the compost when it is watered. They are best fed also with dilute urine and wood ash, or a liquid comfrey plant food.

Tomatoes growing on toilet compost direct.

3. Growing trees in toilet compost

When an *Arborloo* is used the tree is planted directly in the toilet pit. The tree is planted in soil placed on top of the composting ingredients. It is also possible to transfer the composting faeces (plus soil and ash) into a pit to which additional soil, ash and leaves are also added.

The “tree pit”

For instance the contents of the bucket or bag from the single vault urine diversion toilet can be added to a pit (about 0.6m deep and 0.6m in diameter) in stages. Additional soil and ash and leaves are added as well. The pit is covered temporarily with a cover to protect it. When ¾ full the rest of the pit is filled with good soil and a tree planted. This is called a tree pit.

Adding toilet compost to tree pit

It is also possible to plant trees in toilet compost which has been excavated from a compost toilet pit and transferred to a hole dug specifically for a tree. Partly composted pit compost from a *Fossa alterna* can be transferred with care into the tree pit under controlled conditions together with extra ash, soil and leaves. The period of time when the partly decomposed material is exposed is small. Once in the tree pit, the partly decomposed material is covered with a protective layer of topsoil (at least 150mm thick). The tree is then planted. Shrubs, herbs, tomatoes, pumpkins and other valuable plants can be placed in the pit if desired.

Tipping excavated shallow pit compost into a "tree pit" measuring about 60cm X 60cm X 60cm. The tree pit is almost filled with the toilet compost. Topsoil is added and a brick surround made. A hole is dug in the middle and a young tree is planted (Mulberry). Leaf mulch is then added and the tree watered. As the tree grows extra food is added in the form of compost, manure or diluted urine. Watering is important.

4. Digging into vegetable beds

Toilet compost can also be dug into flower and vegetable beds to enhance the nutrient content and humus levels. Mixed in roughly equal proportions for the upper 75mm of soil layers. When sieved toilet compost also makes a good potting soil. Seeds can grow in it!

Distributing and digging in pit compost onto an existing vegetable garden in Zimbabwe and Malawi.

7.3 Ways of using urine in the garden

Urine is a valuable supply of nitrogen and also phosphorus and potassium. It is particularly effective at enhancing the growth of green vegetables, tomatoes, onions, maize, herbs and many trees. Urine can be collected in bottles and containers or from urine diverting toilets. Urine is best diluted with water before application in most cases (3:1). On maize it is best applied neat, allow the rain to dilute it. Urine works best when applied to good topsoil rather than poor sandy soil. So it is best to mix compost (garden or toilet) to poor soil to get the best result from urine. Soil bacterial convert the urine nitrogen into a form of nitrogen that can be used by plants, a process that takes about a week. The use of urine is not familiar in the Zimbabwean culture and there is much resistance to its use. Careful educational programmes are required. People may only accept using their own urine and not the urine of others. It is possible to demonstrate the effect of urine in many ways. This may be a first step to acceptance of the idea. The following examples show what can be achieved.

Effect of urine application on Rape and Spinach

These photos show the dramatic difference in crop yield as a result of urine application to plants growing in 10 litre basins. In each case the same number of plants were treated or untreated. The treatment consisted of applying 0.5 litres of a 3:1 water/urine mix twice a week to urine fed plants. Control plants were watered only. Crop yield was increased five times in the case of rape and 3.4 times in the case of spinach. On poor soils the beneficial effects of urine application are even greater. However urine works best when applied to poor soil which is mixed with better soil or compost.

The effect of urine on maize

Urine can have a significant effect on maize growth. It is applied neat into hollows made near the growing plant during the growing season. This also coincides with the rainy season.

Effect of urine on maize planted in poor sandy soil. The plants on left were not fed with urine. On the right the plants were fed a total of one litre of neat urine applied weekly in 125mls doses during the growing season. The urine was applied with a pill bottle fitted with a handle. The rain diluted the urine.


The urine dispenser in bucket of urine. Applying to a hole next to the growing plant.

The application of a total of 1 litre of urine per plant doubled the grain yield of maize growing on poor sandy soil compared to unfed plants.

Another method of applying urine to maize grown on poor soil

This method may be valuable in back yard plantations of maize where hundreds of plants are being grown and not thousands as in larger maize fields. A source of water also needs to be available. For the best germination of seeds they must be planted in fertile soil. This means planting the seeds in a 400ml (tin measure) plug of compost placed in the soil at each planting station. This can be toilet compost or garden compost. Alternatively the seeds can be sown in good soil placed in seed trays first, then transferring the seedlings to the planting stations in the plantation. Which ever method is used the seeds or seedlings are best planted in a plugs of compost in each planting station in rows about 90cm apart and plants about 30cm apart in each row. The soil is dished around each plant.

The urine is diluted with an equal volume of water in a bucket. For instance a 2 litre plastic container of urine is diluted with the same container of water. A 125ml pill bottle with wire handle can be used as a urine dispenser. 125mls of the diluted urine is applied to the soil around each seedling. This is allowed to drain into the soil and is then flushed in with a further 400mls of water. This procedure is followed once a week during the life of the plant. Once a small cob appears the dose can be increased. This method will be described in more detail in later texts. The effect of the urine on maize growth is remarkable.

Diluted urine being applied to school garden in Chisungu School, Epworth, Harare using the method described above. The urine treated plants are easily distinguishable from the untreated plants. This method will be described in more detail in later texts.

The effect of urine on mulberry and tomato

Mulberry trees respond well to the application of diluted urine (as do banana). The mulberry trees shown here had periodic applications of urine and water added. As with all fruit trees, the application of potassium, in the form of wood ash, also helps. Tomatoes also respond well to urine. But because urine contains so much nitrogen in relation to phosphorus and potassium, there is a tendency for the plants to bear much green leave and less fruit. A healthy fruiting tomato also needs plenty of potassium. If the soil contains compost a balanced food can be achieved. Adding wood ash to enhance the supply of potassium is very valuable. Mulching with comfrey leaves helps or liquid comfrey, which contain much potassium.

Healthy mulberry fruit contains many valuable vitamins. The trees also respond well to the application of diluted urine and wood ash.

Healthy tomatoes can grow well when being fed with a urine water mix. In this case 400mls of urine mixed with 1200mls of water (3:1) was added once or twice a week. The vegetative growth is spurred on by the application of diluted urine and once the flowers develop also by the application of a liquid food made from comfrey leaves and urine added to water and allowed to liquefy. Roma tomatoes shown here on left are more resistant to disease.

The effect of urine on onion, green bean and cabbage

Onions, as well as most green vegetables respond well to urine. Healthy onions also need plenty of potassium. This can come from wood ash or leaf mulch. Comfrey leaf mulch or liquid feed is ideal.

10 litre basin planted with about 10 onion plants and fed a water/urine mix (3:1) twice a week for most of the duration of growth. The onions were mulched to reduce water loss.

Diluted urine (about 3 litres of 3:1, three times a week on a one metre diameter ring beam garden) also produced a good crop of green beans. Diluted urine also has a significant effect on the growth of cabbage. The right photo shows cabbage growing in basins two months after planting seedlings. The left basin is urine treated (400mls of 3:1, three times a week), the right basin was watered only. Many vegetables and plants like tomato, potato and beans also benefit from the application of comfrey with its high potassium content.

Effect of urine on spinach in ring beam garden

A total of 26kg of spinach was produced in this single ring beam garden within a year. The ring beam is part of a toilet system. It can also be used as a miniature garden with a diameter of 1 metre. Crops were reaped and weighed during the year. Old plants were replaced with new seedlings once during the year. Urine was applied at the rate of 800mls + 2400mls water (3:1,) twice a week, for several months and then for the rest of the year 400mls + 1200mls (3:1) twice a week. This is a high yield for such a small area of soil.

Comparing spinach yield with urine on poor soil

Photo showing ring beam of urine fed spinach on poor soil (in foreground) and spinach on the same poor soil but not fed urine behind. The application rate was 400mls urine + 1200mls water (3:1) twice a week. The yield after 3 months growth was 7 times greater in the urine fed plants.

Effect of urine on covo in ring beam garden

The vegetable covo growing in a ring beam garden. Poor topsoil taken from a peri-urban settlement (Hopley) was placed in each ring beam. About 30 seedling covo were planted in each ring beam. The ring beam on the right was fed with 4 litres of a water urine mix (3:1) twice a week (Monday and Fridays) after the plants had become established. The control plants on the left were watered only.

After several weeks, the unfed plants showed signs of nutrient deficiency. The fed plants grew much larger and greener. After 3 months 310gms of covo was reaped from the untreated ring beam and 1720gms from the urine treated plants, an increase in yield of about five times.

Once reaped leaves continued to be cropped from the plants and young shoots were transplanted to a bed nearby. Covo is a popular vegetable since it copes with water scarcity and new plants can grow from cuttings. It is also more resistant to rain and insects than some other green vegetables. It can be propagated from cuttings. Urine has a positive effect on the growth of many green vegetables. It is best diluted before use, 3 parts water to 1 of water being ideal.

7.4 Showing effects of urine on vegetables grown in poor soil in the school garden.

There is no better place to demonstrate the effects of urine on vegetables than in the school garden. Using the same ring beam gardens described earlier (one metre diameter miniature gardens surrounded by bricks) it is possible to demonstrate the effects of diluted urine on various vegetables and maize within a month or two. The chosen seedlings are planted within the ring beam (rape, spinach and maize, for instance) and watered. A few days later the application of diluted urine can begin. Within a one metre diameter garden 800mls of neat urine is diluted with 2400mls of water (3:1) and applied to the soil twice a week. Each garden is watered regularly in addition to the urine treatment. Within a few weeks the effect of urine treatment can be clearly seen. Pupils, teachers and surrounding communities were able to witness the effect. Where fertilizers are expensive or not available this method has great merit. This method will be described in more detail in later texts.

The effects are clear to see. Rape yield was increased 7 times, spinach 4 times and the increase in maize growth very significant. The untreated plants are on the left, urine treated plants on the right.

Effect of urine on Comfrey

Comfrey is a very valuable plant and a source of nutrients which are most valuable to the gardener. It is particularly rich in potassium which is valuable for growing many important crops like tomato, potato, onion and others. Comfrey is able to effectively remove nutrients from the soil and make them available in the leaves. Comfrey can be used as leaf mulch on vegetables. It can also be converted into liquid fertiliser by soaking broken up leaves in water and allowing them to liquefy over two or three week period The nitrogen content of this liquid comfrey can also be enhanced by the addition of urine. Comfrey is also an excellent food for rabbits and chickens. Comfrey also has medicinal properties.

Comfrey plants growing in toilet compost and enriched by the addition of urine diluted with water.

Chickens and potatoes together with many other crops benefit greatly by being fed comfrey.

Using urine in a high potassium liquid food made from Comfrey

Many plants benefit from a generous supply of potassium. It is essential for the best yields of fruit. The tomato is an example. If there is too much nitrogen, the plant will grow with luxuriant green vegetative growth, but the fruiting may be poor. Adequate supplies of potassium are also required to make a good nutrient balance which will aid fruiting. Comfrey is the best source of non-chemical potassium so far known to organic gardeners (Hills 1981). Comfrey is able to extract minerals from the soil and store in sappy leaves and thick stems that are also high in protein. Comfrey helps to make excellent compost and also a good “mulch” for plants. Comfrey can be grown in any part of the garden including ring beams, where various sources of organic minerals can be added (manure, urine etc).

Making the liquid comfrey

A large bucket, drum, container or other vessel is used to prepare the mix. The comfrey leaves chopped up and added at the rate of approximately 2kg per 30 – 40 litres of water. This is stirred and 2 litres of urine added. This is then allowed to ferment for about 2 weeks. Then an additional 2 litres of urine is added and the mix can then be used after stirring. It can be diluted with water – 3 parts water to 1 part comfrey liquor. A convenient mix is 2 jam jars comfrey mix (800mls) to 6 jars water (2400mls). Apply 400mls to a 10 litre container with tomato (etc) twice a week or 3200mls in a 1m diameter ring beam. This mix helps balance the potassium/nitrogen ratio. Potatoes and onions also benefit from comfrey liquor.


Chopped up comfrey in 35li bucket. Adding the urine.

Examples of the effect of urine on valuable food plants


Pumpkin fed diluted urine (4:1 mix with water twice a week). It is clear which had been fed the urine in both cases.


Classic photos of the effect of urine on maize – more urine more maize!


The effect of diluted urine on spinach and maize is dramatic. But trees also respond to urine treatment. On the right two young mulberry trees were planted in buckets using the same soil. The tree on the left was fed with a 3:1 mix of water and urine (400mls) three times a week, the tree on the right was fed with water only. Both trees were watered to keep healthy. The urine fed tree is growing more rapidly.

8. Summing up and conclusions

This book comes as a sequel to the earlier work entitled *“Toilets that make Compost”* in which low cost ecological toilets were described and what benefits could be achieved by the use of toilet compost and urine. Here the theme has been methods of upgrading the toilet.

This book reveals that it is possible to start very simple with basic building components such as a concrete slab and ring beam and in a series of upgrades use these same components to construct a range of toilets that can suit many different environments. The standard “starter” slab is made with a hole for the squat or pedestal hole and also a hole for the vent pipe (90 mm to 110mm diameter). Suitable slab sizes range from 0.9m to 1.2m. In simpler toilets the vent hole will not be used at first, and is plugged with a weak cement mortar mix until such a time that the upgrade of adding a vent pipe takes place. A series of matching ring beams can also be made to suit the slabs. Both slab and ring beam can be made with half a bag of cement (and river sand) or less. That is 10 litres of fresh cement (PC15) and 35 - 50 litres of river sand depending on slab ring beam size. That is 20 litres of cement or less than half a 50kg bag per toilet. If masonry cement is used 10 litres of cement can make a durable slab 1m in diameter. If the cement is old, or the sand of poor quality cement must be added in higher concentration.

The simplest basic starter toilet unit is an *Arborloo* built with a single slab and single ring beam and almost any structure which provides privacy mounted on top. Flies and smells are partly controlled by the addition of liberal amounts of soil and wood ash, a process which also promotes composting in the pit. Using this toilet as a starting point, a whole series of more sophisticated toilets can be built later using the same slab (and ring beam if applicable). A ventilation pipe can also be added to an *Arborloo* which makes it more pleasant to use. *Arborloo's* can make excellent low cost toilets which have many benefits including encouraging people to plant more trees.

By using an extra ring beam an alternating shallow pit compost system *(Fossa alterna*) can be built. Where ring beams are used to protect the pit, light and portable superstructures should be used. Also ring beams must be used on moderately firm soils.

By lining the pit with bricks and using a corbelling technique, the pit size and stability can be increased significantly without the need to enlarge the slab. So the same 1.0m or 1.1m diameter slab can be used.

This may be useful with the *Fossa alterna*, where extra capacity is required for larger families. The longer the pit contents can compost the safer the material will be at the time of excavation.

Both the *Arborloo* and *Fossa alterna* can be upgraded to variants of the VIP toilet. This upgraded demands that a ventilation pipe is fitted to the slab with a corrosion resistant fly screen fitted to its head. Suitable fly screen materials are aluminium and stainless steel. These materials will last almost indefinitely against corrosion. PVC coated fibreglass screens may last 5 years. Normal metal screens last only a year or so. The pipe can be placed within the structure, and this will be a necessity when the standard 1.0m or 1.1m diameter slabs are used. Vent pipes can be made of PVC (90mm or 110mm), asbestos, tin, and an array of home made pipes can be made as low cost.

The second requirement of the VIP toilet is that the superstructure has a roof and is semi dark within. If the structure has a door it must be self closing. Hinges made of car tyres are ideal and long lasting. Door-less spiral structures can also be built. Structures with no moving parts are more durable. Glass bottles can be fitted in brick walling to increase light.

The VIP toilet interior need not be as black as night. It can be made light enough to read inside comfortably. The requirement that it must be very dark is a myth. Neither should the pipe be made black – also a myth. It can be left the natural colour of grey or painted with any colours if that is desired. It can be made of reeds or cemented paper - there are many variants to pipe making.

A further upgrade is made by fitting a pedestal in place of the squat hole. This upgrade can also be made cheaply and easily using a little cement and a plastic bucket. Older people and those not used to squatting may fall over if they are not used to the squatting position. And reading in this quiet place is far more comfortable when sitting. A comfortable toilet may be our last refuse for some peace!

There is no requirement with VIP toilets that the pit is deep or lined with bricks and no specific design is required for the superstructure apart from the requirement that it must offer semi darkness. So shallow pits used with a ring beam with the *Arborloo* and *Fossa alterna* are perfectly acceptable and can be made into variants of the VIP by fitting a screened vent and suitable structure. They are all ventilated pit toilets.

With the normal deeper VIP toilet it pays to build the pit with the largest capacity possible. Using the same small slabs it will be essential to use the corbelling (stepping in) technique for the brickwork. In this way a small 1.0m slab can be fitted over a 1.3m diameter pit. Or even a 1.5m diameter pit which is 2m deep. A deeper 1.5m diameter pit 3m deep may last two decades for a family. The deeper and wider the pit the better, if pit excavation is not envisaged later on.

However wider pits which are not so deep can be made with a good working volume, yet offer a suitable environment for composting if sufficient soil, ash and leaves are added during the life of the toilet. To some it may make sense to use the VIP toilet in a different way. Not as a bathroom or site for garbage disposal, but as a composting unit, where the compost can later be dug out and used to fertilise the garden with the brick lined pit being “reclaimed” and used again. Using one 50kg bag of masonry cement it is possible to make a 1.0m diameter concrete slab and make the mortar to brick line a pit 2m deep and 1.3m wide. Using Portland cement, there would be sufficient cement to make the slab and brick up the pit even wider – from the same bag! When cement is scarce it is remarkable what can be built with a single bag!

The concept of urine diversion can also be embraced in this series. Using the same slab and 2 matching ring beams a vault can be built above the ground and fitted with a urine diverting squat plate or pedestal. If desired both these urine diverting units can be home made. Urine can be collected in a 20 litre plastic container and the solids (faeces plus soil and ash) can collect either in the vault or in containers like bags and buckets. The urine can also be piped around trees. Sacks of semi dried faeces and soil/ash can be removed and soil and leaves added and planted with useful plants like comfrey. The contents of buckets can be tipped into secondary composting sites like bags, jars or shallow pits and left to compost before use. The contents can also be tipped into “tree pits,” mixed with soil and leaves and a tree planted.

Many types of superstructure can be used. At first poles and reeds or grass can be used to make neat and effective structures for all the toilets described. Wood ash or old engine oil should be added to the holes made for poles to reduce termite attack. Traditional structures can be both neat and very effective.

If brick structures are built, they must be mounted over pits which are also lined with bricks. Steel frames structures which can be repeatedly covered with low cost replaceable materials like grass are valuable, but expensive at first. They can last almost indefinitely.

This series does not only encompass the construction of low cost toilets alone but also how to use the compost and urine produced to increase food production for the benefit of the family. So the toilets are processing units which can be put to good use as well as being sites for disposing of “human waste.” As we have seen human waste can actually be very valuable if processed and used properly.

The “ring beam” part of a toilet can be used as a miniature garden when it has composting material beneath it. The “ring beam garden” can produce an abundance of green vegetables, onion or tomatoes. All these valuable plants respond well to the application of diluted urine and can be used as a relish on our tables.

Coupled with health and hygiene, no toilet should be built without some form of hand washing device nearby. And these can be made simply and at almost no cost. They are worth their weight in gold, as far as the benefits they offer are concerned.

Local traditional methods and techniques must be used in the best way possible. This book outlined basic principles. Local innovators abound and their skill and thoughts must be used to embrace and expand on these principles in every country where these methods have application. A huge oasis of ideas waits to be investigated.

It is hoped that this book and those that preceded it will help put low cost sanitation more prominently on the agenda of donors and users alike. By making so many links with agriculture, trees and food production the eco-toilet offers a valuable facility in the environment where it can serve its users and the environment well.

Keep it simple. Use locally available materials and techniques to best advantage. They will be time tested and work well in the environment for which they were intended.

Try ideas of your own - experiment. Adapt and learn from others. Teach others what you have learned and what works in practice. There is no better learning environment than the home. The school also offers the most ideal learning environment in this discipline. Several of the photos shown in this book were taken in the school environment where school children were the active participants.

Listen to others – all folks have a story to tell. We can learn from them.

Use natural principles and logical ideas. Embrace Mother Nature and become her partner. If you hold hands with Nature, she will not let you down.

As the Navajo once said in their "Song of the Earth."

"I am indeed it's child.
Absolutely, I am Earth's child."

With beauty all around me, I walk
Navajo Night Chant

Bibliography

I have used the following books and references as a source of valuable background information in this text.

Balfour, E.B. (1943). *The living soil*. Faber and Faber. London.

Carson Rachel. (1962). *Silent Spring*. Penguin Books Ltd, Harmondsworth. England

Del Porto D. & Steinfield. C. (1999). *The Composting Toilet System Book*. Concord USA. Centre for Ecological Pollution Prevention. pp. 234.

Epstein, S. (1995). *Growing fruit trees*. Forestry Commission, Harare, Zimbabwe.

Esrey S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hebert, M., Vargas, J., Winblad, U.,(ed). 1998**.** Ecological Sanitation. Sida. Stockholm.

Esrey S.A. (1999)**.** Nutrition - Closing the Loop. *Proceedings of the Workshop on Ecological Sanitation. Mexico.* October 1999.

Esrey S.A. & Andersson, I., (1999) Environmental Sanitation from an Eco-Systems Approach. *Proceedings of the Workshop on Ecological Sanitation. Mexico*. October 1999.

Feachem, R.G., Bradley, D.J., Garelick, H., & Mara, D.D., (1983). Sanitation and Disease: Health Aspects of Excreta and Wastewater Management (London: John Wiley).

Hills, L. D. (1981)**.** *Fertility Gardening.* Cameron & Tayleur. London.

Hopkins, D.A. (1945)**.** *Chemicals, Humus and the soil.* Faber and Faber Ltd. London.

Howard, Sir Albert, (1943). *An Agricultural Testament.* Oxford University Press. London.

Jenkins, Joseph, C. (1994) *The Humanure Handbook*. Chelsea Green Publishing Co. PO Box 428, White River Junction, VT. USA.

Jönsson H. Stenström TA, Svensson J. and Sundin A. (1997). Source Separated urine - nutrient and heavy metal content, water saving and faecal contamination. Water Science and Technology, 35 (9).

Manson. T. (1975) *Tom Manson's* New *Garden Book.* Pioneer Head (Pvt) Ltd. Salisbury, Rhodesia.

Manson. T. (1991) *Tom Manson's Garden Book.* Roblaw Publishers, Harare, Zimbabwe.

Morgan, Peter R. (1990). *Rural Water Supplies and Sanitation*. MACMILLAN. London.

Morgan, Peter R., (2007). *Toilets that make Compost.* Stockholm Environment Institute.

Steinfeld, Carol. (2004). *Liquid Gold. The lore and logic of using urine to grow plants.* Green Frigate Books, Sheffield, Vermont. USA.

Stenström, Thor-Axel, (1999). Health Security in the Re-use of Human Excreta from on-site Sanitation. Proceedings of the Workshop on Ecological Sanitation. Mexico. October 1999.

Strauss, M. & Blumenthal U. J. (1990). Use of the human wastes in agriculture and aquaculture - utilization practices and health perspectives. IRCWD, Dubendorf, Switzerland.

Sykes, Friend. (1946). *Humus and the Farmer.* Faber & Faber Ltd. London.

Tompkins, P. and Bird, C. (1998). *Secrets of the Soil*. Earthpulse Press. Anchorage, Alaska.

Winblad U. & Kilama W. (1985) *Sanitation without water.* MACMILLAN. London.

Winblad U. & Simpson-Hebert M. (Editors). (2004). *Ecological Sanitation* – revised and enlarged edition. Stockholm Environment Institute.