An Ecological Approach to Sanitation in Africa

A compilation of experiences

Peter Morgan

(2004)

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Acknowledgements

The material presented in this text has been abstracted and edited from earlier materials written by the author, mostly in reports and a series of four books entitled *Ecological Sanitation in Zimbabwe.*

Many people have offered me support and encouragement during my personal venture into the world of ecological sanitation. In Zimbabwe I am much indebted to the staff of the Friend Foundation, in particular Mrs Christine Dean and Baidon Matambura for offering an excellent testing ground for prototypes. Marianne Knuth is much thanked for her support and enthusiasm in ongoing training activities at Kufunda Village Training Centre. Annie Kanyemba is also thanked for her most valuable assistance not only in construction, but also in grass roots training activity at Ruwa and elsewhere. Jim and Jill Latham of the Eco-Ed Trust are much thanked for teaching me about permaculture and organic gardening and also making available a valuable testing ground for more prototypes in Mutorashanga. Ephraim Chimbunde, Edward Guzha and David Proudfoot of Mvuramanzi Trust are thanked for their efforts in promoting eco-san in Zimbabwe. I also wish to thank Frank Fleming and Ilona Howard of Clinical Laboratories for the bacteriological testing of soil samples derived from various eco-toilets. I am most grateful for the help, encouragement and collaboration with WaterAid, particularly Ned Breslin in Mozambique and Steven Sugden in Malawi. These two countries have provided a source of encouragement and stimulation in the promotion of low cost eco-san. From Malawi I also wish to thank Mbachi Msomphora, Boyce Nyirena, Nelly Magelegele and Shadreck Chimangansasa from WaterAid, Twitty Mukundia and Jim McGill from CCAP, and Gary Holm and Elias Chimulambe from COMWASH, Thyolo. I also wish to thank Obiero Ong'ang'a and Kinya Munyirwa from OSIENALA in Kenya, for their support in Kisumu. Many thanks also to Mr Musyoki from the Coast Development Authority, Mombasa, for much help and encouragement. Many thanks are also due to Aussie Austin, Richard Holden, Dave Still and Stephen Nash from South Africa. The work in Maputaland was stimulating. Almaz Terrefe and Gunder Edstrom – thanks for the early enlightenment of eco-san – yours was indeed pioneering work in Ethiopia. Thanks also to Piers Cross and Andreas Knapp of the WSP-AF programme, Nairobi, for your interest and support of this work. From Mexico I thank Ron Sawyer, George Anna Clark and Paco Arroyo who have offered much advice and encouragement. I am most grateful to Xiao Jun from China for her valuable insights in pathogen studies. I also thank Jeff Conant, of the Hesperian Foundation, Berkley, California, USA, for introducing many of these eco-sanitation concepts into a new book – *Sanitation and Cleanliness for a Healthy Environment.* Uno Winblad is much thanked for his long experience and much advice and also for including the lower cost methods described here into his book *Ecological Sanitation*. Many thanks to Paul Calvert for his valuable insights and enormous encouragement from India. Many thanks indeed to Arno Rosemarin and staff of SEI, Stockholm, who have supported the research side of this work as part of the new EcoSanRes research programme. Your support and encouragement in this venture is much appreciated. Many thanks also to Håkan Jönsson for valuable comments on an earlier version of this manuscript and together with Björn Vinnerås for important inputs and advice on urine use and the agricultural perspective. I offer sincere thanks and much gratitude to the late and much missed Steve Esrey from the USA, who was the greatest believer in eco-san and "closing the loop." I wish to offer special thanks to a great friend and fellow traveller, Rolf Winberg, who has shown me much of East Africa and offered enormous support. I am constantly indebted to Ingvar Andersson, for his long friendship, support and personal encouragement, which has meant much to me over so many productive years. I also offer thanks to Bengt Johansson and his staff at Sida for their support which has made so much work including this venture into ecological sanitation possible. Finally and most importantly, to my wife Linda, thanks for your patience, encouragement and every other possible support.

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Harare
June 2006

1. An Introduction: understanding the concept of ecological sanitation

For most people sanitation means sitting on a toilet and flushing away the excreta to waste or simply sitting or squatting on a pit toilet and letting the waste matter build up in a pit. In both cases the excreta is disposed of and forgotten in the quickest and most convenient way. To be frank, this is an entirely logical view - there are far more important things to concern us all. But in a world which is becoming increasingly polluted from excreta, and where many of the world's population do not have access to a decent toilet at all, it does make sense to look at excreta in another way. The fact is that excreta can easily be made safe and contains valuable nutrients which can be used for enhancing the growth of food. And the methods of achieving this are not complex or expensive. On the contrary, they can be undertaken very cheaply, with great benefit to those who try.

Ecological Sanitation concerns the recycling of human excreta to form products which are useful in agriculture. Those who believe in ecological sanitation see the human excreta, not as a waste but as a valuable resource. And a resource which is renewed every day! To put it simply… *ecological sanitation is* a *system that makes use of human excreta and turns it into something useful, where the available nutrients can be recycled in agriculture to enhance food production, with minimal risk of pollution of the environment and with minimal threat to human health.*

In fact processed faeces can turn into excellent compost. This material contains a well balanced mix of nutrients, such as nitrogen, phosphorus and potassium, which are easily taken up by plants. Urine also contains a similar range of nutrients, being particularly rich in nitrogen, which makes it useful for feeding green vegetables and maize. Even a combination of urine and faeces, when mixed in a shallow pit, with soil, wood ash and leaves, can turn into a sweet smelling and fertile compost. This pit compost is quite unlike the original matter from which it was formed, and when mixed with poor soil can greatly enhance vegetable production. Such a conversion is nothing short of a miracle of Nature.

But there are problems. Human excreta is odorous and unpleasant in the extreme. The excreted products, particularly the faeces, are known to carry a multitude of pathogenic organisms which carry disease. For most people they are best disposed of and forgotten as quickly and as effortlessly as possible. That means the use of a flush toilet or a pit latrine - out of sight and out of mind. And for much of the world's population the flush toilet and the pit latrine must continue to form the basic form of excreta disposal for a long time to come.

But there is a growing concern about the use of ever depleting fresh water supplies to flush away such wastes, which can often lead to greater pollution "down the line." Where there is a lack of space, even the ubiquitous pit latrine cannot easily be emptied to form space for another. And even deep pit latrines eventually fill up and must be abandoned. The problems faced in high-density urban areas are the most pressing and also the hardest to solve. And for much of Africa, the cost of an improved latrine may also be prohibitive.

Perhaps the answer may lie in applying the principles of ecological sanitation. Now there is an extended range of options that can suit a wide range of users – from the very poor to those who are well off. Slowly but surely the concept of ecological sanitation is broadening and rising to help solve these serious problems.

There is also a concern that valuable nutrients are being lost, in vast quantities, every minute of the day by the disposal of excreta in conventional ways. The nutrients available in processed excreta are ideal for use on the lands and in vegetable gardens – and yet these valuable resources rarely come anywhere near our gardens in most parts of the world. Where flush systems are used they fertilise our lakes and seas instead of our fields, with dire consequences.

Shallow pit systems

Two of the three main toilet systems described in this book process the excreta in shallow pits. The third system separates urine from faeces and these two products are processed separately. The methods using shallow pits are simple and relatively cheap to construct, and are thus more suited for uptake in the poorer countries of the world, where pit sanitation may already be the standard method of excreta disposal.

This approach has been undertaken for several reasons. The world of ecological sanitation has been broadened to include very simple and forgiving methods which are similar (if not identical) in their use to the standard pit toilet – the most commonly used excreta disposal system in the world. These systems have been given names – the ***Arborloo*** (a simple pit -toilet in which a tree is later planted) and the ***Fossa alterna*** (an alternating twin pit toilet which forms compost). Such methods are, in this account, seen as introductory or entry points into the world of ecological sanitation and the recycling of human excreta. They are particularly useful and appropriate for use in parts of Southern and Eastern Africa. The urine diverting system is seen as an excellent but more sensitive concept – its success depending greatly on meticulous use and regular maintenance. Thus the range of options is expanded to include methods which are more forgiving and thus less sensitive to misuse. Also there is a problem of cost to consider. Urine diverting systems are more complex and costly to build and may be beyond the scope of the less well off, which on a continent like Africa, may be most. However, there are many ways of collecting the valuable urine other than separating it in a pedestal or squat plate. Urine can be collected in containers, bottles, potties and stored and later mixed with water for application to the soil. There is much flexibility.

Urine diversion

There are many ways of putting ecological sanitation into practice – and it starts off with the use of an appropriate toilet. A huge range of ecological toilet designs exist from the very simplest to the most complex. Most ecological sanitation programmes throughout the world use a concept known as 'urine diversion' to separate the urine from the faeces. The faeces accumulate in one place and the urine in another. A specialised urine diverting pedestal or squat plate is used for this purpose. These are designed for sitting or squatting. Both faeces and urine are much more easily handled when they are separated. The smell is much reduced, as is the potential for fly breeding, common to most pit latrines. The urine can be contained, and then later:

a. Diluted with water to make a plant food particularly rich in nitrogen, or
b. Applied undiluted to the soil and watered in, or
c. Applied to the land without dilution, and then left, before planting, for soil bacteria to convert the urea into nitrate nitrogen for later uptake by plant roots.

In most urine diverting toilets, attempts are made to desiccate and sanitise the faeces. Lime or wood ash (and often dry soil or sawdust) are used for this purpose, being added regularly to the faeces which accumulate in vaults or containers. The combination of desiccated faeces and ash or lime turns into an alkaline, sterile product which in countries like Guatemala is known as "abono." This inert and inoffensive material can be stored in bags and is often applied to the land as a soil conditioner. Being very alkaline it is good for acid soils. When it contains much ash, this will help to increase the potassium level of the soil. In its dry state it is certainly quite a safe material.

Most practitioners of ecological sanitation feel the greatest value of excreta lies in the urine, which contains most of the nutrients, and a very high proportion of nitrogen. They see the dried faeces as a secondary product of much reduced value. Some advocate digging it into shallow pits or burning it. But this book promotes the view that compost derived from biologically processed (as opposed to dessicated) human faeces is far too valuable to burn or to dig into holes which are then abandoned. In fact this compost has a far better overall balance of nitrogen, phosphorus and potassium than urine alone.

The ideal is to use a combination of both composted faeces and urine in our gardens, taking advantage of the best qualities of each. Much has been written on the subject of urine diversion and reference should be made to the bibliography at the end of this book. This book deals mainly with the almost unknown range of non urine diverting methods, since they have been little researched and written about before. One chapter in this book is devoted to urine diversion and another to urine and its use.

Upgradeability

The concept of being able to upgrade from one system to another is also embraced here. It is for instance possible to start in the simplest possible way with an ***Arborloo,*** and then upgrade to a ***Fossa alterna.*** This too can be upgraded later to achieve a fully urine diverting system, when the concepts of recycling are fully understood and appreciated. Thus urine diversion is a system to aim for in a step-by-step upgrading process. In all cases the primary aim of ecological sanitation is to recycle human excreta in a simple, safe and effective way. Whichever method is used, the results should be obvious to the users and useful to them. For without a true value being perceived from the user's point of view, the ultimate aim of ecological sanitation can never be realised. To form a convincing appreciation, the compost formed in the "eco-toilet" must be seen to enhance the condition of the soil and actually lead to greater production of vegetables, food crops and trees. The urine must be seen to make plants grow larger and provide more food. Without such evidence, people will not be convinced.

The management of ecological toilets must also be simple enough to be achievable. The extra effort involved in managing eco-latrines must be repaid many times over in the end result – and in most cases this simply means more food to eat or trees to use as fuel or to provide fruit. Without this return, in the eyes of the user, ecological sanitation can never attain the position it deserves.

Recycling – the central issue

Ecological sanitation embraces far more than building eco-toilets. The toilet is important but it is only part of the system. The toilet fits into a concept of recycling compostable materials within the homestead as a whole and plays its part in recycling biological wastes from the kitchen as well as the garden. Obviously the "eco-toilet" is a central component, but the system also includes the processing of human excreta into products which are safe and valuable in agriculture. The aim is to show that the nutrients held in processed human waste can be recycled in a simple, safe and effective way to increase the production of food (both vegetables and fruit). This is known as **"closing the loop."** That means that food is consumed, excreta formed, excreta converted into compost and that this product (together with urine) can be used to grow more food which is consumed again. That is closing the loop!

The **practical demonstration** of the usefulness of the by-products of human excreta in agriculture is seen as an important component of all ecological sanitation programmes. Consequently the crucial step of linking toilets with a method of producing compost or urine for use in agriculture (or forestry) must be emphasised. It is this very important management procedure which is vital to the success of ecological sanitation. In ecological sanitation, success depends on proper management, and thus depends on user participation to a far greater extent than conventional sanitation systems. It is no longer a case of sit and flush or squat and deposit. Ecological sanitation embraces a philosophy which the users must belief in and practice daily. Such an understanding and practice takes time to fulfil.

Forming links with agriculture

Ecological sanitation has come at a most important time, not least because it is able, unlike most other forms of sanitation promoted before it, to form direct links with other important disciplines. The need to improve top-soils in a world where most soils are poor and unable to generate good crops is an important consideration. On a small scale, ecological sanitation can greatly assist this problem. The compost resulting from processing human faeces makes an excellent "soil conditioner", admittedly not in huge quantities at the family level, but certainly sufficient to enhance vegetable production in the back yard. The aim is to mix the compost formed in toilets with infertile and worked-out soil, thus making a "new soil" in which plants can grow far better. The urine can also be used to enrich the soil further, particularly for growing green vegetables, maize and even trees. Those practising ecological sanitation should also be familiar with the methods of making garden and leaf compost so that all these fertile materials can be mixed to form an enriched soil suitable for planting vegetables and other useful plants. Such compost, when properly used in agriculture, helps to improve food yields considerably and hence provides more food security and improves the nutritional status of the beneficiaries.

It is accepted that gardening and home based vegetable production may not be important to all potential users of ecological sanitation. But in the context in which this book has been written, which is for use in the urban, peri-urban and rural areas of Southern and Eastern Africa, food production in the home can be an important issue, and is taken seriously by most families. However, as we shall see, eco-toilets can solve other problems related to conventional sanitation, not least the saving of water or ease of excavation of shallow pits.

Thus important links can be made between sanitation and the worlds of agriculture and forestry. And also of importance is the link to permaculture, where methods associated with the best organic farming are emphasised. Permaculture emphasises the use of natural methods, where organic materials of all types are used to make valuable soil. The miraculous change of human excreta into compost is one of Nature's marvels. Without this natural process of "building up" and "breaking down" no animal or plant life could exist on Earth.

The living soil – humus is important.

The message contained in this book sees the converted faeces as a product of considerable value and no less important than the urine. The soil is placed at centre stage as a converter of excreta into compost. The ideal is a mix of excreta, soil, ash and leaves, which, within a year turns into a valuable compost within a shallow pit. Even with urine diversion, the separated faeces, initially mixed with some wood ash and soil in the latrine, can be moved to a "secondary composting site" where additional soil and leaves are added. The end result is also a nutrient-rich compost, not a sterile dust. The converter is the "living soil," greatly assisted by the presence of leaves and ash.

Global considerations

Perhaps there are broader objectives too. Turning a renewable waste product like excreta into a valuable product in which plants of all types can thrive has considerable merit in its own right. Even more so, in a world overlaid by depleted soils and barren landscapes. Saving valuable phosphorus, a vital nutrient in plant formation, is also vital – for world supplies are being depleted at an alarming rate. Human excreta is a most valuable source of phosphorus, and also of nitrogen and potassium – all vital elements to food production.

Letting Nature work so effectively for Man has supreme merit. *Nature at work* lies at the heart of the message provided by this book. The conversions are natural - the growth of plants a natural response to the fertile soil. The soil organisms of all types, beneficial bacteria, fungi, worms and insects, are seen to be at work throughout the entire process. The nutrients resulting from this process can work well for the benefit of Man. Whilst these processes of Nature take place, for the most part out of sight and out of mind, in combination they represent a great movement towards improving the fertility of the Land - something of supreme importance for the survival of Mankind on a planet which is fast being depleted of its natural resources.

Compost toilet built above a shallow pit

2. The answer lies in the soil

The theme which is central to this book about ecological sanitation is its link to the soil. Soil with its complex makeup of living organisms and nutrients is essential for the formation of humus. Even the recycling of urine is linked to the soil, for soil bacteria are essential for the conversion of urea and ammonia contained in urine to the nitrate - a salt of nitrogen which can easily be taken up by plants. When a mix of soil, leaves and excreta are combined, the organisms in the soil help to break down the excreta to form a type of compost. The excreta in return offers additional nutrients to the soil and also improves the soil's texture. Adding urine increases the nutrient content further. So the living soil is central to the process.

The various latrine systems and recycling methods described in this book have been so designed that the excreta which accumulates is converted into compost which is readily used by a great variety of plants – whether they be vegetables, crops or trees. In the case of the ***Arborloo***, a shallow pit latrine which becomes a tree, compost formation is encouraged in the shallow pit by the regular addition of soil, wood ash and leaves. Once the pit is almost full, the structure and slab are removed and placed on top of another shallow pit nearby. The used pit is topped up with leaves and more fertile soil and a young tree is planted in this soil, watered and protected. It is planted in the soil – not the excreta – plants do not survive when planted in fresh excreta. If the fates are kind, the young tree grows, at first in the topsoil, whilst the excreta below is turning into compost as it would in Nature. In this way the nutrients held within the pit contents are utilised by the growing tree, and when the tree matures, can be recycled to produce fruit (fuel or building materials). Much of the urine is absorbed into the mass of compost or leaves held within the pit, and the excess will be drawn up into the surrounding soil and converted into usable nutrients – which the tree can also use later in its life. The ***Arborloo*** thus travels on a "never ending journey" through the "lands" followed by a series of trees which may eventually form a woodlot or an orchard – or just simply shade trees scattered here and there. Sometimes a young tree will hesitate as it starts to grow. A few may die, but most grow strongly right from the start if well cared for.

The *Arborloo is* the simplest ecological toilet. Photo at Eco-Ed Trust.

In the case of the ***Fossa alterna***, the second simple eco-toilet described in this work, a similar process takes place in the shallow pit, with soil, wood ash and leaves being added as well as excreta. But the structure, which is portable, alternates between just two pits, which are permanently sited. Once the first pit is nearly full, the structure is moved to the second pit and the first topped up with a good layer of leaves and topsoil. After one year the contents will have changed their form into nutrient-rich pit compost which can be dug out and used on the garden. The structure is moved back on to the emptied pit. It moves from one pit to the other once a year, every year – a process which is fully described in this book.

A *Fossa alterna* in Epworth, Zimbabwe. The twin pit system makes humus

In the case of urine diverting toilets where the urine and faeces are separated, the faeces normally accumulate in a vault beneath the pedestal and the urine collects in an offset plastic container. There are many descriptions of urine diverting toilets in the international literature (see bibliography at the end of this book, notably *Ecological Sanitation* by Esrey et al. 1998). In the example described in this book, known as the '*Skyloo*" the faeces accumulate together with soil and wood ash in a bucket held within the vault. The soil and wood ash are added after every visit made to deposit excreta. This mix of faeces, toilet paper, soil and wood ash is removed within the bucket and deposited in a "secondary processing site" where more soil and leaves are added. Here the mixture changes its form into fertile compost for onward passage to the garden at a later date. Human faeces readily turn into compost if they are in close contact with a fertile soil and some form of plant life – and are kept moist and are well drained and aerated. The aim is enable the soil to form layers within the accumulation of faeces to effect the change. The mix of faeces, soil, ash and paper and preferably leaves can be added to shallow pits, trenches or containers such as cement jars and covered with layers of fertile soil. The change in form from a most obnoxious, foul smelling mass into pleasant smelling humus-like material is quite remarkable. It takes place in nature all the time, in the forest, for instance, where the wastes produced by animals turn into humus on the forest floor together with leaf litter formed from the trees. All the nutrients formed are recycled back into the forest. Humus like material formed from human excreta is rich in nitrogen, phosphorus and potassium – all essential for healthy plant growth.

The importance of humus

Humus is the dark crumbly material formed from decayed matter formed in nature from a constant supply of residues from animal and plant life. These residues are constantly converted in nature by the organisms present in the soil and also in the residues themselves. Moisture is required during the whole period during which the humus is being made and also abundant aeration is essential. Even in Nature, if too much water is present, the aeration of the forming humus is impeded and the process slows down or stops. If too little water is present, the activity of the micro organisms slows down and then may cease altogether if the mass becomes desiccated. Desiccated leaves can remain unchanged for decades or even centuries – but when they are moistened they decompose readily. Rainfall is an excellent method of watering since it is a saturated solution of oxygen. The conversion of the various natural products into humus is a result of activity by beneficial bacteria and fungi and also by a myriad of other micro organisms and small animals. Bacteria are essential to this process. Most bacteria present in Nature are beneficial to life and present no health threat. In fact by far the majority of bacteria are essential to the natural process of breakdown. Without this process of breakdown, followed by re-growth, life on this planet could not exist. The soil is the home of millions of beneficial bacteria.

Jar with a mix of faeces, soil and ash after 4 months composting. It is just plain humus.

Humus is essential to soil fertility and adds an important physical condition to the soil, making it more crumbly, more moisture retaining and physically capable of greater oxidisation, which is essential for the growth of all living organisms including plants. The best humus is derived by mixing the soil formed from excreta with other humus like soils and plant material like leaf compost. Thus good humus can be built up, in a series of generations by adding and mixing. The earth worm, the bacteria, the fungi, and a myriad of other micro-organisms of a benevolent character whose habitat is the soil are important actors in this process. The only way to farm or to manage a successful garden is to maintain the fertility of the land by adding humus – thereby preserving the living content of the soil. That living content of the soil is best maintained by the constant refreshment of further supplies of life

in the form of humus. Everything we see in nature shows the greatest use of every type of waste. In fact nothing anywhere in Nature is allowed to go to waste. Recycling is a central theme in Nature. Ecological sanitation also promotes this ideal.
These views, well expressed by Friend Sykes in his book *"Humus and the Farmer"* and other promoters of the humus theory (Howard, 1943 and Balfour, 1943) make a lot of sense (see bibliography). Others promote the use of chemical fertilisers as the best means of obtaining adequate crop yields on the land. The probable truth lies somewhere in between, in striking a balance between using natural and artificial fertilisation (Hopkins (1945). This wise concept is also discussed by Louis Bromfield in his book Malabar Farm. In his studies of the land, Bromfield found that chemical fertilisers were of very little use on soils devoid of organic material and of great immediate value upon soils high in organic content. Studies revealed in this book also show that the same holds true for the application of urine to the soil. Urine adds only chemical nutrients to the soil and no living material. Bacteria in the soil are essential for the conversion of the urea present in urine into forms of nitrogen (nitrate) which can easily be absorbed by plants. So the use of urine as a plant nutrient depends very much on the soil and its living content to be effective. Soil containing humus is far more effective at processing urine than soil deficient in humus, such as very sandy soil. So once again, the soil plays a central role, even in the use of urine.

The capacity of chemicals to burn out crops or to destroy bacteria, earthworms and other living organisms in the soil, Bromfield found, was largely determined by the amount of organic material present and of the moisture content which accompanies its presence in the soil. Nothing was so effective in trapping and holding rainfall and moisture as organic materials in every stage of decay. Thus it would appear that the value of humus holds true, whether or not artificial fertilisers are added, in what ever form they are used. This must also hold true even where diluted urine is the source of liquid feed. Plants will respond better to urine if the soil is more humus like and has water holding properties. Thus the recycling of both solids and the liquids of human excreta much depends on the presence of humus - the living soil.

One major difference between the process taking place in the garden compost heap and that seen in our shallow pit eco-toilets or the production of humus from excreta in bags, buckets, jars or shallow pits, is the relatively larger proportion of "manure" (human faeces) and the smaller proportion of vegetable matter. Vegetable matter in abundance is vital to the "Indore Process" of composting promoted by Sir Albert Howard. With less vegetable matter being present in the humus formed in shallow pits and jars containing human excreta, there is little rise of temperature – as compared to the compost heap where significant rises of temperature occur. The conversion of excreta into compost in this case does not depend on the activity of heat loving (thermophilic) micro-organisms (bacteria and fungi) but rather those bacteria and fungi which thrive at ambient temperature (mesophilic), that is close to the temperature of the surroundings. All manner of other beneficial organisms, including insects, worms, and many other life forms also thrive best at ambient temperatures. Not only do these animalcules and microbes digest the excreta but also inhibit, compete with, consume or otherwise antagonise those pathogenic organisms, such as bacteria, that carry disease. The process is an entirely natural one leading to the formation of humus and compost. The addition of fertile soils and leaves to excreta also help to absorb much of the moisture content of the excreta itself – a process which is associated with a reduction of the volume of the mass. The end result of this process is friable darkened humus, which when mixed with topsoil makes an excellent soil conditioner and nutrient enhancer.

The conversion of raw excreta into compost or humus, in the presence of adequate volumes of soil, leaves and ash, reveals a change of colour, odour and texture of the original faecal matter, which darkens, becomes pleasant to smell and handle and also become more friable. The activity of insects and their larvae may also be important in breaking up the faeces as well as bacteria, fungi and earthworms where they are present. Roots from trees and other plants also invade the highly organic layers in the eco-pits or containers where excreta is converting, and are very visible when the pit is being excavated or the jar is opened. Where plants grow into the organic materials held in pits or containers, their roots also convey oxygen into the body of the material, which greatly assists the decomposition process. In Nature, all living organisms and their products eventually end up in the soil and become part of it, only to be recycled again and again within a never ending process of building up and breaking down.

These descriptions of the humus and the important part it plays in the fertilisation of the land, together with the capacity of urine to increase the amount and availability of some essential nutrients, are in my view, central to our own promotion of the eco-sanitary process.

The top soils of many parts of Southern Africa are worn out and almost devoid of humus or nutrients. In Zimbabwe 70% of rural farmers work on a soil which is labelled as poor or very poor, holding less than 42ppm of phosphorus. Nitrogen is being lost at the rate of 30 kg per ha. and applied at only 3 kg per ha – a net loss of 20 kg per ha. Even when nitrogen is applied, heavy rain can leach out the nitrogen and drive it down to deeper layers where it is not available to plants. Most naturally occurring soils where people live are not only deficient in nitrogen but also in phosphorus and potassium and also many trace elements. Nitrogen, phosphorus and zinc, amongst other minerals are seen as limiting to meaningful agriculture in 70% of samples collected around Zimbabwe. Most soils are sandy and have a low pH. Few soils in the rural and even peri-urban and urban areas can sustain any form of healthy crop growth without meaningful inputs of both humus and nutrients.

Barren soils are a common site in Africa but can be enriched by recycling human excreta. The photo on right shows a series of trees growing on *Arborloo* pits in Malawi.

Since the soils of Africa are so depleted in nutrients there is an overwhelming case for using all methods available to restore both nutrients and fertility. The use of animal manure is widely used in those areas where cattle are kept and this technique forms part of a long standing traditional practice. But the great majority of people do not own cattle. In a world where commercial fertilisers are becoming increasingly unaffordable, there is an even greater need to harness any other form of humus or nutrient suitable for crop growth. It is in this context that processed human excreta must be considered. Whilst the volume of excreta produced by a family is not large, it is certainly enough, once processed, to sustain a family vegetable garden and that should be the initial aim. This means taking full advantage of whatever humus can be processed, and also urine and combining their best properties to increase the food crop.

The successful use of the specialised toilets used in eco-san depends to a large extent on the users understanding of the processes involved, and the potential benefits to be gained. Compared to pit latrines, which can provide an almost maintenance free service for a decade, ecological toilets require more attention and the advantages may not be immediately obvious. A tree planted in an ***Arborloo*** pit may take a few years to bear fruit. Two years are required before the first humus can be dug out and used from the ***Fossa alterna*** pit. Thus sound educational programmes and novel forms of demonstration must therefore precede programmes of construction – with ample evidence of the benefits to be gained. Most people simply do not believe that excreta can turn into "soil." And this "soil" together with their own urine can save them money that would otherwise have been spent on buying fertiliser. One needs evidence to believe and that means individuals seeing the proof with their own eyes – "ahead of time." ***Seeing is believing!***

Teaching people about toilet design and construction and also the potential of recycling nutrients from human excreta is an important part of the educational process. Annie Shangwa teaching a group of trainees in Kufunda training Village in Ruwa, Zimbabwe. This important aspect of ecological sanitationand its promotion is described in a later chapter of this book.

3. Modifications of the pit toilet

Man's most commonly used toilet, the pit latrine, has been used in some form, on most continents for thousands of years. This concept continues to be the simplest, cheapest and most favoured method of excreta disposal for most of Africa, not counting the towns and cities. But even in the towns and cities, pit toilets are used a great deal. Their relative cheapness, together with ease of construction, use and maintenance make them popular. Problems of odour and fly breeding can be largely overcome by fitting a screened vent pipe, or by adding generous amounts of soil and ash to the pit. Indeed a properly made pit toilet can be as comfortable to use as the best of other conveniences, although of course it must be built outside and very close to ground level. For these various reasons more people use pit toilets than any other form of excreta disposal, world wide.

The pits under most pit toilets are invariably dug about 3 metres deep, although in Kenya they may go much deeper. Most times, pits fill with a mix of excreta and garbage – the pit toilet is a convenient dustbin! Some pits are lined, others not. Most pits are covered with a slab made of wood or concrete, and the house above, made in a thousand different ways, provides privacy. The worst pit toilets are a menace, generating foul odours of the worst possible type and breeding flies in alarming numbers. Those in high water table areas in the denser settlements can also pollute underground water, and wells polluted in such places can carry disease. However, well constructed pit toilets can be a pleasure and comfort to use. They can be odourless and fly free. Well sited, they are not a threat to health in any way. By far the best are those built and used by a family, where they are generally kept clean and tidy. The vast majority of pit toilets are used until their vaults are full, and then they are abandoned, and new facilities built.

But in some countries and some communities, the value of the pit contents as a fertiliser has long been known. In several countries in Africa, and indeed elsewhere, trees are deliberately planted on old toilet pits because they are known to grow well, with the fruits growing large and tasty. Sometimes nature sows a seed in an old pit and a new tree will grow. Sometimes tomatoes or pumpkins will grow out of abandoned toilet pits, no doubt because kitchen scraps have been thrown there. There are some cases where the contents of old pit toilets, after a period of a few years, are deliberately dug out and used as fertiliser on the lands. So in these rather more isolated cases, the usefulness of the pit toilet extends far beyond its normal life. This book attempts to extend the logic of this concept and make it better known and understood. The usefulness of the pit toilet can indeed be extended far beyond its normal working life.

Some basic concepts about pit toilets

Once faeces and urine enter a pit, a process of breakdown begins. The end result is what may be termed pit compost. If the pit is filled with excreta and garbage alone, the composting process can take many years to complete, since there is little air in the compacted excreta and few suitable microbes. If the excreta is mixed with other materials like soil, wood ash and leaves, more air is introduced into the mix and also a complexity of microbes which are able to change the excreta into compost more efficiently. The end result is that the composting process is much accelerated. This shows the important effect the soil and its living content has on composting excreta. Perhaps the word compost or humus is not strictly correct as they convey the impression that the material has gone through a process of decay either by a heating process, as in garden compost or by natural decay where a large amount of plant material is available. This is not necessarily the case with pit compost. However the use of the word compost (or pit compost) and in some cases humus has been used for simplicity and convenience. The process may be called ambient temperature composting.

The process is best undertaken in shallower pits. In deep pits the contents become more compact, and once again contain less air. In shallower pits, which are less compact, there will be more air, particularly if there is a mix of ingredients. This is particularly so if leaves are added to the mix in addition to soil. Leaves help to reduce the density of the final humus and therefore increase the air content, which in turn makes composting more efficient. Shallow pits are also easier to dig out and further away from the underground water table. The eco-toilets described in this book use shallow pits which are rarely more than 1.5 metres deep.

However, shallow pits do fill up more quickly then deeper ones and it is necessary to strike a balance. If a mix of ingredients is added, the pits will certainly fill up faster, but not as fast as one would think, as much of the bulk of excreta is in liquid form which is partly absorbed by the soil and ash thrown down the pit, and partly leaches away into the surrounding soil. At least 70% of human faeces is made up of water, and when mixed with soil, the volume of composted faeces is much reduced. Actively composting excreta significantly reduces in volume over time. So a balance must be struck and a choice made. Deeper longer lasting pits need less attention, but eventually fill up and are usually abandoned. Shallower pits holding a mix of composting ingredients fill up more quickly, but the resulting humus can more easily be dug out, and used for growing vegetables or for growing trees.

The processes involved are simple and natural, and if care is taken the composted humus is considerably safer than hands soiled after anal cleansing. The increase in food production can be considerable, as this book reveals. This process adds a new interesting dimension to the rather dull story of building toilets. The worlds of sanitation and agriculture are now combined with a definite benefit being gained by the family in addition to the disposal of excreta alone. Food production can be enhanced. Also the eco-toilets, as they are best called, are relatively cheap and easy to make. With a little training it can all be done by the homesteaders themselves.

In this book we look at ways of building and managing the various simple eco-toilets designs. Then the important subject of using the recycled materials in agriculture is discussed and explained in detail with many working examples described.

Simple eco-toilet in Malawi.

4. The Arborloo - the single pit compost toilet.

The simplest of ecological toilets is called the ***Arborloo,*** the toilet that becomes a tree. But it differs in several fundamental ways in its design and the way it is used from the commonly used pit toilet.

A**ll the parts of the ***Arborloo, apart from the pit, are portable. This includes the “ring beam” protecting the pit head, the concrete slab and the superstructure. Each of these components moves on a *“never ending journey”* from one pit to the next at about 6 -12 monthly intervals. The toilet is literally picked up and moved, leaving the almost filled pit behind.

* ***Arborloo*** pits are shallow, - normally no more than one metre deep and they are not lined with bricks or other materials. The pit is normally protected at the head with a “ring beam” made of bricks or concrete which strengthens the pit head and reduces the effects of erosion and pit flooding from rainwater. In very sandy soils, a 200 litre drum may be used to make a pit lining. If the soil is very firm, no ring beam is required at all from a constructional viewpoint, but it helps to raise the toilet foundations on a ring beam to stop pit flooding during the rains.

*****Soil, wood ash and leaves are added regularly to the pit in addition to excreta. These aid the composting process considerably. The remarkable conversion from excreta into pit compost is normally complete well within 12 months of closing off the pit. The addition of soil and ash on a regular basis also reduce fly and odour nuisance.

* The ***Arborloo*** pit is NOT used as a dumping ground for rubbish like most pit latrines. The dumping of plastic, bottles and rags etc, is not recommended.

An *Arborloo* in Phalombe, Malawi

Once the latrine has been moved to the new site, a layer of leaves and fertile topsoil between 15cm and 30cm deep is added to the contents of the pit, which are first levelled off. The pit contents can be left for a month or two or more to settle or can be planted with a young tree straight away. Some people prefer to leave the day of tree planting until after the arrival of the rains. This is a wise move if water is scarce. But it is also possible to plant the young tree directly after topping up with soil. Trees will not grow in raw excreta - they must be planted in a good layer of soil placed above the excreta. Within a few months the layers containing the excreta will have changed into compost which the tree roots can then start to invade. So in effect the old latrine site becomes a site for a tree. Most trees will grow well in these shallow pits if planted properly and cared for. The young tree should be watered regularly, and protected from animals like goats and chickens like any other young tree. Covering the surrounding soil with “mulch” helps to retain water. With a combination of excreta, soil, ash and leaves in the pit the pit contents turn into compost which most tree roots can cope with easily and later will thrive on. Later on diluted urine can be used to provide additional nutrients.

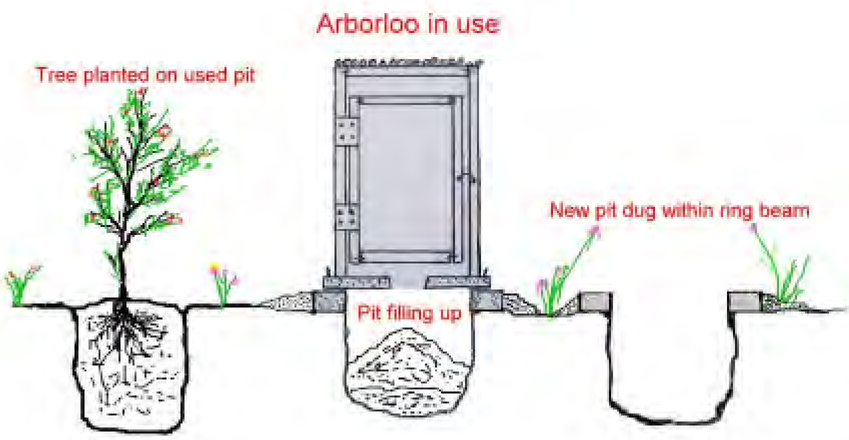
The ***Arborloo*** fulfils all the basic requirements of ecological sanitation. The recycling of human excreta is made as simple and convenient as possible. Natural processes are involved in a way that retains a simplicity of method and flexibility of design. The latrine is safe from a health point of view - the excreta is never touched by hand and contained below a layer of leaves and topsoil. Thus contamination of the environment is minimal. The pit is shallow and thus further away from ground water than any conventional pit latrine. The excreta (faeces and urine) combine with the soil and other ingredients to form pit compost which becomes an ideal medium for tree growth. Thus the odorous and potentially dangerous raw excreta are converted far more quickly into compost than in “deep pit” latrines. The combination of human excreta and soil, ash, leaves etc greatly enhances the nutrient levels found in the parent soil. This applies to all soils - whether they are rich or poor. The compost formed is more crumbly, with much elevated levels of all the major nutrients like nitrogen, phosphorus and potassium, which the trees can use. The ability of the “new soil” to retain water is also enhanced. Urine added to the pit is either absorbed into the pit compost or leaves or soaks into the side walls and base of the pit where some of its nutrients (particularly phosphorus) become available later, when the tree roots penetrate the soil. As the tree grows it absorbs more and more of the nutrients laid down earlier. Over time some nitrogen is lost, but this can be applied later with diluted urine.

The ***Arborloo*** also provides an excellent example of how the nutrients derived from human excreta can be recycled through the production of food - in this case fruit. The concept of “closing the loop.” is well demonstrated. The fruits eaten from trees grown on older ***Arborloo*** pits, once processed by the human body, are reintroduced back into the ***Arborloo*** pit currently being filled. Over a period of time “woodlots” of gum trees or “orchards” of fruit trees will result and the general fertility of the land is improved. Trees also offer shade, leaf compost and stability to the soil.

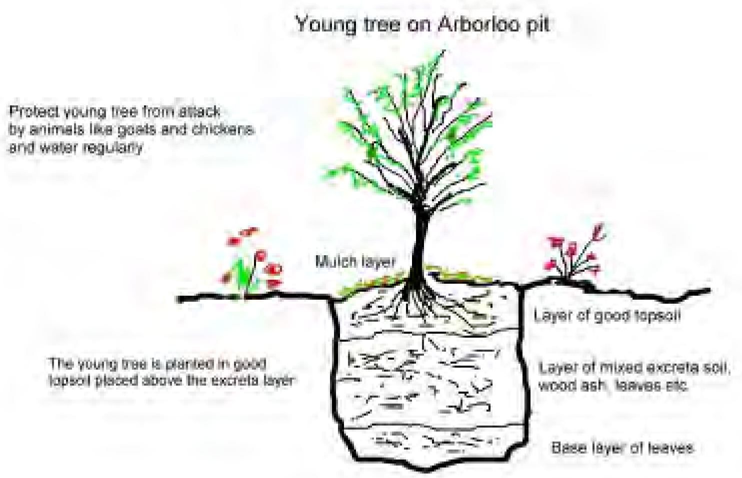
Remarkably, the mixing of barren topsoil and human excreta, results in a mix with enhanced nutrient value. If a fertile soil and leaves are also added, the resulting mix is even richer. It is into these soils that the tree roots will eventually grow. Tree growth into the pit contents represents only the first stage of root invasion - it continues into the surrounding soil which will also be nutrient enriched to a lesser extent.

Not surprisingly, a similar method of processing human excreta, has been used in the African traditional way of life for generations. In countries like Malawi, Mozambique, Kenya and Rwanda, villagers traditionally plant trees on disused latrine pits. And even nature uses the same principle - often the seeds of trees fall into disused and abandoned pits and germinate there. What better means exist to show that even human excreta, once changed into humus, can be an ideal medium for tree growth. The ***Arborloo*** is a refinement of this simple and well established principle. The physical structure of the latrine is designed to be portable, unlike more conventional latrines. Also the shallow pit is fed a mix of ingredients, deliberately, to ensure a more rapid conversion of excreta into pit compost and thus a better survival and growth rate of trees.

In practice the latrine is used until the pit is nearly full, which for a family should be between 6 and 12 months. Once the pit is nearly full, the structure, slab and ring beam are removed and the ring beam is placed on another suitable site nearby and a new pit dug within the beam - about one metre deep. The slab and superstructure are now placed on top of the beam and the latrine is put to use once again. The family may start off by using the toilet in any convenient place, but may then decide to place it within a specific piece of land set aside for an orchard or wood lot. Gum trees grow particularly well on these organic pits. However fruit trees are generally far more popular. In Malawi, citrus trees like orange and tangerine are the most popular trees because they have a commercial value.



The *Arborloo* moves on a never ending journey leaving behind a series of fertile pits filled with a mix of human excreta, soil, wood ash and leaves etc which provide a suitable planting medium for trees when composted. Nutrients in the excreta are used by the tree to enhance its growth.



The *Arborloo* - Stages of construction

Now we shall describe how to build and manage the simplest eco-toilet – the ***Arborloo***. The basic building components of both the ***Arborloo*** and ***Fossa alterna*** are the same, but the ***Arborloo*** is built with a single shallow pit about one metre deep in a temporary location. The ***Fossa alterna*** is built with two shallow pits which are deeper (1.2 – 1.5m deep), wider and permanently located. Generally ***Arborloo*** slabs and pits are made round to suit a more traditional type of structure, and ***Fossa alterna*** slabs and pits are made rectangular. But in fact whilst the building components of both these eco-toilets are basically the same, there is much variation in the way they are built. There are four basic components:

1. The shallow pit or pits
2. The component protecting the shallow pit (concrete or brick ring beam or brick lining)
3. The concrete slab
4. The "house" (superstructure).

To this can be added additional components like pedestals, vent pipes or hand washing facilities, which are optional additions. Low cost pedestals can be made very attractive by using standard plastic toilet seats in combination with a off-the-shelf 20 litre buckets. The method is described later in this book. Vent pipes (PVC or asbestos) help to ventilate the pit, providing a throughput of fresh air as well as removing odours from the toilet. Vents also remove excess moisture and condensation from the pit and composting materials. Hand washing devices attached to the toilet are essential if personal hygiene is to be improved.

Which slab and ring beam?

The ***Arborloo*** is normally made with a small round concrete slab and matching ring beam made of bricks or concrete. But there is much variation in the size and shape. Slabs and ring beams for the ***Arborloo*** can also be made rectangular (see chapter on ***Fossa alterna***). If a rectangular portable superstructure is to be used, the rectangular shape is preferred. If traditional poles and grass are to be used, the round shape may be better. Each has its advantages and disadvantages. Round slabs can be moved by rolling them, which can be a big advantage. This means that for the one metre diameter slab (and matching ring beam) a single person is able to move the slab and ring beam to the intended toilet site. Rectangular slabs and rings beams cannot be rolled so they need at least two people, and normally four persons to lift and move them. But rectangular pits are easier to dig and excavate than round pits. The pit linked to the one metre diameter slab is about 80cm wide, and this is not so easy to dig and re-excavate compared to the rectangular pit which provides more room for using the digging tools, and in the case of excavation, also for repeated excavation.

There are advantages in using a rectangular slab together with a rectangular movable superstructure. The superstructure just sits on top of the slab. The structure need never touch the surrounding soil and this can have its advantages. If part of the structure is made of timber, the termites are less likely to eat the wood if it is sitting on a concrete slab compared to being part dug in the ground. With round slabs, the structure is normally built around and outside the slab. This means that the soil must be raised around the slab. Generally round slabs are best for simple structures made from poles and grass.

Then there is a question of economy. A high strength round slab made with cement and river sand can be made one metre in diameter using ¼ bag of cement (10 litres) and 30 litres river sand (1:3) and 3 - 4mm reinforcing wire. This is a very strong and relatively light weight slab. It can be moved after 7 days of curing. The same size slab can be made with a mix of 5 litres cement (1/8th bag) and 30 litres river sand (1:6) and 3 – 4mm reinforcing wire. But in this case the cement and sand must be of the highest quality and great care must be taken at every stage of construction. 10 days of curing is required for this "economy slab." If care is not taken the economy slab will crack. If care is taken, it is as good as the high strength slab. The larger 1.2 metre diameter round slab can also be made also with 10 litres of cement and 50 litres river sand (1:5) and 3 – 4mm reinforcing wire. A 1.2m X 0.9m rectangular slab can also be made with the same mix of ingredients (see later). 8 litres of cement is provided in the "Compost Toilet Starter Kit" and is mixed with 30 litres river sand to make a 1metre diameter slab (see later).

The concrete ring beams linked to these various concrete slabs are made with the same mix of materials (cement, river sand and wire) as the matching slabs. All these alternatives are described in this book.

The ring beam is valuable since it helps to stabilise the head of the pit. In very loose sandy soil a ring beam may be inadequate, but in most places it works well. To lower costs ring beams can be made of local bricks. These can be mortared together with weak sand and cement for the ***Arborloo*** since they will be moved every 6 – 12 months. Termite mortar or clay can also be used to mortar the bricks together. Where the ring beam is made for the ***Fossa alterna,*** it will remain in position for long periods of time. So if it is made of bricks it is best mortared together with strong cement mortar. A concrete ring beam is ideal for the ***Fossa alterna***. If the soil is very loose and a ***Fossa alterna*** is chosen, then the shallow pit (dug down 1.2 – 1.5m) should be brick lined to the base.

Upgradeability

Since this concept of making humus in shallow pits for growing trees and vegetables is still evolving, there is still room for various ways of doing things. A family may decide to start by building an ***Arborloo*** using a one metre diameter slab and bricks as a ring beam. This slab may use a quarter bag of cement (or even an eighth of a bag with care for the economy model). Then the family may decide to make a concrete ring beam later. If well made, the concrete work will last almost indefinitely – it is just moved from one location to the next – there is no need to reconstruct it every time the toilet moves – and this can be an advantage. Then, later on, the family may choose to use the pit humus for use in the vegetable garden rather than grow trees. In this case the family can make two extra ring beams of bricks or concrete and rotate the toilet around the three permanent toilet sites and excavate the humus after one year of composting. Even the toilet which uses one slab and three rings beams will use only a single 50 kg bag of cement for the high strength concrete version or half a bag for the economy model. But care is required with using economy concrete. It must be made and cured properly with quality sand and cement. Otherwise it may crack, which is not such a good idea on a toilet. The family may decide to grow trees some years and make humus in other years. The options are open and available.

Protecting the pit – ring beam and brick linings

If the soil is firm and a light superstructure is used, and particularly for the ***Arborloo,*** it may not be necessary to protect the pit at all, since it will be used for a limited period of time (up to 12 months) and the chances of collapse are minimal. However, it is always best to lay the concrete slab above ground level to avoid erosion due to surface water flowing during the rains. Composting does not work very well in very wet conditions and it is best to avoid pit flooding. So it is desirable to build a ring of bricks around the rim of pit, on which the slab is mounted. Such a ring of bricks is called a “ring beam.” But not all ***Arborloos*** are built with them.

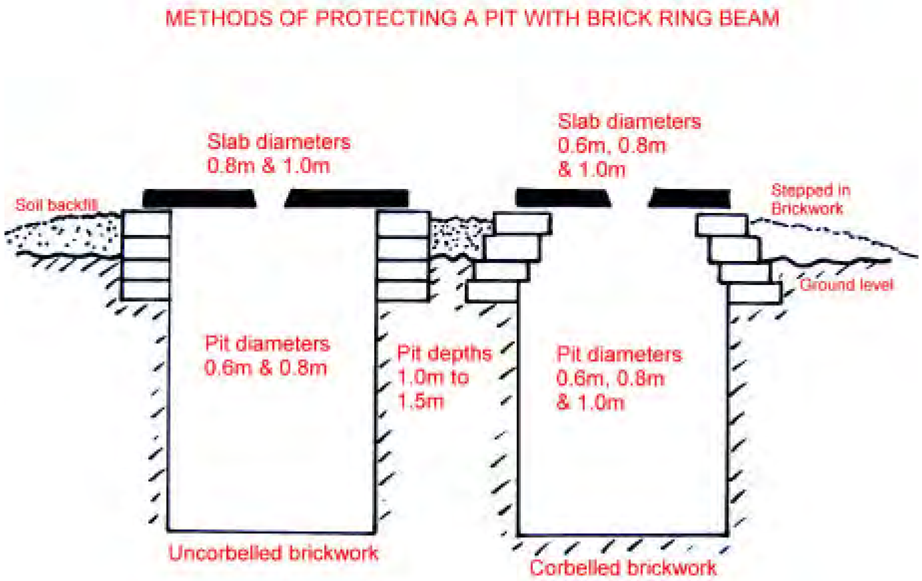
These *Arborloos* built in Embanweni, Malawi, where the soil is firm, do not have any form of pit protection. The 0.8m diameter concrete slab is laid directly over a 0.6m diameter hole and the simple superstructure built on top. The pits are dug about 1.0m deep.

In most other cases where the structures are made of light traditional materials like poles and grass, it is best to mount the concrete slab on a “ring beam.” This raises the slab above ground level and helps to reduce the chances of pit flooding during the rains and also stabilises the whole unit. This is true for both the ***Arborloo*** and the ***Fossa alterna.*** In most cases where the soil is moderately firm and stable, and the superstructures are not made of bricks, the ring beam may be all that is required for pit protection.

Only when the superstructure is heavy and built with bricks, must the pit be fully lined with bricks. But since most of the toilets described here do not use bricks, they do not require fully lined pits. In any case the ***Arborloo*** will rarely be made of bricks and is relocated once or twice a year and the pit may need little protection unless the ground is soft. In most cases a “ring beam” which is constructed in a round or square shape is made up of bricks or concrete and built around the pit head. Or rather the other way round! The ring beam is made first on the site and only then is the pit dug inside it. Then the slab and structure are mounted on top. There are several ways of protecting the pit with a ring beam.

Brick ring beams

These can either be made round, square or rectangular depending on the slab shape chosen. If made of bricks, it is often best to cut down into the soil about 0.3m and dig out an area large enough to lay cement or termite mortared bricks so that the internal measurement of a round pit is at least 0.6m across. The bricks are built up from beneath ground level and then at least one course above ground level. Ring beams for the ***Arborloo*** do not need to penetrate the earth so far, because the toilet will not remain in the site for more than one year. Many ring beams made for the ***Arborloo*** in Malawi are made to support slabs which are only 0.6m in diameter, but one meter diameter slabs can be placed over slightly wider pits which last longer.



The arrangement of slabs and upper brickwork protection of circular pits. The brickwork can be constructed vertically upwards or "stepped in" a little at each course (corbelling). The corbelling method is more complicated but allows for a slab to be added which is the same diameter as the pit. This is useful, as a slab of a particular diameter can be fitted on a wider pit with greater volume.

Arrangement of brick "ring beams" for the *Arborloo*

Arborloo pits in Malawi are dug round, and using a 0.8m diameter slab the pit is about 0.6m in diameter and about 1m deep with straight sides. The ring of bricks is cement mortared around the rim of the pit, preferably cut down into the softer topsoil and built up to at least one course above ground level. If a 0.8m diameter round slab is placed on top, the ring beam will give 10cm of support all the way round. If a 0.6m diameter slab is used, the pit can be dug to the same diameter, but the layers of brickwork in the ring beam must be stepped in (corbelled) to give sufficient support for the slab. If a 1m diameter slab is used, the internal diameter of the pit and ring beam (without corbelling) can be 0.8m diameter. A 1m diameter pit can be held up by a corbelled ring beam on a pit 1.0m in diameter. With less experience avoid the use of corbelling and use a 0.8m diameter slab mounted over a 0.6m diameter pit or a one metre diameter slab mounted over a 0.8m diameter pit.

The left picture shows the arrangement of bricks in the corbelled (stepped in) method of making a ring beam to protect the pit in Malawi. In the case shown four courses of bricks have been laid. Two courses are laid end to end around the pit and two courses with the bricks laid radially. This provides extra strength. The bricks are best bonded with cement mortar or traditional mortar made of special soil cut from anthills or from other sources. The brick protection usually starts beneath the ground and rises above ground level. On the right a concrete slab is mounted over the ring beam of an *Arborloo.* In this case both the pit and the slab are 0.6m in diameter. The pit was 1.0m deep below ground level. Soil cut from the hole is then placed back around the ring beam up to slab level and the structure then built on top. This makes a stable unit.

Another case in Malawi showing corbelled brickwork protecting a shallow pit of an *Arborloo.* Once again the diameter of both the pit and slab is 0.6m. Here the poles for the structure have been mounted in the ground before soil from the pit soil is placed back around the brickwork up to slab level.

A brick ring beam being built at Kufunda training centre, Ruwa, Zimbabwe. In this case two courses of bricks are laid on top of each other without any corbelling as this is considered easier for villagers. The bricks are mortared with local ant hill soil which resists erosion. The 0.8m diameter hole is dug inside the ring beam and the soil placed around the ring beam and rammed in place. The 1m slab is then fitted.

Making concrete ring beams

Making toilet components in concrete is usually a good investment. If well made and cured, concrete lasts for decades, and its services can be relied on for generations. Thus a well made concrete ring beam (or two in the case of the ***Fossa alterna***) should last indefinitely if cared for, and will not require reconstruction. This also applies to the slab which should always be made in concrete.

The concrete ring beam can be used in both the ***Arborloo*** and the ***Fossa alterna***. The ***Arborloo*** will use one ring beam, the ***Fossa alterna,*** two ring beams. This system of construction is used in some parts of Zimbabwe and ring beams and concrete slabs are either round or rectangular in shape. Normally round ring beams are used for the ***Arborloo*** and rectangular ring beams for the ***Fossa alterna***, but these are interchangeable. Larger ring beams use more cement but protect wider pits which have greater volume and last longer. The volume of a 1m diameter pit (using a 1.15m diameter slab) is 1.5 times the volume of a 0.8m diameter pit (using a 1m diameter slab). The 1.15m diameter slab uses only 2 litres more cement (10 litres) compared to the 1m diameter slab (8 litres). This small increase of cement use (for both the slab and the ring beam) must be seen as good value for money when equated with the extra pit life (1.5 times). Descriptions of how to make smaller and larger slabs and matching ring beams now follow.

Making a small round concrete ring beam for use with 1m diameter slab.


In this case a concrete ring beam has been made in a circular shape with a mix of 10 litres cement and 30 litres quality river sand. The mould is made from bricks over a plastic sheet. For the inner ring of bricks a mix of full and half bricks has been used. Spaces between bricks in the inner ring have been filled with segments of stiff plastic. The inner diameter of the concrete ring beam is 85cm and the outer diameter 115cm. This provides for a ring beam width of 15cm all round. Half the mix (5 litres cement mixed with 15 litres sand) is made up first and added between the two brick rings. Then one circle of 4mm wire is placed on the cement midway between the bricks. If in sections the ends of the wire should be slightly bent.


The second half of the full mix is then made up and added to the mould and smoothed off with a wooden float. Two handles are added, one at each side of the ring beam. The beam is then covered with plastic and left overnight. The following morning it is watered down, covered and kept wet for another 10 days before being moved. The fully cured ring beam is then taken to the toilet site and placed on the ground and levelled off. A hole is dug down within the ring beam down to a depth of between 1m and 1.5m. The removed soil is placed around the ring beam and rammed in place (right photo). The matching 1 metre diameter slab can now be fitted (see below and later). This is followed by the construction of the superstructure.


The one metre diameter slab fitted to matching ring beam.

Making a concrete ring beam with 1 metre internal diameter.

(for use with 1.15m diameter slab)


Lay plastic sheet on ground and make 2 circles of bricks. The concrete for the ring beam is laid between the two circles. The inner diameter should be 1 metre, the outer 1.4 metres. This makes the width of the ring beam 20cm. Pre-cut sticks can be used to make the measurement .


Make up a mix of 10 litres cement and 50 litres clean river sand and mix into concrete. Add half the mix to the brick mould and level off.


Add two complete circles of 3mm wire on the concrete. Then add the remainder of the concrete mix and level off with wooden float. Cure in the same way as concrete slab. When slab and ring beam have cured, move both on to toilet site. Place the ring beam on levelled ground and dig pit. Heap and ram soil around ring beam. Place slab on ring beam on bed of weak mortar.

Concrete slabs

The concrete slab is an essential part of any toilet. Once well made and well cured it should last almost for ever. So it is worth investing in the cement and good ingredients right from the start. Once a good concrete slab has been made, it can be fitted on various types of toilet including the ***Arborloo*** and ***Fossa alterna.*** The ingredients are fresh cement, clean sharp river sand and some 3 – 4mm diameter wire for reinforcing. Even better if granite chips can be found to mix with the sand, but it is not easy to find in most rural locations. The cement should be fresh, since over time its ability to make good concrete does fall off. Also the type of sand is important. Pit sand dug out of the ground will not do. Clean river sand taken from the river and washed is best. It should have a range of sizes of sand including some chips and very small stones. Also some reinforcing wire is required. It does not need to be thick steel bar. It can be wires between 3mm - 4mm in diameter. 3mm wire is fine. Concrete slabs are cast in a mould which is normally made of bricks or wooden planks depending on the shape. It is best to lay the concrete over plastic sheet, as this retains the ingredients and helps to improve the final strength The wire is placed inside the concrete half way up, so half the mix is added to the mould first, the wire is added, then the final part of the mix is added and smoothed down with a steel float. A hole is made for squatting and a special mould is required for this. It also helps to add handles, made from lengths of 8 - 10mm steel bar. These make lifting the slab easier. A most important aspect of making concrete is the curing. Concrete sets quite quickly and within a day can be quite hard. But it takes much longer to develop strength. The concrete cannot develop strength if it is allowed to dry out. So a curing slab must be kept wet at all times. Also the longer the curing time, the stronger the slab will become. So it is best to keep the slab wet and cure for at least a week before it is moved. For the more economic slabs using a 6:1 mix, 10 days curing is recommended. It is also best kept the slab under a plastic sheet or at least under a layer of wet sand to keep it wet. If properly made, a well cured concrete slab will last indefinitely. It is a good investment in money, time and effort.

Concrete slabs are a very important part of the structure of all pit toilets. They are not difficult to make if the simple constructional details are followed. Making concrete components is a very good way of investing money for the future. If well made, concrete lasts almost for ever. Here school children make a concrete slab in Mombasa, Kenya

Making round concrete slabs

Round slabs suit the ***Arborloo*** and ***Fossa alterna*** principles very well. Very often round slabs are made in a dome shape in Malawi without reinforcing. But concrete slabs are easier to make flat with a little reinforcing. Reinforcing wires (3mm) are generally available in most local hardware stores. Some of the new generation round slabs are also made with handles for use in eco toilets so that the movement of the slab from one location to the next is made easy.

Making a strong 1 metre diameter round concrete slab


The mould is made from bricks laid on plastic sheet. This slab is 1 metre in diameter and made with a total of 10 litres cement (quarter bag) and 30 litres quality river sand. Four pieces of wire 3 - 4mm in diameter each 90cm long are used as reinforcing. The mould for the squat hole is placed slightly to the rear of centre. The same size slab can also be made with a weaker mix of 6 litres cement and 30 litres quality river sand (5:1). In this case the construction and curing must be undertaken carefully. 10 litres of cement mixed with 50 litres river sand can also be used to make a 1.15m slab (see below).


Half the mix is made first with 5 litres cement and 15 litre river sand in a wheelbarrow. The concrete slurry is added to the base of the mould and distributed evenly over the whole surface. The four wires are then added as shown at right angles to each other.


Another mix of 5 litres cement and 15 litres river sand is now made up as before and added to the mould over the wire reinforcing. The concrete is levelled with a wooden float and then finished off with a steel float. Two handles are placed on either side of the squat hole to make picking up easier and more hygienic. 10mm steel bar is best for the handle if it is available. The concrete is left overnight and the following morning watered down and then kept wet for about7 days. The slab is only 32mm thick, and relatively light to pick up or roll into place. The 3:1 mix is a very strong one. This slab is made to fit over the circular concrete ring beam shown earlier or over a ring beam made of bricks.

Making a 1.15m diameter slab for a 1m diameter pit.


Lay a plastic sheet on level ground and lay bricks in circle 1.15m in diameter to make a mould. Add a shaped bucket or bricks to make the squat hole.


Make a mix of 10 litres cement and 50 litres clean river sand. Add about half of the mix to the brick mould and level off.


Add lengths of 3mm wire across the slab as reinforcing. At least four 1 metre lengths of wire are required, 2 in each direction. Add more wire if it is available. Then add the remainder of the concrete mix and level off. The squat hole mould can be removed with care once the slab has started to harden. The slab must now be cured. This means allowing it to harden overnight, then covering and watering down. The slab must be kept wet for at least 7 days to cure. 10 days is better. It must not be allowed to dry out. When thoroughly cured and strengthened it can be moved to the toilet site. The ring beam is laid down first on levelled ground, the pit dug and the slab added.

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 is dug down at least one metre and up to 1.5 metres deep. The deeper the pit the longer it will last.

Digging pit inside brick ring beam

Digging pit inside concrete ring beam.

IT IS IMPORTANT TO MAKE THE RING BEAM FIRST AND PLACE IN POSITION AT THE TOILET SITE BEFORE DIGGING THE PIT. THE PIT IS DUG INSIDE THE RING BEAM. SOIL TAKEN FROM THE PIT IS PLACED AROUND THE RING BEAM AND RAMMED HARD IN PLACE. THIS RAISES THE SOIL LEVEL AROUND THE TOILET SITE AND HELPS PROTECT THE PIT FROM EROSION CAUSED BY RAINFALL.

Sequence of fitting the circular concrete ring beam and slab.

The construction of a concrete slab with matching concrete ring beam using between one quarter and half a 50kg bag of cement (depending on the size and mixture used) is a good investment for the family. The advantage of the concrete ring beam, as opposed to the brick one, is that it is permanent, will last almost indefinitely and can easily be moved from one location to the next. The circular slab and ring beam are easy to move because it can be rolled.

Once the slab has cured properly it is removed from the mould, washed down with water and fitted over the ring beam at the head of the pit. It is a good idea to bed the slab in some weak cement mortar laid over the beam to allow the slab to settle properly (slabs and beams are never made perfectly level). Alternatively some anthill mortar can be used. Hopefully at this stage two sacks of dry leaves will also have been deposited into the base of the pit to help the composting process. Once this has been done, the time has come to fit the superstructure.

Round concrete ring beams and slabs can be made off the site and rolled into position as these photos show. In this case the larger ring beam (ID 1 metre) is being rolled onto site and fitted with a 1.15m diameter slab.

The ring beam has been embedded in levelled ground and the pit dug out to required depth. Soil extracted from the pit is placed around the ring beam. The slab is then fitted on the ring beam

The same sequence using the smaller 0.85m internal diameter ring beam and one metre diameter slab. The hole is dug inside the ring bean down to a depth of 1 to 1.5 metres. The excavated soil is placed around the ring beam and rammed in place. The slab is then embedded on a layer of clay, weak cement or termite mortar laid on the ring beam, Now the superstructure must be built around the slab.

Where the concrete ring beam/concrete slab combination is used as an ***Arborloo,*** the toilet is used for as long as the pit can accept the combination of excreta, soil, ash and leaves. Once full, the entire structure (ring beam, slab, house) is moved to the next location. The ring beam is put in place, the pit excavated within it, the slab mounted and the superstructure put in place again or reconstructed. At each full pit site soil is added to the pit contents and a tree planted.

But the system can also be used to make humus (like the ***Fossa alterna***) for the vegetable garden. Using these smaller ring beams and matching 1 metre diameter slabs, 3 ring beams and one slab can be made from between half and one 50 kg bag of cement, depending on the mix. In this case the 3 ring beams are made and located on site and remain in their original locations. The matching slab and superstructure rotates around them in sequence. Since the pits are smaller than the normal ***Fossa alterna*** pit, the slab and structure may need to be relocated every 6 months. But by the time the third pit has been filled, the humus in the first pit will have had adequate time to compost. The compost can be dug out and the slab and structure relocated on its original site. In this way there will be a never ending source of humus. If for some reason the ground starts to fail, the ring beam can be moved to a new site.

Optional pedestal

It is possible to fit a pedestal on to any pit or eco-toilet, but the slab must be made specifically for it – with a 30cm diameter hole, rather than the 30cm X 19cm squat hole. This includes the ***Arborloo***. Commercial pedestals are available, but expensive. It is possible to make a strong home made pedestal at much lower cost. As time passes pedestals are becoming more popular in several countries where squatting was once the norm. Those who are more elderly greatly appreciate them. Constructional methods for home made pedestals are described later in this book.

Home made pedestal placed on the slab. The pedestal is smart, cheap and durable.

Superstructures

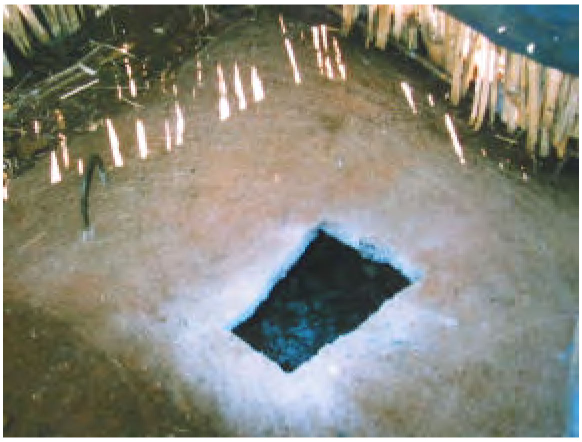
Toilet superstructures are built mainly for privacy, and protection from the weather. For the ***Arborloo***, they need to be portable or easily moved from one location to the next. A large range of materials can be used for the construction of the superstructure. These include poles and grass, frames made from poles, reeds, bamboo, wooden planks and steel etc with a variety of coverings for privacy. Coverings include grass, reeds, reed mats, plastic sheet, shade cloth, timber planks, iron sheeting, Hinged (using car tyres) or hanging doors may be fitted or the structure can be made without a door in a square spiral configuration. The type of superstructure chosen may depend on the availability of local materials. There is enormous variation in the type of structure which can be built, both for the ***Arborloo*** and the ***Fossa alterna.***

The Arborloo photo gallery

Left, the simplest superstructure – poles and grass – no door - no roof. Thanks to Jim Latham, Eco-Ed Trust. Right, more sophisticated pole and grass structure with door and roof. Durable door hinges can be made with cut sections of car tyres. Photo taken at Kufunda Village, Ruwa.

Left, simple portable structure made from poles and grass in Mozambique. This one has no door but has a roof, which has just been removed. The various sections are in panels and can be taken apart. Photo taken in Niassa Province. Thanks to Ned Breslin, WaterAid. Right, *Arborloo* structure built at Kusa Village, near Kisumu. Thanks to Osienala and RELMA

Woven basket superstructure from Malawi. Thanks to Steven Sugden and WaterAid.
Woven basket structure on *Arborloo* in Northern Malawi. The door is made from sacking. A neat and effective unit. Photo: thanks to Jim McGill, Embangweni eco-san project.

Arborloo **structure with low cost vent pipe. On the left the structure is made of poles and grass with low cost vent made with sacking and cement slurry. The interior is shown on the right. Thanks to staff of Mvuramanzi Trust. Zimbabwe.**

Structure made of bamboo and reeds. The four main bamboo uprights are anchored in the ground. They can be protected to a certain extent from ants with old engine oil or wood ash. The hinge for the door is made of old car tyre, as shown on the right. This material makes an effective and durable hinge.

Structure using small gum poles and old cement packets – also with a door Photo taken at Kufunda Village Ruwa. Thanks to Marianne Knuth. Moving an *Arborloo* superstructure in Maputaland, South Africa. Note the wooden structure has legs. Thanks to Dave Still and Stephen Nash of Partners in Development.


Two portable structures at Woodhall Road, Harare. One made of gum poles in sections which are wired together (right). The structure on the left is a steel frame covered with grass walling. Note hand washing device hanging from structure. All toilets should be provided with a hand washing facility. The structure made with steel frame and grass covering is easy to move. This is an excellent system where the frame is light and very durable and will last for many years. Less durable low cost walling materials like grass can be replaced when required. Photo taken at Fambidzanai, near Harare.


Photos of the steel frame *Arborloo* structure with grass walls and door made of sacking cloth. The vent pipe is a low cost home-made type made by wrapping plastic sheeting around a PVC pipe, then applying hessian and cement slurry. The structure has a door with car tyre hinge (see close up).


Simple *Arborloo's* at the Eco-Ed Trust, Mutorashanga, Zimbabwe. The pole and grass structure is easily taken apart and reconstructed from the original materials. The grass can be replaced every year if required. This type does not have a roof, but a roof is desirable to keep out rain. Thanks to Jim Latham,

Management of the *Arborloo*

Daily management of the *Arborloo*

The ***Arborloo*** is used like a normal pit latrine in that urine, faeces, anal cleansing materials (preferably paper) are added to the pit on a daily basis. In addition and in order to build up the mix of ingredients which assist in the conversion of faeces into pit compost it is important to regularly add dry soil and wood ash to the pit, preferably after every visit made for defecation. This material is best made up beforehand in the dry state, stored in sacks or bags and then added to a smaller container within the latrine. About four parts sifted dry soil and one part wood ash are mixed. Half a mug full of the soil/ash mix should be added after every visit made to deposit faeces. It also helps to add leaves to the pit – these improve the texture and nutrient value of the final compost.

It is wise to collect fertile soil in dry weather conditions and store this for future use in the latrine. It can be stored in bags or even in heaps in a part of the garden and covered with a plastic sheet during the rains. Wood ash should also be stored for future use. Although fertile soil is the best for use in the ***Arborloo*** pit (and also the ***Fossa alterna*** pit), the actual soil used will depend on what is easily available. The most obvious choice is to store the soil that was dug out of the pit during the initial excavation and put this back into the pit, every day. Sometimes wood ash may not be available or will be added separately. The most important ingredient to add is soil. Adding wood ash helps a great deal, especially in reducing odours and fly breeding and making the mix slightly more alkaline. Leaves improve the texture and also nutrient levels in the humus and also help to aerate the mass.

Experience over time, by the householder, will show that the best results are obtained when a mix of ingredients is put down the pit. This mix may include: excreta (urine and faeces), paper, topsoil, wood ash and leaves. The exact amount and mix must be judged over time. Clearly it would make no sense to add an excessive amount of soil, as the pit will fill too fast. As a rule of thumb the amount of soil added should approximately equal the volume of the excreta.

These additional materials help to improve the final texture and quality of the compost formed in the pit. It is also very desirable to add a sack full of dried leaves to the base of the pit before use and also a small sack full of leaves to the pit at 3 or 6 monthly intervals to increase the proportion of air and humus like material in the pit. The proportion of addition materials placed in the pit should be about equal to the volume of solids added. About half to a full mug full per visit after faeces have been added. In fact much of the bulk of the excreta will be absorbed into the dry soils and other dry materials (wood ash) added. It is important to add dry soil and dry wood ash to the pit, as these will help to absorb moisture from the excreta. Certainly some of the urine will be absorbed into the pit soil. Excess urine may also percolate into the soil surrounding and under the pit which will enhance it nutrient content prior to root invasion by the tree, even though some also nutrients will be lost.

No Garbage please !!!

It is also important to avoid placing non - biodegradable materials down the pit. These include rags, plastic sheets and bags, bottles, rubber objects and all manner of other objects that are often put down standard pit latrines. Whilst this part of the management is more important with the ***Fossa alterna*** where the pit contents are excavated (see next chapter) it is wise also in the case of the ***Arborloo.*** It is important that the pit is filled with good soil, not a pile of rubbish mixed with soil.

Flooding!

The conversion of excreta into compost will not take place if the pit is flooded with water. This means that only limited amounts of water should be added to the pit. Good pit drainage is very much dependent on soil type and area of soil in the pit available for drainage. Where the ring beam method of pit protection is used a large surface area of soil will be available for pit drainage. Pits lined with bricks or concrete rings do not drain so well.

Distributing pit contents

For the best results, and to ensure the best possible use of the pit volume, it pays for the user to look down the pit from time to time and level the contents. Since dry soil and ash when added to the pit tend to make deposits of excreta less fluid, the pit contents tend to rise up within the pit directly under the squat or pedestal hole. A central mound is thus formed – a process called "turreting." If the most economical use of the pit volume is to be made, it is very important for this mound to be flattened off from time to time with a stick. This flattening out of the pit contents and the occasional addition of a bucket of water helps to keep the contents moist and well distributed within the pit. These procedures will lengthen the life of the pit.

Relocating the *Arborloo*

When the ***Arborloo*** pit is almost full**,** the superstructure and slab are removed and put on one side. The ring beam is dug out and removed (or taken apart if made of bricks) from the old site and placed on a new site nearby. It does help to have handles fitted to the concrete ring beam in the case of the ***Arborloo***. This makes the movement easier and more hygienic. After the ring beam has been well placed and levelled on the new site, a new hole is dug down within the ring beam, as before, and the ring beam surrounded by soil taken out of the hole. The soil surrounding the ring beam is rammed hard in place.

The slab and superstructure are remounted on the ring beam as before. A seal is made between the ring beam and slab using a weak mix of cement and sand (1:20) or a clay like or termite soil made into mortar. The new location is chosen with care, taking note that the trees once planted will often grow large. Pits should not be closer than 3 metres apart. For trees which are known to grow large 5 metres may be a better distance. In a school setting or family homestead the ***Arborloos*** may be placed in an area which will turn into a wood lot or fruit tree orchard.

Preparations for tree planting

The contents of the used pit (filled with excreta, soil/ash/leaves etc) are now levelled off and topped up with fertile soil, at least 150mm deep. This soil can come from old compost heaps, fertile soil/leaf litter found under trees or any other place where the soil looks good. The aim is to plant the young tree in the topsoil so the roots come nowhere near the excreta layer. The more energetic can actually cover the pit contents first with soil and ram it into the mass with a pole, thus increasing the soil content of the pit. Ramming in soil actually promotes the conversion process. After ramming in extra soil into the pit contents, the final topsoil layer is added to completely cover the excreta lay and prepare it for tree planting. This final layer of topsoil should be at least 150mm thick.

Natural growth of trees in latrine pits

When a latrine pit is abandoned the contents contract in volume. Seeds of various types may fall into the depression formed and start to germinate. The kitchen wastes may also be thrown into such an abandoned pit. Pumpkin and tomato seeds will almost certainly germinate in such an environment. The same holds true for the seeds of trees that may fall into the old pit depression. The fact that this process occurs in Nature suggests that the medium found in these pits offers a suitable medium for plant growth.

A new latrine is being built to the left. On the right is the depression left from an old latrine pit. Close inspection reveals that an indigenous tree is starting to grow there. Photo a Kusa Village, Kenya.

The importance of trees

The most important aspect of the promotion of the ***Arborloo*** principle is that a link is made between the worlds of sanitation and forestry. The world lacks trees and they have such a beauty and value of their own which adds much to the world we live in. There is no part of the world that could not benefit by having more trees. This applies particularly to those barren parts of the developing world where trees may have been lost years ago and the resulting effects of erosion or reduced soil fertility are being felt. By linking the production of new trees with the reuse of human excreta we combine a problem (the disposal of human excreta) with a need for new trees and the many benefits they may bring forth. With each tree a story can be told. After ten years of use an ***Arborloo*** can leave behind a fine orchard of fruit trees or a wood lot of gums suitable for fuel or building. The tree is one of nature's marvels. It can be the provider of food, fuel, building materials, and medicine. It helps to stabilise the soil and offers shade. It provides leaf litter and thus provides additional fertility to the soil. It also provides beauty and richness to our environment. It helps to reduce erosion. The ***Arborloo*** is an elegant solution, which in the simplest possible way is able to provide an effective solution for low cost sanitation, adds greatly to the promotion of trees, and also offers an excellent example of recycling human excreta. Not surprisingly it is gaining popularity in many African countries.

Magnificent trees near Lake Victoria

The time has certainly arrived when we need to make the world of sanitation more interesting. And certainly one effective way of doing this is to make strong links between the sanitary world and that of agriculture in its many forms. Ecological sanitation has come at the right time, to offer us a practical way of doing this. That is what is good about ecological sanitation. It brings the worlds of agriculture, forestry, horticulture, food, fruit, herbs, natural medicines, fuel and many other things together.

Every means possible should be taken to grow more trees of all sorts, exotic trees and also indigenous trees. The links made between sanitation and the propagation of more trees is an important one. The value of the nutrients available in excreta, even if they exist below ground level, can be realised and witnessed with ease. Fruit trees grow very healthily on such organic pits if planted correctly, watered and protected. The fruits when tasted are delicious. What simpler and better way of demonstrating the concept of ecological sanitation and "closing the loop!"

The concept of the ***Arborloo*** is being promoted and tested in countries like Kenya, Mozambique, Malawi, Zambia, as well as Zimbabwe, where it is thought to have considerable practical application. The potential for its use throughout Africa is enormous. Because the method and concept is simple and yet retains the basic elements of ecological sanitation, it is thought of as a good first step along a route of increasing sophistication within the realm of ecological sanitation. It is, for instance, possible to upgrade the ***Arborloo*** and make a ***Fossa alterna***, moving quite simply from a series of single pits into a permanently sited alternating double pit system (***Fossa alterna***). By slight modification or replacement of the latrine slab (making a vent pipe hole), the system can be upgraded further to a VIP latrine. The ***Arborloo*** is the very best method of entering the world of ecological sanitation. The method is simple and cheap and there is no handling of processed human wastes. Many people may prefer to start off with this option. It is an excellent "entry point" for ecological sanitation.

Examples of *Arborloo* programmes

The *Arborloo* in Malawi

The ***Arborloo*** is very popular in Malawi perhaps because trees have been planted on old latrine pits for generations. Where the ground is hard the slab may be placed directly on the pit cut in the ground. In softer ground a ring beam or corbelled brick ring wall is built up from below ground level to above ground level and backfilled. Round slabs are very common in Malawi. As many as 8 slabs 0.8m in diameter can be made from a single bag of cement (left). Many domed slabs have no reinforcing. The one shown at left has 2 metres of 2.5mm wire placed in it. Photos taken in Phalombe district.


Most *Arborloos* in Malawi are of simple construction using poles and grass Photos taken in Embangweni (left) and Phalombe (right). Thanks to CCAP and COMWASH.

Making the 0.8m diameter round slab in Malawi


Making a round 0.8m diameter concrete slab in Malawi with sharp river sand and cement. When the river sand is of high quality, the addition of granite stones may be unnecessary. In this case a tin strip 40mm deep is formed into a circle 0.8m in diameter and supported by bricks. It is laid over a sheet of plastic. 4 wires are cut as reinforcing. In this case 2 metres of 2.5mm wire has been cut into 4 pieces (2 X 0.55m and 2 X 0.45m). 3mm or 4mm wire can also be used. The mix of sharp river sand and cement is 4 to 1(20 litres river sand and 5 litres cement). 8 slabs can be made from one 50 kg bag of cement using this method. High quality river sand and proper curing are important.

The sand and cement are thoroughly mixed and water is added to make a stiff moist concrete. The squat hole mould is added in the centre. Half the volume is added first, then the reinforcing wires, then the final part of the mix is added and trowelled flat and finished off with a steel float. The tin and squat hole moulds are removed and the slab covered with plastic sheet and left for 10 days to cure being kept wet throughout the curing process after setting. Photos taken in Phalombe. Thanks to COMWASH

The 1.0m diameter round slab in Malawi

Making a round 1.0m diameter concrete slab in Phalombe with high quality sharp river sand and cement. In this case a circle of bricks one metre in diameter is laid on the ground. Some sand is added to level off. A sheet of plastic is then laid inside the brick mould. 4 wires are cut as reinforcing. In this case 3 metres of 2.5mm wire has been cut into 4 pieces (2 X 0.7m and 2 X 0.8m). 3mm or 4mm wire can also be used. The mix of sharp river sand and cement is 3 to 1(30 litres river sand and 10 litres cement). The process is the same as for the 0.8m slab. Cure for 10 days and keep wet at all times after setting. 4 slabs can be made from one 50 kg bag of cement using this method. High quality river sand and proper curing are important. Thanks to COMWASH

A quality hand made 0.8m diameter domed circular slab made with a mix of stone chips, river sand and cement with footrests and handles. No reinforcing has been used. With this method 4 slabs can be made from a single 50 kg bag of cement. This is mounted over a circle of bricks laid as a ring beam for the *Arborloo* as shown on the right. Where the slab is used on a *Fossa alterna* it is mounted on a ring beam made of bricks (or concrete) at the top of the pit (where the soil is firm) or on the uppermost course of bricks in a fully lined pit which extends above ground level. The larger diameter one metre slab is best used on the *Fossa alterna* and the smaller 0.8m diameter slab on the *Arborloo.*

On the left a pole and grass *Arborloo* in the Phalombe plain. Thanks to COMWASH. On the right a brick *Arborloo* built in a peri urban settlement near Lilongwe, Malawi. Thanks to WaterAid, Malawi.

Sequence of building low cost *Arborloo* in Zimbabwe at Kufunda Village

Making the 1 metre diameter concrete slab


The circle for the 1 metre diameter slab mould is marked on levelled ground and bricks placed together in a circle


Plastic sheet is placed inside the mould and the concrete mix is made up in a wheel barrow (30 litres of good clean river sand and 5 litres of fresh cement. This is thoroughly mixed before and after adding water to make the concrete mix. Using this economy mix 8 slabs can be made with a single 50kg bag of cement.


A mould for the squat hole is made with a bucket or with bricks as shown here. Half the mix (about 17 litres) is added to the mould first and levelled off. The four 90cm pieces of wire (3 – 4mm thick) are added to make a wire square around the squat hole. Then the remaining concrete is added, levelled, tamped down hard and finished off with a wooden float and steel trowel.

Two thick wire handles are made up and inserted in the concrete on either side of the slab. A little extra cement can be added around the handles for extra strength. After an hour or two the mould for the squat hole is removed and the hole made neat with a trowel. The slab is covered with plastic sheet and left overnight. In the morning it is soaked in water and covered again. It is kept wet for 10 days under the plastic sheet. The longer it is kept wet under plastic sheet the stronger it will become.

Making the brick ring beam

A suitable site for the toilet is located, preferably on slightly raised ground. A circle is marked on the ground 80cm in diameter. A ring of fired bricks is laid on the chosen site around the mark to start making the ring beam. Anthill mortar is gathered, broken up and mixed with water to make a stiff mortar.

The brick ring beam is bonded together with anthill mortar, in between and above the bricks. Two courses of bricks are laid, one above the other and placed so that the upper bricks lay over the joint between the lower bricks. (note - if bricks are not available a concrete ring beam can be made instead).

The pit is dug out down to 1 – 1.5 metres and the extracted soil placed around the ring beam and rammed in place. The ring beam and surrounding soil will help to make the toilet stable.

The slab is then moved and placed over the ring beam embedded in a layer of anthill mortar to keep it steady. The superstructure is now built with locally available materials like wooden poles and grass).

Making a concrete ring beam

Two circles of bricks are laid over a plastic sheet. They are arranged so they form a mould in which the 6:1 mix of river sand (30 litres) and cement (5 litres) is placed. The open joints formed between the bricks of the inner circle of bricks can be filled with wet sand before adding the concrete mix. The mix is made in a wheel barrow and thoroughly mixed. Half the mix is added first to the mould. This is followed by a complete circle of 3 – 4mm wire. The remaining half of the mix is now added. The concrete is beaten down hard with bricks (see left photo) and smoothed down. The ring beam is then covered with plastic sheet and left over night. The following morning it is soaked in water and left to cure for 10 days. It is kept wet and under the plastic sheet throughout the curing period. After 10 days it can be lifted and placed on to the toilet site. A pit 1m – 1.5m is dug inside the ring beam. A sack of leaves is added and the concrete slab placed on top (in anthill mortar). The structure is then built around the slab. Soil, ash and leaves are added frequently to the pit contents to encourage the formation of good compost. For more detail see Appendix on low cost construction of *Arborloo.* Thanks to Marianne Knuth and Kufunda Village.

The Kufunda outreach programme in the villages

Trainees from Kufunda go back to their villages and show others how to cast simple concrete slabs and build the ***Arborloo.*** Whilst the cost of the cement is low (one 50 kg bag costing around USD8.50 can serve five families), most families prefer to spend their scarce resources on food or school fees. Consequently the concept of a "Compost Toilet Starter Kit" has been introduced. The Starter kit provides enough cement to make a one metre diameter concrete slab and also provides a young tree and simple instructions. The Kit contains 8 litres of cement (one fifth of a 50 kg bag), which is mixed with 30 litres of river sand to make the concrete slab. Some wire is also required. Both river sand and wire are available in most villages. Ring beams are normally made with local fired bricks bonded together with termite mortar. Structures are normally built in the simplest way at first – made from grass and poles. Often there is no roof at first. But even at this stage, a significant step forward has been made to the provision of sanitation in the village. The regular addition of soil and wood ash ensures significant reductions in both odour and fly breeding without the use of a vent pipe. Simple as it is, the construction of the ***Arborloo*** signifies a significant step forward in the provision of low cost and affordable sanitation.

Once the ***Arborloo*** has been made, the toilet can be upgraded at a later date, using the same slab with a more permanent concrete ring beam, and a more substantial house fitted with a roof. The family may choose to build a second or third pit and use the ***Fossa alterna*** (alternating pit) system in time, rotating the use of the toilet between two or three pits. This becomes a more obvious method, once the value of the humus formed in the pit has been seen by family members. The pit humus can significantly increase the production of vegetables and also maize, especially when combined with the use of urine. Such advantages become very apparent when a combination of humus and urine are used on very poor sandy soils – soils which are all too common in rural Zimbabwe and other parts of the sub-region. Once the effects of the humus on tree, vegetable or maize production have been witnessed, the popularity of the toilet system increases. Also once the method of making concrete slabs has been learned, the family may choose to make more slabs of its own.

The stage has not yet been reached when the enhanced growth of fruit trees has been experienced in this programme, which is in its infancy. Programmes in Malawi and Mozambique are more advanced. One thing is certain – families are very pleased with their own efforts in finally being able to construct their own toilet at minimum cost and without the use of artisans and labourers. Women are particularly proud that they can construct the system, normally the role of the men. In programmes promoted by Kufunda in Rusape, Ruwa, Mondoro and Zvimba, women are the most active participants and also the best instructors. During 2005, 100 compost toilets were built in Zvimba district

The Starter Kit concept, currently being tested, provides an incentive for the family member (often a woman) to start the process off. The Starter Kit also provides small trees (currently mulberry) which are planted, first in pots, at the same time as the toilet is built. Later, the partly grown trees are transferred from the pot to a generous layer of soil placed above the filled ***Arborloo*** pit. With watering, care and attention, the tree can grow into a considerable family asset later. All the instructions are provided in the Kit. It is an interesting and low cost method of promoting the uptake of low cost sanitation. Other excellent promotional methods are also being tried by WaterAid in Malawi and Mozambique and COMWASH in Malawi.


Participants at a "compost toilet workshop" in Mondoro are busy making the concrete slab. Instructions in the local language – Shona – are available. With the cement provided in the kit, a strong one metre diameter concrete slab can be built together with local river sand and some wire. The slab is flat and easy to construct. The importance of proper curing is emphasised. Cover with plastic sheet and after hardening keep wet for at least a week. The important aspect of this programme is that local villagers who are neither artisans or builders by trade acquire the skills. By far the greatest number of participants are women. In Mondoro, it is the women who train others to make the slab and toilet.


The ring beam is an important part of the structure, as it elevates the toilet slab above ground level and helps to the protect the unlined shallow pit. Most ring beams are made with local fired bricks and termite mortar. The slab sits on top of the beam and then the structure is built around this. On the right a group of villagers attend the compost toilet workshop in Mondoro.


A sack of soil near the home made slab on an *Arborloo.* The finished *Arborloo* made in the simplest way, provides a safe way of disposing of excreta. The facility offers privacy, with almost no smell or fly nuisance. It is an important first step in the provision of sanitation for low income families. These photos were taken in the Mondoro district.

Simple superstructures suitable for the *Arborloo, Fossa alterna*, urine diverting toilets and even VIP latrines can be made very attractive and serviceable using local timber and grass. This unit at Kufunda Training Centre, Ruwa, has been built on top of a rectangular concrete slab sitting on a rectangular concrete ring beam (see constructional details in chapter on *Fossa alterna*). The slab and ring beam each use a quarter bag of cement (10 litres or ¼ 50kg bag) together with river sand and some wire. The structure is portable, so when the shallow (1+ metre + deep) pit has been filled with the mix of excreta, soil, ash and leaves, the ring beam, slab and structure are moved to another site. Soil is added over the pit contents and a young tree can be planted immediately if the soil added is deep enough (at least 15cm). Alternatively the pit contents can be left to compost until the rains arrive, when the young tree is planted. For longer life the pit can be dug deeper up to 2m. Alternatively two rings beams can be made over two 1.5 metre deep pits and the toilet alternates between them at yearly intervals (see *Fossa alterna* – next chapter). The ring beam concept will work if the soil is moderately stable and the structure on top is light (ie not made of bricks or blocks). For more permanence the superstructure frame can be made of steel with replaceable grass walls and roof (see chapter on special techniques).

The simple *Arborloo* system can be upgraded by adding a vent pipe to control odours more (although the addition of plenty of soil and ash will help control both odours and flies). Also the squat hole can be upgraded by adding a pedestal for sitting. Also the system can be upgraded to urine diversion. This is easier on a pit system with a urine diverting pedestal with a urine off-take above the base (see chapter on special techniques). By diverting urine, the pit contents will become less moist which will also cut down on odours and flies. The urine can be led to a hardy nitrogen hungry tree like a banana. These various techniques are described in this book. The main point is that the simplest toilet systems can be upgraded over time. Low cost does not mean poor function. Some of the most effective toilet systems are low cost.

5. The Fossa alterna – the double pit compost toilet.

The ***Fossa alterna*** is a simple alternating shallow pit toilet system designed specifically to make compost suitable for agriculture. It is based on a twin pit system - the use of the toilet itself alternating between two permanently sited shallow pits. The toilet is managed in such a way that the conversion of human excreta into compost takes place within 12 months. After 12 months of processing the compost is dug out and used on the garden. The pit volume is calculated so that this 12 month period is less than the filling time of the pit when used by a small to medium sized family. This means that the ***Fossa alterna*** can be used continuously on the same site, almost indefinitely, simply by alternating between one pit and the second, with the compost being excavated once a year, thus making available an empty pit - every year.

The *Fossa alterna* is designed to make humus from human excreta. It has two shallow pits protected by two concrete ring beams, a single concrete slab and a superstructure, in this case made from gum poles and reed mats. This unit is also equipped with a low cost home- made pedestal, a vent pipe and hand washing device. The system is simple and can be made at low cost. Photo taken in Marlborough, Harare.

As in the ***Arborloo***, the conversion of excreta into compost in such a short space of time (12 months) becomes possible because extra ingredients, like topsoil, wood ash and leaves are added regularly to the pit contents. These extra ingredients alter the biological makeup of the pit contents, and also make it far more aerobic than would be the case with a deep pit latrine filled with excreta alone. Adding soil (especially fertile topsoil) and leaves brings into the mix a myriad of beneficial soil organisms such as beneficial bacteria, fungi, even worms and insects which excavate the soil and help to process the excreta. The addition of leaves (and other vegetable matter) increases the air content. Unlike solid excreta alone, this combination of ingredients readily converts into humus if sufficient quantities of the extra ingredients are added. The volume of soil, ash and leaves added to the pit should be about equal to the volume of faeces added. And it should be well distributed – in other words, the various ingredients should be added regularly. The conversion is improved if the soil itself is fertile and humus like. Adding clods of wet clay soil from time to time will not result in the desired effect. Neither will the occasional sprinkling of soil or ash on a huge volume of excreta held in the pit. The proportion of soil, ash and leaves should be significant and well distributed and should make up about half the volume of the pit. These important facts should be known to those people who are being introduced to the ***Fossa alterna***. In adding this combination of ingredients the process of decomposition within the pit is quite different to the one that normally takes place in the deep pit latrine. In the deep pit latrine, it is only excreta which enters the pit, together with garbage, and this combination may takes many years to convert into a useful compost, depending on the conditions. Under such an inefficient conversion - the alternate use of twin pits on a regular basis would be impossible. Thus the process of humus formation in the shallow pit systems used in the ***Fossa alterna*** is a significant departure from the system seen in conventional double pit latrines.

The ***Fossa alterna*** could be classified as a double vault pit latrine, but it is different in so many fundamental ways, that it has been given a specific name which distinguishes it from other twin pit systems.

* The ***Fossa alterna*** is specifically designed to make compost from human excreta (urine and faeces combined) in an efficient manner. This is achieved by the regular and generous addition of soil, wood ash and leaves together with the excreta.

* An important requirement of the ***Fossa alterna*** is to produce a relatively safe and valuable humus in the 1.2 – 1.5 meter deep composting pit within the space of 12 months. This is less than the time taken for a family of six persons to fill a shallow pit, which the ***Fossa alterna*** is designed to serve. This conversion from human excreta into compost could not be achieved within a year in a normal pit latrine, and the addition of the soil, ash and other ingredients into the pit is essential for this process. It is this feature which distinguishes the ***Fossa alterna*** from other double vault pit latrines. The aim therefore is to roughly match the rate of conversion of the excreta into compost in the one pit with the rate of filling of the second pit. When this is achieved it is possible to change sides once a year, with a regular out-put of compost being achieved each year. In practice a family should take a little more than a year to fill each pit and the conversion into humus is achieved in a little less than a year. So there is a safety margin built in.

***** The twin pits of the ***Fossa alterna*** are shallow, each about 1.2 meters deep, with 1.5 meters being a maximum. This makes excavation for the family relatively easy. The formation of compost takes place under reduced conditions of compaction (which would be the case in deeper pits). The excavation of compost is also usually easier than digging out the original pit. The shallowness of the pit also reduces the risks of contamination of underground water from the system, partly because the waste materials are contained further away from the water table and partly because the conversion of excreta into compost is accelerated.

***** The pit which has been filled with a combination of excreta, soil, wood ash and leaves is exposed in such a way that it is easy to excavate. It is important that the pit is topped up with additional soil and leaves and left to compost for 12 months. For safety reasons it may be covered with a wooden cover. Ease of excavation is important.

***** There is only **one** toilet slab used in the system. This is deliberate, so that only one pit can be used at one time. This avoids the problem seen in some other double pit systems which are equipped with two slabs - allowing both pits to be used simultaneously. The concept of the ***Fossa alterna*** cannot work if both pits are used simultaneously.

***** The system can be equipped with a portable structure, like the ***Arborloo,*** so that transferral of the superstructure from one pit to the other is easy and convenient. This is not an essential requirement however, and most ***Fossa alternae*** in Mozambique and Malawi house both pits within a single permanently sited superstructure.

***** The ***Fossa alterna*** is designed to use the nutrients derived from urine and faeces in combination which are composted together with the soil entering the pit. The resulting compost is rich in nutrients, derived from both the urine and faeces (see later soil analyses). The ***Fossa alterna*** concept of producing compost in shallow pits can be used in combination with urine diverting pedestals, but this increases the cost and complexity of the unit. The urine diversion concept is best used in combination with above-the-ground vaults, but it will work on shallow pits as well

***** The system is adaptable, - if overloaded by heavy use - a third or even fourth pit can and should be built and the single slab and superstructure can be used on a rotational basis between the series of shallow pits. The aim must always be to allow for at least one year of composting.

***Fossa alterna* in Epworth near Harare. It has two shallow pits, a single concrete slab and single superstructure, made with a light steel frame covered with grass. The *Fossa alterna* was initially designed for per-urban use on medium sized plots, but can be used on smaller plots and also in the rural areas.**

Like the ***Arborloo***, the ***Fossa alterna*** attempts to fulfil all the basic requirements of a toilet used under the umbrella of ecological sanitation. The recycling of human excreta is achieved in a simple manner and the end product, in the form of compost, is relatively easy to excavate and introduce directly into the garden or into bags for future use or. An entirely natural process of "ambient temperature composting" takes place in the pit. Pit content temperatures rarely exceed 25 degree centigrade in Southern Africa. Where the ***Fossa alterna*** differs from the ***Arborloo*** is that the humus will be excavated from the pit, and hand contact will subsequently be made with it. Certainly when it is mixed with topsoil, and vegetables are planted, the material will be handled. Thus the health implications are important to consider.

After one year, properly composted pit compost is infinitely safer to handle than hands soiled in the toilet. It is important to wash hands after handling and this would be a normal procedure when handling garden compost before eating. **It is essential that the recommended materials (soil, ash and leaves) are added to the pit regularly and a full 12 month period of composting is allowed**. Without this method of management, where the excreta builds up without any, or very little additional material to help it compost, the excreta will not change in the desired way within the recommended 12 month period. Then, handling the resulting semi composted material may pose a health threat. Also ***Fossa alterna*** compost has not yet been fully investigated for the inactivation of viable helminth (round worm) eggs to date. Existing data shows that within 12 months the great majority of helminth eggs will have been rendered non viable for composted human sludge (Martin Strauss. 1990). Thus there is a small element of risk associated with handling the ***Fossa alterna*** humus, but this risk is infinitely less than handling many other sources of potential contamination in the environment in which the ***Fossa alterna*** was designed to work. Contact with the unwashed hands of another person who has attended the toilet or with a contaminated door or towel may constitute an infinitely greater health threat, than handling well composted excreta dug out of the ***Fossa alterna*** pit. The health threat is even greater if food is handled by the unwashed hands of those leaving a toilet. So the risks are relative. In very few aspects of human life, can one put a 100% guarantee that one will be safe and one's state of health can be assured.

The importance of placing a simple hand washing facility close by the toilet is an essential requirement if person health is to be taken seriously – and it must be. Regular hand washing is an essential component of improved personal hygienic behaviour. A number of low cost hand washing devices can be made in the home from locally available containers and materials and these are described in this book. The danger of handling ***Fossa alterna*** compost must be considered in relation to other potential contaminants related to the toilet, raw excreta itself being the most obvious.

If there is doubt about the safety of the excavated pit compost, for immediate transfer to the garden or vegetable bed, it can be transferred to sacks for storage for an additional length of time. Sometimes this method of "bagging" may actually be preferred by the family. In excavating and storing in bags, the material is turned and aerated, and this certainly helps to promote the composting process. This period of "secondary composting" in bags may be preferred because the time of excavating may not necessarily coincide with the time of planting vegetables. Some gardeners may on the other hand prefer to dig in the humus into the bed well before planting. Thus the humus will undergo further processing. The humus will nearly always be mixed with local topsoil before planting. Semi processed pit compost can also be placed in to pits which are covered with soil and in which trees will be planted.

The nutrient rich compost (see soil tests later in this book) excavated from the fully composted pit is far more fertile than normal topsoil, so by mixing the "pit compost" with existing topsoil the fertility of the topsoil is greatly improved. This is true for all the major nutrients, nitrogen phosphorus and potassium. Because the volume of pit compost derived from a family latrine is relatively small (about 0.6 cubic meters per year), most compost derived from the ***Fossa alterna*** is mixed with soils used in vegetable gardens in the back yard. A 2:1 mix of topsoil and pit compost is a useful ratio to use on small vegetable beds (see later). A 2:1 or 50/50 mix results in a considerable enhancement of the nutrient value of most top soils, which can lead to significant increase in the production of vegetables (see later). Thus the "close the loop" principle is once again achieved - and this is a central requirement of ecological sanitation. What is eaten goes back into the system and is recycled.

The ***Fossa alterna*** was originally designed for use in peri-urban settlements. The total area required for this toilet is quite small - about three square meters. Within this area it is possible to excavate two shallow pits lined wholly or partly with bricks or protected with two ring beams at the head of each pit. Time has shown that the simplest method – using concrete ring beams, is the most effective if the soil is moderately firm. This is because when a ring beam is used, there is maximum exposure of the pit ingredients to the surrounding soil. This improves drainage and also exposes the converting excreta/soil mix to the myriad of organisms present in the soil - and also, interestingly, of plant roots which are found in the topsoil. The conversion of excreta into compost takes place more rapidly in unlined or partially lined pits compared to those that are fully lined with bricks, or concrete rings.

The ***Fossa alterna*** also has considerable application in the rural areas as well. In Niassa Province, Mozambique (Ned Breslin, WaterAid, Mozambique) and in Thyolo District Malawi (Elias Chimulambe, COMWASH), for instance, the ***Fossa alterna*** is the preferred option because it offers a simple method of constructing a relatively permanent solution to sanitation. It is also relatively cheap to built, helps reduce flies and odours (even in the absence of a vent) and also provides a yearly supply of humus which can be used in a variety of ways

Much of what has been said in the preceding chapter on the ***Arborloo,*** applies equally to the ***Fossa alterna.*** The ring beam, slab and even superstructures can be identical in both units. The shallow pit receives regular additions of soil, wood ash and leaves in addition to excreta in both systems. The addition of garbage to the pit is not recommended in either system, but perhaps a tree will be more forgiving. It is no pleasure to excavate garbage like rags and plastic when the compost is being excavated. The difference is that in the one system the compost is left in place and a tree is planted in it. In the case of the ***Fossa alterna*** the compost is excavated, thus making available a "new" empty pit which can then be reused and refilled with a new mix of ingredients (urine, faeces, paper, soil, ash, leaves etc) again.

Perhaps the greatest asset of the ***Fossa alterna*** is its forgiving nature. It is no more than a pit toilet - and very simple to use, with the specific requirement that the users add soil and ash and leaves to the pit regularly, and do not add various other non compostable materials like rags, bottles, rubber, plastic and all manner of other garbage. The system still works if soil alone is added, but the texture and nutrient content of the humus produced is improved if leaves are added too. Also the conversion is far more efficient if humus like fertile soil is added compared to infertile soil or clay. Ash also helps to reduce odour and fly breeding and adds potash to the mix. The addition of dry leaves helps enormously, both as a layer at the base of the pit (two sacks full), and also throughout the filling process and also on closing off the pit. So the way a ***Fossa alterna*** is used and managed is a little different from the way a normal pit latrine is used and managed. However the differences are not great and should easily be managed by those who are familiar with the pit latrine. And in the world in which we live, this accounts for most.

Digging out pit latrines, though, is not commonly practiced in Africa, or in any part of the world. This is because the process is most offensive in the extreme. Consequently the first time users of the ***Fossa alterna*** are cautious at first about this part of the management. They will need convincing. The acceptance of this excavation as part of the procedure for using this system may not be immediate. The potential users will need to have seen other ***Fossa alterna*** pits excavated without difficulty and examined the compost for themselves. After a season of use however they will be convinced. Also they will be more convinced if they have seen evidence that the mixing of the humus with poor local top soils does actually enhanced the growth of vegetables. They will need to be convinced that the system is simple to build and simple to use, and also offers many benefits in addition to the conventional pit toilet. Potential users must be made aware, ahead of time, that for the system to work well, it is important to add soil, ash and leaves to the pit, regularly, and that they must also excavate the compost once a year. Thus projects involving the ***Fossa alterna*** require an effective component of education and demonstration. It does require more attention and effort than the use of a normal deep pit latrine. Indeed all solutions involving ecological sanitation require much more user participation than the standard pit or flush toilets systems demand.

Inspecting humus taken from the *Fossa alterna* in Mozambique.

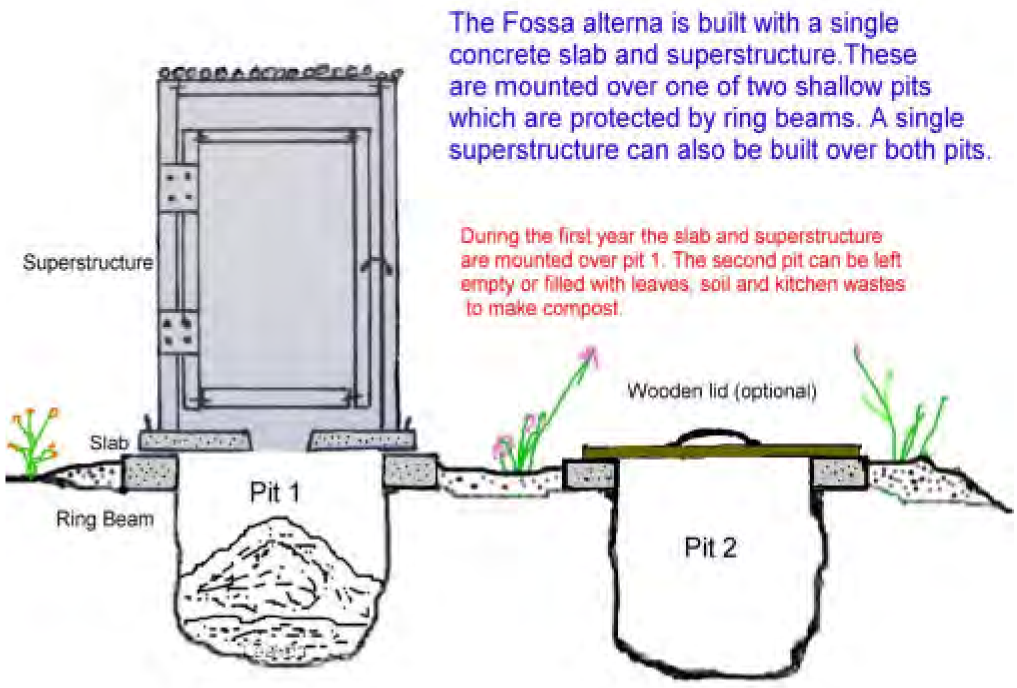
There is now much evidence that the pleasant nature and perceived value of the pit compost, with its ability to enhance soil fertility within the homestead, is encouraging people to excavate at the appropriate time. The excellent project in Niassa, Mozambique, which has studied various aspects of the uptake and use of the ***Fossa alterna*** has provided much evidence for the popularity of this system (Ned Breslin, WaterAid, Mozambique. See bibliography). A similar pattern of uptake is also seen in Malawi (Steven Sugden, WaterAid, Malawi). These are encouraging signs.

HOW THE *FOSSA ALTERNA* WORKS

There are two shallow pits close to one another and a single slab and superstructure. Both pits are dug and protected from the start. If this is not done, there may be confusion about how the system operates. The ***Fossa alterna*** concept cannot work with a single pit. If only one pit is dug and protected, by the time the first pit has filled the initial enthusiasm, drive or money for the latrine project might have gone. The message is simple - build the whole unit - with both pits - from the start with the slab and superstructure mounted over one of the pits. The second pit can be filled with leaves and covered with a lid for the first year.

As the first pit is being used it is filled with a combination of materials - not just excreta. These include faeces and urine and also soil, wood ash and leaves. The pit is used as if it was a composting pit filled from the top. The pit is used until it is nearly full, which for a family of up to 6 persons should be about one year or more.

During this first year period, the second (empty) pit may be covered with a wooden lid and left empty for the year. Alternatively it can be used as a “leaf composter” by adding leaves regularly throughout the year interspersed with thin layers of soil. The resulting leaf compost will be of considerable value in the garden (see nutrient levels in following chapters).



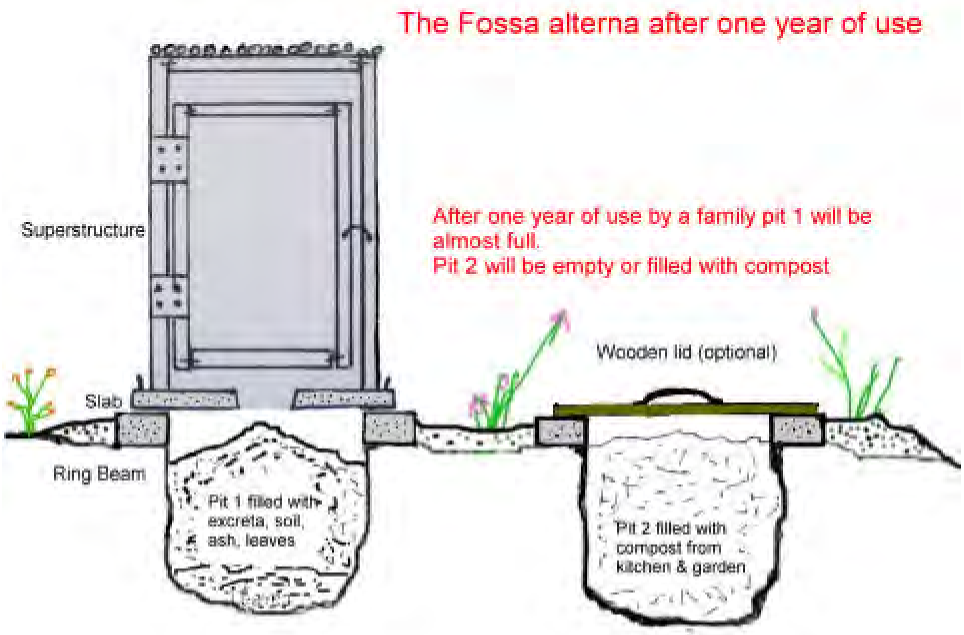
To start, two sacks of leaves are added to the base of the first pit. The slab and superstructure are fitted and the use of the toilet can begin. Buckets of dry soil, ash and leaves are placed inside the toilet. Every day, and preferably after every visit to defecate, some soil is added. Ash should be added too. Periodically leaves are added in addition.

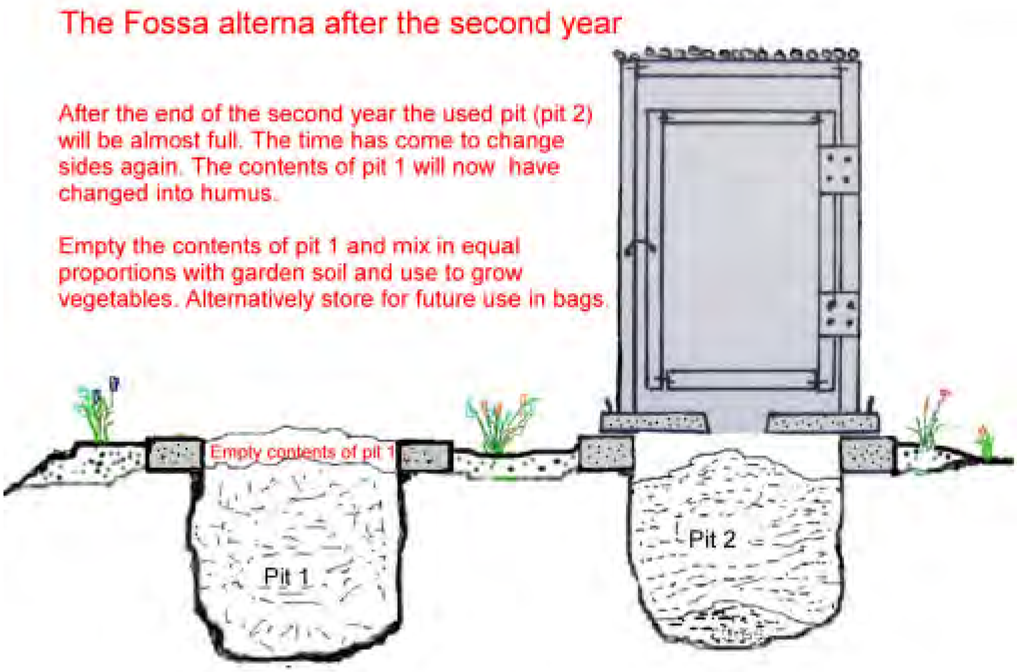
When the pit filling with excreta and other materials is nearly full (after about a year), the slab and superstructure are removed and placed over the second pit which should be empty. If it has been filled with leaves, the leaf compost is removed and used on the garden. Two sacks full of leaves are added to the base of the new pit before it is put to use. The first pit filled with the mix of materials is then "topped up" with leaves and a layer of soil at least 75mm thick and left to form humus over the following 12 months. If there is doubt about the correct proportion of leaves and soil being added to the pit, more soil and leaves can be added and rammed into the pit. The final covering layer of leaves and soil is then added. This process has the effect of increasing the proportion of soil/leaves within the mix and also distributing it more evenly throughout the pit.

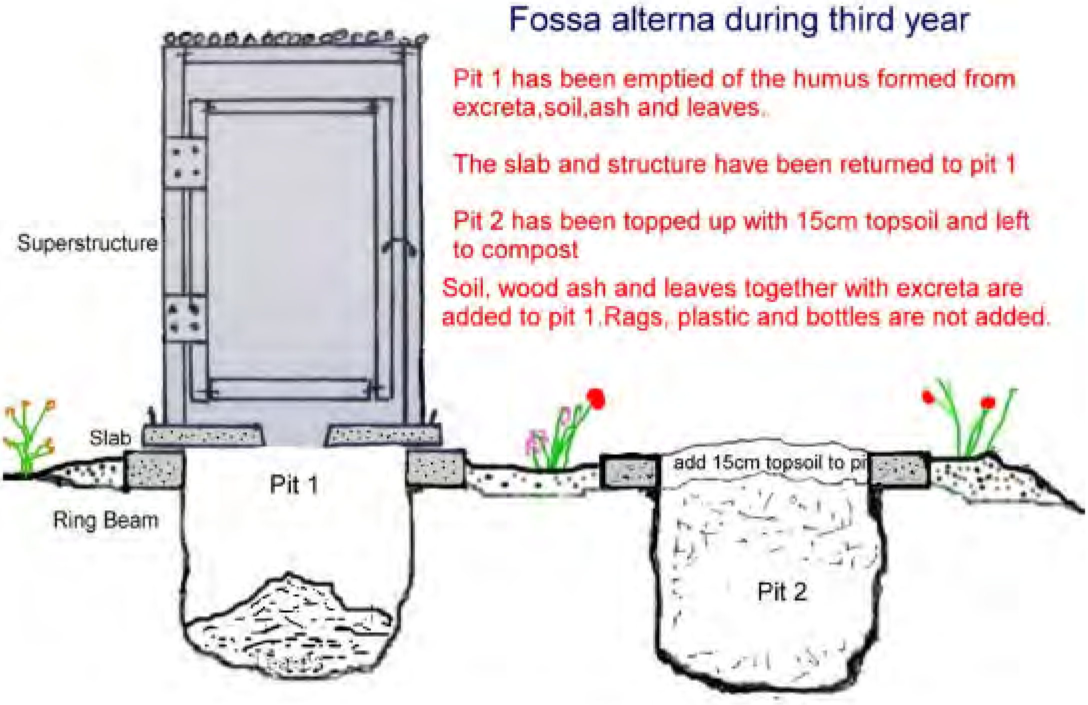
During the second year, the second pit will be filling with the mix of excreta, soil, ash and leaves whilst the first pit is composting. At the end of the second year the second pit will have nearly filled. By this time, the contents of the first pit will have already converted into compost which can then be excavated.

The excavated pit compost can be mixed with topsoil and dug into vegetable beds in preparation for planting (see later). Alternatively the humus can be placed at first in large sacks until the time comes to mix it with topsoil and grow vegetables. The excavated material can also be stored in a heap under the cover of a plastic sheet.

Once the pit compost has been excavated, the superstructure and slab are then returned to the original pit after more leaves have been added. The filled pit is covered with leaves and soil and the whole process is repeated again. Every year the process is repeated, possibly at the same time of the year. In Zimbabwe, the best months are during the latter part of the dry season (September – November). The process can in fact take place at any time of the year, but is normally easier to undertake during the dry season. The process will still work if leaves are not added, but the finally quality of the humus will be reduced. Leaves add air to the composting mix and improve the efficiency of composting. It is important to add leaves if they are available.







The *Fossa alterna* - Stages of construction

Siting the *Fossa alterna*

This will be very similar to siting the ***Arborloo,*** in terms of access and distance from a well, homestead etc. But there will be no future trees to consider in the siting procedure. In essence the ***Fossa alterna*** must be sited in the most convenient place for the family. It can backed on to a fence line. There should be room to move the structure from one pit to the next. Proximity to the vegetable garden may help but is not serious. The most important point in siting is convenience and privacy.

Methods of protecting/lining the twin pits.

Unlike the ***Arborloo*** the twin pits of the ***Fossa alterna*** are sited in permanent or semi - permanent locations. That is, they are sited in a place which may not change for some years - although of course it is very easy to re-site the pits at any time if there is space. Such pits may be fully lined with bricks or partly lined with bricks or fitted with ring beams of brick or concrete at the head of the two pits. It is an advantage that the ***Fossa alterna*** concept is adaptable and can use light and portable structures which impose a much reduced load on the soil around the pit, thus reducing the possibility of pit collapse. If a brick superstructure is used, as in Malawi, then it is essential to line both pits with mortared bricks to the base.

The ring beam method is the simplest and cheapest way of protecting the shallow pit with the ***Fossa alterna*** and also the most effective in terms of humus formation. So far this method has worked well in Zimbabwe even on moderately sandy soils under experimental conditions. But the experience of time alone will tell. With these types of structure with portable components, if there is any sign of movement, the parts of the latrine can be moved quickly to another site.

The decision as to which type of pit protection to use depends on local soil conditions. In very loose sandy soil, the pit will need lining with bricks to the base. If the soil is firmer a ring beam or part brick lining may be quite adequate, since a portable superstructure is not heavy. In most situations a ring beam will be perfectly adequate. It is also by far the cheapest and simplest method. If there is doubt about soil stability always line the pit with bricks to the base.

1. Ring beam method

Concrete ring beams

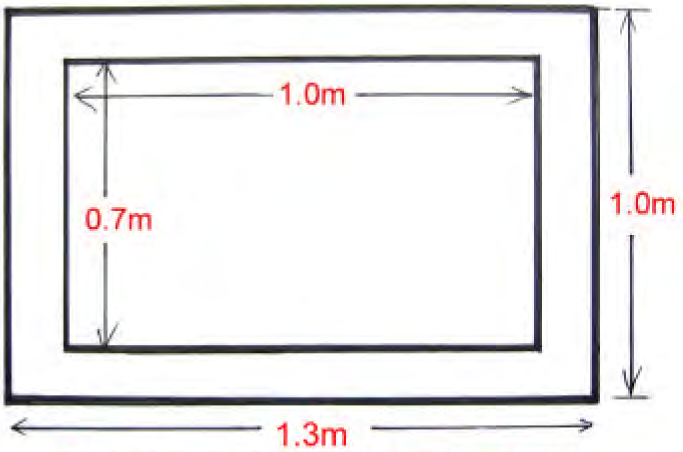
The best ring beam method uses a reinforced concrete beam which is strong and permanent. When well made, concrete structures like ring beams and slabs last almost indefinitely. They are a good investment in time and money. This is the recommended version for firm or moderately firm soils. A concrete ring beam can be laid on the surface of the ground in the same way as the ring beam for the ***Arborloo*** is laid (see previous chapter). If the ring beam is made of bricks, the soil near the head of the pit should be cut back down to about 150mm below the surface and the bricks can be built up from this level to one or two courses above ground level (see later). In both these cases the final pit is dug down within the ring beam to a depth of between 1.2 and 1.5 metres. This will provide an effective full pit volume of about 850 litres with a useable pit volume of approximately 650 litres.

Note here that the twin ring beams of the ***Fossa alterna*** can be cast in situ (ie in the final position) since they will not be moved. This is the preferred method. With the ***Arborloo*** the ring beam is best caste in another place and transferred on to site when it has cured. Since the ring beam of the ***Arborloo*** will be moved every year it must not be bonded too tightly too the soil as it may be difficult to remove at the time of the toilet migration. A tight bonding between ring beam and soil is desirable with the ***Fossa alterna***.

The internal measurement for ring beams used with the ***Fossa alterna*** should be around 1.0m diameter for round ring beams, or about 0.8m square for square ring beams or 0.7 X 1.0m for rectangular ring beams,. These will accept concrete slabs which are 1.2m in diameter, 1.0m square or 0.9m X 1.2m respectively.

Making the two concrete ring beams for the *Fossa alterna*

In those examples described here, the external measurements of the beam are 1.3 metres X 1.0 metres, the inner measurements (the size of the hole) being 1m X 0.7m. This ring beam is made for a slab measuring 1.2m X 0.9m. Wire reinforcing is used within the concrete mix, two strands of 3 - 4mm wire down each length, making a total of 8 pieces (total length approx. 9 metres). With the ring beam, the corners are a potential weak point.



Measurements for ring beam (metres)

When constructing the ***Fossa alterna***, the two ring beams can be cast on the actual toilet site directly on the ground, at least 0.5m apart and preferably at least 1.0m apart. A level piece of ground, preferably on a slightly elevated site is best. Alternatively the two ring beams can be cast away from the toilet site and moved on to site after curing. In this case a plastic sheet should be laid on the ground on which the ring beams can be made. The mould for the ring beam can be made with bricks as shown in the photo. Wooden shuttering can also be used as a mould, or a combination of bricks and wood. The ring beams are made 75mm thick, the thickness of a brick.

One 10 litre bucket of cement (weighing 12 kg) is mixed with five 10 litre buckets of sharp river sand to make each ring beam. If a 5 litre bucket is available the total mixture can be made in two batches. Half the full mixture is made first, that is 5 litres cement (6kg) and 25 litres clean sharp river sand (or if small stones are available, 5 litres cement, 15 litres sand and 10 litres small stones). A 5 litre bucket is useful for measuring, but 10 litre buckets are easier to find. Sufficient water is added to the mixture to make a thick slurry. Do not add too much water. This half mix is added to the lower half of the mould and spread out and tamped down with a wooden float. Then the wire reinforcing is added (4 lengths of 3 - 4mm wire in each direction). This is followed by the second half of the mix. If this square ring beam is used to construct the ***Arborloo***, four handles will help with the relocation. The four handles (if required) can be made from 4 steel bars about 8- 10 mm diameter and about 25cm long - four can be made from a one metre length of rod. These are bent and set in the concrete (see photo). No handles are required for the ***Fossa alterna*** ring beams as they remain permanently in position. The concrete is finally levelled off with a wooden float. The beam is covered with a plastic sheet if possible and allowed to set overnight. It is watered the following morning and kept covered and wet for at least a week before lifting. The longer it is allowed to cure the stronger it will become.

The ring beam shuttering can be made with bricks or wooden planks or a combination of both laid over a plastic sheet. Two ring beams have been cast within brick moulds over plastic sheet. After a few days the bricks can be carefully removed – watering continues. Note the handles inserted into the ring beam at the edges – these are useful if used with the *Arborloo*, but not necessary with the *Fossa alterna*, since the ring beams will never be moved. In practice handles are rarely used on the ring beam!


In the case of the *Fossa alterna* the two ring beams can be cast on the site where they will be used about 0.5m apart. In the case of the *Arborloo*, the ring beam is best made on one side and then placed in position as it will be easier to move later. Once the ring beam has been positioned and made level, the soil inside is excavated to the required depth. This is about one metre for the *Arborloo* and between 1.2 and 1.5m for the *Fossa alterna*. The excavated soil is deposited around the ring beam and rammed hard. This simple procedure will protect the pit in all but the loosest soils. Two bags of leaves are deposited on the floor of the pit before the slab is fitted. The leaves help to start off the composting process.


Here two ring beam for the *Fossa alterna* have been cast on site. On the right a completed *Fossa alterna* mounted on one of two permanently sited ring beams

Brick ring beams for the *Fossa alterna*

Ring beams can also be made from bricks which are bonded together with strong cement mortar. These beams can be built around the upper part of the pit. It is wise to start constructing the ring beam from below ground level and build up to one or two courses above ground level. The outer measurements are the same as for the concrete ring beam. However measurements for the both the slab and the ring beam are optional. A brick ring beam may be constructed from between 0.3m (shallow ring beam) to 0.5m (deep ring beam) below ground level. This leaves at least half the pit unlined but in most soils this is quite satisfactory for light weight structures placed over shallow pits.

Partly lined pits offer better drainage potential for the ***Fossa alterna*** compared to fully lined pits where the area of seepage is reduced to the base area only. There is a chance that this may become plugged if the water table does rise into the pit, or if too much water/urine is added. If the soil conditions allow for good drainage it may be best to fully line the pits. A generous layer of leaves (2 sacks full) added to the base of the pit helps drainage, as well as improving the efficiency of composting.

Deeper ring beams are normally constructed from 0.5 metres below the surface and rise to one or two courses above ground level. They can be made 100mm wide (single brick thickness) or 225mm wide (double single brick thickness) for extra stability.

If the "standard" slab size of 0.9m X 1.2m is used, the outer measurements of the brickwork for the single course should be just over 0.9m X 1.2m so the slab will fit neatly over the ring beam. Allow about 1 -2 cm all round - that is 0.95m X 1.25m for the outer measurements of the brick ring beam. In the case of the double course the outer measurements for the ring beam will be about 1.15m X 1.45m (pit excavation size about 1.2m X 1.5m).

The initial hole should be dug down about 0.5m below ground level - the hole size determined by the thickness of the brick construction (single or double course). The brick wall is build up from the base of this shallow 0.5m deep pit to one or two courses above ground level with strong cement mortar. The uppermost brick layer should be covered with a strong cement mortar for strength and protection. Once the mortar has hardened after a few days, the hole can be deepened to 1.2 – 1.5 metres within the brickwork. Two such partly lined pits are built about one metre apart. Since concrete slabs will be taken off and placed back on the ring beam/upper pit lining at yearly intervals with the ***Fossa alterna***, it is desirable that the working surface of the uppermost concrete/plaster layer be durable. This should be made of high strength mortar or concrete which is well cured. It should be well formed and left to cure under wet conditions under a cover for a week to develop a good strength. Often this final plaster layer is thin and made in weak mortar, just for appearances. The brick work of this vital working layer may fall apart when put to use if not properly made.

Arrangement of brick ring beams for the *Fossa alterna* with permanent structure

In Mozambique the slabs and pits are square and the brick ring beams are also made square and built up about four courses, three below ground level and one above. There is a little variation depending on the type of soil. In Mozambique, as in Malawi, the two shallow pits, which are dug up to 1.5m deep are "housed" within a single, permanently placed, non movable superstructure, made of grass and poles in Mozambique, and often bricks in Malawi (see later). In these cases the ring beams are built about 0.5m apart to conserve space.

Examples of brick ring beams for the *Fossa alterna*


Prototype *Fossa alterna* being built at Woodhall Road. Each ring beam was constructed with three courses of cement mortared brickwork. The two pits were only 0.3m apart. This distance was later increased to 1m. The experimental prototype had a shallow pit only 0.6m deep. Later pits are dug over 1m deep, and normally at 1.2metres. 1.5 metres is a maximum depth for the *Fossa alterna.*


***Fossa alterna* ring beams being constructed in Lilongwe, Malawi. Here the soil is firm. In this case the pit is first dug down to about one metre. The upper end has then been widened to allow for the 2 course brick ring beam to be constructed from one brick course below ground level. Two brick courses have been built above ground level. Soil taken from the pits is then built up around the two ring beams. This raises the site of the toilet above the surroundings, which helps divert rainwater from the site.**


On the left two brick ring beams have been built for a *Fossa alterna* in Lichinga, Niassa Province Mozambique. On the right two brick ring beams have been built in Kusa, near Kisumu, Kenya. The ring beams are permanently sited and are best bonded with strong cement mortar.

Brick ring beams for the *Fossa alterna* at the Friend Foundation in Harare. On the left three ring beams have been built in a line. This communal unit is heavily used and in order to attain the one year composting period, three pits, each one metre deep have been built. The slab and structure rotate between the three pits. On the right the brick ring beam is shown. It has been built with four courses of bricks. The pit is first dug down 0.5m and about 1.3m X 1m wide. The brick beam is then built up to one course above ground level. The brick mortar is allowed a day or two to cure and then the pit is dug down deeper to the required depth (1m – 1.5m). Note the layer of strong cement mortar covering the upper surface of the brickwork. This mortar is also extended outside the beam above ground level. This makes a strong and durable ring beam unit for the *Fossa alterna.* It is intended to last for many years.

Fully brick lined pits for *Fossa alterna*

These are required for the ***Fossa alterna*** if the soil is very loose. A full brick lining is used in all cases where a brick superstructure is built. Fired bricks and cement mortar should always be used underground. The brick lining is built up to at least one course above ground level. Always use cement mortar for bonding and fired bricks. When pits are lined from top to bottom with cement mortared bricks, it is only the bottom surface which allows for drainage. In clay soils the drainage will be poor and not entirely suitable for the ***Fossa alterna.*** The brick lining is built up to at least one course above ground level. The bottom should be cleaned of cement and a very generous later of leaves placed in the pit before use.

A fully brick lined *Fossa alterna* pit in Epworth close to Harare. The pit was 1.1metres deep. The soil is sandy and less stable. On the left the base of the pit is being cleared of cement mortar dropped during the brick work stage. On the right a layer of weak cement mortar is applied on the brick ring beam before the toilet slab is mounted on the ring beam. This weak mortar forms a good air tight base on which the slab can sit. This is important as it makes a good foundation for the slab and also an airtight seal for the best functioning of the vent pipe(when fitted), which draws air through the system, reduced pit humidly and also controls flies and odours. The ring beams in this case are about one metre apart.

On the left a permanent brick *Fossa alterna* structure is built around two brick lined pits in Thyolo, Malawi (COMWASH Project). The brick lined pits are shown on the right.

Proximity of twin pits/vaults

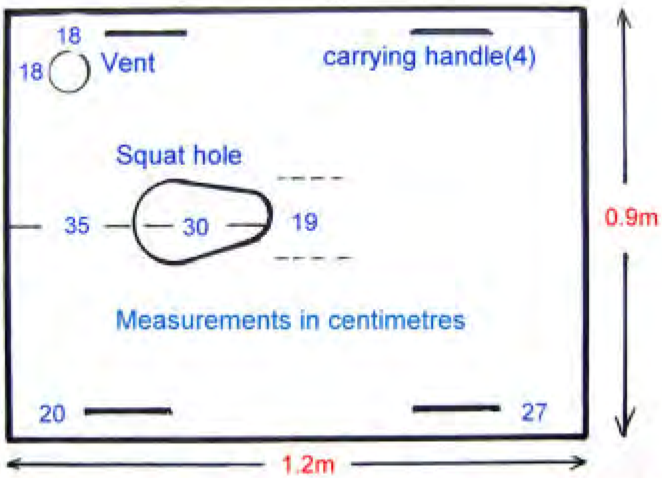
In the first prototype ***Fossa alterna***, built in June 1999, the two pits were placed side by side only 300mm apart. These pits were protected with brick ring beams. By placing the pits slightly apart the possibilities of seepage of digesting excreta from one pit to the other were reduced. If some space is available it is best to place the twin pits one metre apart to avoid any contamination passing from one pit the other. If space is really restricted 0.5m is adequate. The pits can be dug close together for convenience of movement of the superstructures, but far enough apart to reduce the potential of one pit being influenced by the other in terms of leakage of contents. Thus two separate pits, dug about one metre apart is recommended. If the two pits are located within a non portable structure, as is the case in Mozambique and Malawi, then the pits cannot be far apart. Normally 0.5m is adequate.

Making square or rectangular concrete slabs

These slabs are made with either a 3:2:1 mix of river sand, small stone and cement or a 5:1 mix of clean river sand and cement. They use the same amount of materials as the concrete ring beam described earlier – that is 10 litres cement (one quarter of 50 kg bag) plus the other ingredients. If small stones are available, then this will be stronger, but usually small stones are not available so river sand alone is normally used. The river sand should be clean and sharp, with little dust and small chips included. As with the ring beam, half the mix is made up first (5litre cement + 25litres river sand) and added to the mould and levelled off. The wire reinforcing is now added (same as ring beam – 4 pieces of 3 - 4mm wire in each direction – making a total of 8 pieces).The final half of the mix is now prepared and added, levelled and finished off with a steel float. Four handles should then be added, made from 8mm or 10mm steel bar and bent into shape.

The concrete slab described here is 0.9m wide and 1.2m long and about 40mm thick. The mould in which the slab is cast can be made with bricks or wooden planks or a combination as shown in the photos below. Most slabs are made with squat holes as this is the preferred position, but slabs can also be prepared for fitting a pedestal. In the case of the squat hole a suitable hole can be made by taking a 20 litre bucket, cutting off the bottom and bringing together the base into a pear shape with wire. A squat hole size of about 30cm X 19cm is required. If a pedestal is fitted the hole is 30 cm across and can be formed by a plastic basin. A hole can be made for a vent pipe also in the slab. This is made by inserting a short length of pipe (75mm long) in the slab at the appropriate position (see diagrams). The vent hole size should match the pipe which will normally have a diameter of 110mm. It is possible to make a low cost home made vent pipe using hessian and cement.

One 10 litre bucket of cement (weighing 12 kg) is mixed with five 10 litre buckets of sharp river sand to make each slab. If a 5 litre bucket is available the total mixture can be made in two batches. Half the full mixture is made first. That is 5 litres cement (6kg), 15 litres sand and 10 litres small stones (or 5 litres cement and 25 litres clean sharp river sand). A 5 litre bucket is useful for measuring, but 10 litre buckets are easier to find. Sufficient water is added to the mixture to make a thick slurry. Do not add too much water. This half mix is added to the lower half of the mould and spread out and tamped down with a wooden float. Then the wire reinforcing is added (4 lengths of 3 - 4mm wire in each direction). This is followed by the second half of the mix. The four handles can be made from 4 steel bars about 8- 10 mm diameter and about 25cm long - four can be made from a one metre length of rod. These are bent and set in the concrete (see photo). The concrete is levelled off with a wooden float and finished off with a steel float to make smooth. The slab is covered with a plastic sheet if possible and allowed to set overnight. It is then watered the following morning and kept covered and wet for at least a week before lifting. The longer it is allowed to cure the stronger it will become. 10 days is even better.



Measurements for 1.2m X 0.9m concrete slab

Where generous quantities of soil and wood ash are added regularly to the pit contents, there may be little need to fit a vent pipe, as these additions greatly help to reduce fly and odour nuisance. But the vent does help to reduce any odours that are present and controls flies as well if the required volume of ash and soil is not added. Vents also carry away excess moisture from the pit, which will almost certainly help the composting process. They also ensure that a fresh supply of air is being circulated through the pit, which will also help composting. Because the slabs of both the ***Arborloo*** and ***Fossa alterna*** will be moved at approximately one year intervals, it helps greatly to fit four carrying handles to the slab. These can be made by cutting 4 lengths of 8 - 10mm steel rod each about 25cm long and bending them and inserting in the fresh concrete towards the edges. The concrete is levelled off with a wooden trowel and finally smoothed down with a steel float. Once the concrete has begun to harden, the moulds for the squat or pedestal holes and the vent pipe hole can be carefully removed. The slab should be covered with plastic sheet if possible and left for a week to cure. During this period it should be kept wet continuously. If plastic is not available it can be covered with sand which is kept wet. For all concrete work, good curing is essential.

Photo of slab mould made of bricks and wooden shuttering. The eight pieces of 3mm reinforcing wire have been cut and laid on the plastic ground sheet. Four carrying handles have also been prepared. A 10 litre bucket with the base removed has been shaped by drawing in the two sides with wire. A 75mm length of 110mm pipe has also been cut to make the hole for the vent pipe. Thus all has been prepared for the addition of the concrete.

The addition of concrete is complete. Half the mix is added first, the reinforcing wire is laid, followed by the remaining concrete which is smoothed down. The handles are added by pushing them into the concrete mix. A little extra cement can be added around each handle to increase the strength of the concrete at this point. Finally the slab is smoothed down flat with a steel float and left to cure.

In many latrines, the slope of the slab is made so that washing water will flow into the squat hole. However if no roof is fitted to the structure the slab will act as a rainwater harvester and water will collect in the pit, which is undesirable. It will be remembered that for the natural breakdown of excreta into humus suitable for tree growth, the pit contents should not be too wet, but should be moist. It is undesirable therefore to have too much water entering the pit. One option is to make the slab flat or to slightly raise the central area around the squat hole including the foot rest area. In this case most drainage water from the slab will flow onto the ground around the slab. This might undermine the ring beam or pit head during the rains. However since the slab will move from one pit to the next, undermining of the ring beam within in a season may be unlikely. The simplest method is to make the slab flat – most rainwater will run away from the squat hole. The ideal is to fit the toilet structure with a roof.

Preparing the pit before use

Before the slab is fitted it is a very good idea to add two sacks full of dried leaves to the base of the pit. This will help the composting process from the moment fresh excreta is added. This composting process will take longer if the excreta falls on barren soil at the base of the pit.


Adding dry leaves to the base of a pit helps the composting process A full sack full or even two sacks full works well. The pit is ready – ring beam in place and leaves at bottom

Adding the concrete slab

The concrete slab is now mounted on top of the ring beam. It is wise to bed down the slab on the beam in a layer of very weak cement mortar (20 parts pit sand + 1 part cement). This makes the slab firm and stable. If a vent is fitted to the system it is very wise to seal any gap between the beam and the slab. This will improve venting of the pit and fly control. If there is a gap between the slab and the ring beam, odours may be released and this attracts flies. Also the efficiency of venting is reduced. A very weak mix of sand and cement can be used as a sealer (20:1) or soil cement or termite mortar. If cement is not available at the time, termite mortar could be used. The slab is now fitted centrally over the ring beam.


Adding a layer of weak cement mortar for the slab to rest on. This helps the slab to rest on the ring beam without strain. Also if a vent pipe is used, the pit should be air tight, thus allowing the suction of the pipe to draw air down the squat hole or pedestal. This leads to odourless conditions in the toilet. On the right a slab is mounted over the ring beam. This stab has a larger hole intended for a pedestal caste in it.

Adding dry leaves to the base of the pit in Epworth

The concrete slab is bedded into a layer of weak cement mortar on the ring beam. The photo on the left shows one being fitted at Epworth. The photo on the right shows the prototype fitted in Woodhall Road. Carrying handles are useful when moving the slab from one pit to the other

Superstructures for the *Fossa alterna*

Fitting the superstructure (with optional vent pipe and pedestal).

A great variety of superstructure designs are suitable for the ***Fossa alterna***. The main purpose of the structure is to provide privacy – the functioning of the ***Fossa alterna*** is not much influenced by how the structure is made. However a roof is very desirable, as this helps to control flies and helps to keep rain out of the pit. Very wet pits do not compost well. The various photos in this chapter and the previous chapter on the ***Arborloo*** show the great variation in superstructure design. Not all ***Fossa alternae*** are built with a single portable superstructure however. Most of those in Mozambique built under the WaterAid and ESTAMOS programmes, and also in Malawi under the WaterAid, CCAP and COMWASH programmes use a single larger permanent superstructure which surrounds and is built around both pits. The WaterAid funded work on promoting ecological sanitation in Mozambique and Malawi has been very successful. The ***Fossa alterna*** concept has become very popular because the regular addition of meaningful quantities of soil and ash to the pit have noticeably reduced fly and smell nuisance. The permanent location of the twin pits is attractive to the users since it seems to offer a longer term solution to their sanitary problems. Equally as important is the realisation that within a year, excellent humus can be extracted easily from the shallow pits (up to 1.5m depth). The value of this humus when applied to vegetable gardens is thought to be considerable. All these features make sense to the users. For once the toilet has a value of its own, apart from the disposal of excreta. The ***Fossa alterna***, like the ***Arborloo***, may have come at a time when the sanitation world is in need of a new approach.

Examples of *Fossa alterna* superstructures


On the left the prototype *Fossa alterna* used a wooden structure and two shallow pits with brick ring beams. On the right a *Fossa alterna* in a low density suburb in Harare. This unit used two concrete ring beams, a structure made with a steel frame overlaid by grass and a 75mm PVC vent pipe.


***Fossa alterna* at Woodhall Road, Harare. Note hand washing facility, waste water falling into a flower pot. Second pit during the first year was filled with leaves and compost. It was also used to grow comfrey (see later). Inside a home made pedestal has been fitted. The yellow bucket contains a mix of soil and wood ash and a dispenser. Leaves are also added occasionally.**


Fitting the portable superstructure to one of the twin *Fossa alterna* pits in Epworth, close to Harare. During the first year the second pit was filled with leaves and thin layers of soil to make leaf mould. After 12 months the leaf mould was dug out and the slab and structure moved to the second pit (as shown). The pit filled with excreta, soil, ash and leaves has been topped up with soil (see right of picture).


***Fossa alterna* in Niassa Province, Mozambique built under the WaterAid funded programme. The twin pits are enclosed in a single pole and grass superstructure which is permanently located. A washing area is also constructed as part of the system. These are very popular units, as they are almost odour and fly free, unlike many earlier toilets built in the area. They are also relatively low cost. The pits are each 1.5 metres deep and protected by brick ring beams. Here one of the pits is being excavated for humus.**


On the left a *Fossa alterna* with portable structure being constructed in Kusa Village, Kisumu, Kenya. On the right a permanent brick and thatch *Fossa alterna* built at Kufunda Village, Ruwa, Zimbabwe

Management of the *Fossa alterna*

1. Daily management

Add soil, wood ash and leaves regularly

Two sacks of dry leaves are added to the pit base before use. Then the ***Fossa alterna*** is used much like a normal pit latrine. Urine, faeces, and anal cleansing material, preferably paper are added every day. In addition and in order to build up the mix of ingredients which assist in the conversion of faeces into compost, it is important to regularly add dry topsoil and wood ash to the pit, preferably after every visit made, and also leaves from time to time. At the very least a small cup full of the soil should be added after every visit made to the deposited faeces. It is unnecessary to add the extra ingredients after urination only - this may result in the pit filling up too quickly with soil. If this soil is mixed with ash the resulting mixture will improve, as it will be slightly more alkaline and some potash will be added. Wood ash also helps to reduce odour and flies. The final texture of the compost formed in the pit will be improved greatly if leaves are also added regularly. At least a sack full should be added before the pit is put to use. These compact a great deal and the volume of leaves added should be generous. The leaves may have a considerable nutrient value of their own, as described for leaf compost in the gardening chapter. So they will improve not only the texture, but the overall nutrient value of the final humus. The final quality and usefulness of the pit compost will also be improved by the addition of organic vegetable matter from the kitchen like fruit skins and vegetable peelings. However this will increase the volume of added materials and a balance must be struck between volume added and final quality of the compost. The more soil and vegetable matter (like leaves and vegetable/fruit cuttings, the more crumbly and valuable the product will be in agriculture.

Ideally a premix of soil and wood ash can be made in the dry state and stored for use in bags. Such a mix is best prepared in the dry season. Dry leaves, even when crushed, do not mix well with soil as the heavier soil tends to fall deeper into the mix with the lighter leaves being concentrated on top. Hence the leaves must be added separately to the pit – taken from a separate container, like a sack, within the toilet. The dry soil and wood ash can be mixed beforehand - mixing 4 parts of dry soil to one part of wood ash. This is best mixed in bulk, stored in a larger container or sack and then brought to the latrine in smaller lots. Similarly the dried leaves are stored in bags and also brought into the latrine in smaller lots. The leaves once dry can be crushed to reduce their volume before storing in bags. They can be crushed by treading, by beating with a stick or rake, so that the leaves break down in to smaller units. The volume of dry leaves can be reduced considerably in this way and make for more efficient storage. The leaves will compact a great deal once in the pit and the soil will provide microbes which greatly assist the conversion of the excreta.

Pit filling rates

A little mathematics is required here. The volume of soil and ash added to the pit should be thought out beforehand and a suitable container such as a mug, or the upper part of a plastic milk bottle, with handle attached used for dispensing the soil/ash mix. If a family of 6 persons defecates once a day each into a pit and adds soil/ash after each deposit is made, it is possible to roughly calculate the resulting volume of soil. In a pit of cross section 0.7 X 1m X 1.2 m deep the volume to the top is 0.84 cu.m. or about 850 litres. The actual available space may be slightly less, since the upper part of the pit will not be used. If each member deposits 0.2 litres of soil/ash per day that means that approximately 1.2 litres of soil/ash will be deposited each day into the pit. That amounts to 450 litres of soil/ash per year. The leaves (about a hand full) should also be added, but once composted they will occupy a very small volume indeed - but they will be absorbed into the soil to improve its texture and also add more nutrients. The initial volume of faeces added by the family of six to the pit will be at least equal to this volume if not more - say 600 litres. That is 100 litres per person per year. But about 80% of this initial volume is water. After composting and absorption into the soil, the resulting solid fraction of faeces from a small family may amount to about 250 - 300 litres per year. A much greater volume of urine will be deposited in the pit. Some of this will be absorbed into the pit soil and leaves and later into the resulting compost, but much will seep away into the surrounding ground. This loss of potential nutrients from the urine, particularly nitrogen, must be accepted in shallow pit systems of sanitation like the ***Fossa alterna***. That is unless the excellent practice of storing urine, by urinating into containers is also carried out by the family (see chapter on urine). Such storage of urine is highly recommended. In the ***Arborloo*** not all the nutrients available in the urine are lost from the "loop" as they are absorbed into the surrounding soil and will later be taken up by the tree which is planted on the pit. The accumulation of the stable phosphorus in these shallow pits is particularly valuable.

Thus the combined annual volume of ingredients added to the pit may approximate 450 litres soil/ash/leaves plus a processed volume of faeces amounting to 250 - 300 litres, plus urine which will be absorbed into the compost and leaves or drain into surrounding soil. Thus an annual total of approximately 700 – 750 litres of compost can be expected. In practice a 1.2 metre deep pit will fill up in about one year for an average family. A 1.5 metre deep pit provides more latitude and should be aimed for.

It is accepted that in the real world such additions may not follow these recommendations exactly. In practice the soil may be added less frequently, resulting in a lower proportion of soil to excreta. The concept will still work quite well if soil alone is added without ash, but will not work so well if wood ash alone is added. The combination of human excreta and "any" soil will make a "new" soil which is greatly enhanced in terms of nutrients. The addition of a rich topsoil makes a better product than poor sandy or barren or clay like soil. Leaves provide extra nutrients, but equally as important they improve the texture of the final product considerably and also allow more air into the mass which helps the composting process. Also urine combines well with leaves to make compost. So the best is fertile topsoil, wood ash and leaves in combination. This combination will turn into excellent compost.

However the easiest way may be the only way at first - and this will be to use the soil which has been excavated from the pits or surrounding topsoil, whatever is available. Such soil may be very poor - both in texture and in nutrient content, but remarkably, once combined with excreta, the nutrient levels of the soil rises significantly (see chapter on soil tests).

Sources of fertile soil and compost in the garden

Sources of fertile soil can be found in most gardens to add to the used pit and also to add on top of the leaves which are added to the second pit. A good place to look for fertile soil is under trees where leaves may have fallen and begun to make "leaf compost." Leaf compost is the final product of decomposed leaves. Look around the garden for places where compost may have been made before and vegetables grown. Often the soil is barren in dry areas. Therefore the search for fertile soil will be more difficult. It is always a good idea to start making a compost heap to enrich the garden soil for planting vegetables. Sometimes it may be necessary to import some compost or fertile soil (on a Scotch cart for instance) from some other place where the soil is more fertile. Once the ***Fossa alterna*** is working properly, a yearly supply of compost for the garden will be available within the homestead from the composted pits. It is worth making the effort in the early years. The greater the proportion of these compostable materials added to the pit, the better will be the final humus excavated.

Finding fertile soil or leaf litter in barren environment

The question will be asked: where do we find fertile soil in a barren environment? The answer lies in looking under trees where humus may have been accumulating - or even going farther a field to find it and bring it back to the homestead in bags. Leaves may accumulate in pockets or depressions and may have partly converted into leaf mould over the seasons. The search for a living soil will often come up with something. The best soil which is available should be used first time around. Second time around the humus excavated from the first pit can be added to the second pit which will now be filling

No garbage please!

Since the compost will eventually be dug out, it is doubly important to ensure that garbage (rags, plastic, bottles, wire, glass, rubber, etc) is not tossed down into the pit. Such garbage can make later excavation tedious, difficult, unpleasant and even embarrassing. Thus plastic, rags, bottles and various other non compostable items should be disposed of elsewhere, like shallow garbage pits. They should NOT be placed down the ***Fossa alterna*** pit.

Not too much water either!

The conversion of excreta into compost will not take place if the pit is flooded with water. This means that only limited amounts of water should be added to the pit. Good pit drainage very much dependent on soil type and area of soil in the pit available for drainage. Where the ring beam method of pit protection is used a large surface area of soil will be available for pit drainage. Where the walls of shallow pits are lined with bricks to the base - only the base will be available for drainage. There will be a lot of variation depending on soil type, pit volume, pit protection type and the material content of the pit. But it is wise to add some water to the pit from time to time to keep the content moist. It is an excess of water that is not required. **So eco-latrines should not be used as bathrooms.**

Take a look from time to time!

For the best results, it pays for the user to look down the pit from time to time. One feature of adding soil and ash into the pits of eco-toilets, which is rarely mentioned, is the formation of mounds of excreta rising directly beneath the pedestal/squat hole. This is the result of adding dry soil/ash to the excreta directly after defecation. A pile of material results, which can look like an ant turret - it can be called “turreting.” When this happens, any soil or ash added tends to fall to the sides of the turret and the best mix of excreta/soil/ash cannot result. Thus it is advisable from time to time for the user to take a stick or pole and try to level off the pit contents so that more of the available pit space can be used. Normally this involves moving the pile forwards towards the “front end” of the pit to level out the pit contents. This will help to some extent to mix the ingredients and assist the conversion process. This is very desirable in the ***Fossa alterna*** so that the greater part of the pit can be occupied with excreta/soil mix – and pit life can be extended. This means “spreading the load” a bit. The family should aim to fill the pit up in a year or more, and not less than a year. Thus the spreading out of the pit contents is an important part of routine ***Fossa alterna*** management.

Adding more soil and leaves to pit contents.

The routine of adding soil and ash after every visit, and preferably leaves as well, is important. This will help the conversion process. The soil mix is best stored in bags and then placed within the toilet in smaller containers for daily use.

The ratio of soil/leaves to excreta is increased by adding of leaves to the base of the pit before the concrete slab is fitted. This layer helps start off the composting process. It may also help to add an additional 30 litre bag of leaves to the pit half way through its one year cycle. Thus a good layer of "living soil" can begin to act on the raw excreta during the filling stage. Once the pit is filled and the slab and structure moved over, the final layer of leaves followed by fertile soil is added to cover the excreta. Once again the process is helped along if extra soil is rammed into the pit contents. A good layer of leaves followed by topsoil should be left on top of the pit contents and even these can be covered with leaves again. The overall aim is to get as much living soil and leaves into the pit mix as possible to help the conversion.

Effects of venting

The dry soil, wood ash and leaves do help to remove excess moisture from the excreta and this is desirable, since the conversion of excreta into humus will not take place in wet conditions. The addition of a vent pipe also helps to circulate air through the toilet system and also assists in the removal of excess moisture and condensation from the pit chamber. Vent pipes help to remove odour and if fitted with a corrosion resistant fly screen, reduce fly nuisance as well. However the production of compost will not take place in very dry conditions either. Toilet paper and leaves for instance will remain little changed in a very dry vault. The composting process needs some moisture, just as a compost heap requires moisture. So washing down with water will help from time to time.

Management of the second pit in the *Fossa alterna*

It is essential to dig and protect both ***Fossa alterna*** pits during the initial building stage. Whilst the second (and as yet unused) pit can be left empty and covered with wooden lid, it can also be used to the best advantage, whilst the first pit is filling.

The second pit can be used to make leaf compost by the addition of leaves, interspersed by thin layers of soil which is watered regularly. Since ecological sanitation concerns recycling in all its aspects and the development of a recycling habit within the homestead, it makes good sense for the concept of "pit composting" to be introduced. The aim is to develop the interest of composting as a sound gardening practice in combination with the use and management of the eco-toilet. The ***Fossa alterna*** system makes this possible. Even adding leaves and some local soil to the second pit during the first year of operation can be very valuable. The leaf compost formed in a second a pit in Epworth near to Harare was considerably more fertile then the surrounding soil and proved to be valuable in growing vegetables and maize. At times of heavy rain it is best to cover a composting pit to avoid flooding. If the second pit is not used for growing plants like vegetables or comfrey, it should be covered with a wooden lid.

On left, comfrey being grown on second pit of *Fossa alterna* during the first year. Comfrey is rich in potassium and makes an excellent mulch for vegetables, especially tomatoes. On right leaf compost being made in the pit – a mix of leaves and a little soil – should be kept moist.

Time to change sides!

"Changing pits" on the *Fossa alterna*

Once the used ***Fossa alterna*** pit is nearly full the time has come to change pits. For a family this should be after one year or more. If the latrine is heavily used, and the pit filling time is less than 12 months, it is best to make an additional ring beam and use 3 pits which are filled in rotation. If the pits are used more heavily 4 pits may be necessary. The time of conversion of excreta into compost is dependent on several factors which include moisture content, temperature, mixture within the pit etc - the more topsoil and leaves the better. The pit must not flood, neither should it be very dry. Temperature will depend on altitude and season. In warm/hot areas under the right conditions, compost can be formed in a few months. The higher the ratio of soil/ash/leaves in the pit the more effective the conversion will be. Also the more varied the ingredients - the higher the fertility of the humus will be.

If the second pit has been filled with leaf compost during the past year, this should be emptied - thus making available the empty pit. The excavated compost can be used on the garden, but it is also usefully added to top up the pit filled with excreta and soil etc. The same material can be used to add to the new pit as it fills up.

Changing sides involves first remove the superstructure and slab and placing these to one side. Add plenty of leaves into the empty pit. Now place the slab on the ring beam above the empty pit and also seal this off with a weak cement mortar or termite mortar. Now add the superstructure back on the slab (and any pedestal if used). The procedure for toilet management is now started on the second pit, just as before.

Dealing with the pit filled with excreta etc.

The pit filled with excreta/soil/ash/leaves etc is now levelled off and fertile soil is added. The best results are obtained if extra soil and leaves can be rammed into the body of the pit with a gum pole. This ensures that more soil and leaves are added and well distributed. This may appear to be a most unpleasant task at first. But it pays off. In any event, even if new soil is added just to cover the existing pit contents, this will break down within the year. A layer of about 100mm - 150mm is best. The soil is best fertile and can be taken from the compost pit or from a layer of good topsoil if available. A final layer of leaves can also be added as leaf mulch. The pit is watered a little to make the contents moist. The pit can now be left to convert for one year. Occasional watering is required, even if plants are not added to keep the contents moist. The pit must never be flooded.

Excavation of the pit compost

After one year of composting the pit compost can be removed. The pit contents will have considerably shrunk after one year, perhaps to about two thirds of the volume, as the water content of the faeces is absorbed by the soil and into the walls and floor of the pit. Normally this pit compost is easy to excavate and usually much easier to remove than the original soil when the pit was first dug. A shovel and pick are used. The pick can be used to loosen up the compost, especially nearer the bottom. The compost should be quite dark in colour, but the colour and texture of the material depends on what has been added to the pit.

The compost removed from the ***Fossa alterna*** pit is best stored in bags at first, where it will get more time to compost further. It can also be dug into the garden soil, also in preparation for planting. The process of biological breakdown will continue. It can also be mixed with local topsoil and placed in containers or shallow trenches for growing vegetables or pits for growing trees. These methods are described in another chapter. As with all gardening practice, it is wise to wash hands after doing the gardening and handling compost from these shallow pits.

After the pit has been excavated and the compost stored in bags etc, two sacks of dry leaves are added to the base of the pit and the process is repeated. The slab and structure are moved onto the empty pit. The pit filled with of excreta, soil, ash and leaves is topped up with soil and leaves and allowed to compost for another year.

This same process is undertaken once a year, every year. Excavating a shallow pit does not take long (about 45 minutes) and if the right ingredients have been added through the year the process should be easy and not offensive in any way. It is quite remarkable how the foul human excreta can change into a pleasant material. It will change into compost if there is enough soil, ash and leaves in the mix to help the process along. Seeing it for the first time most people are very surprised to see this miraculous conversion of Nature.

Ephraim Chimbunde excavates humus from a *Fossa alterna* pit in Hatcliffe, a project of Mvuramanzi Trust. The compost is placed in bags for storage and later transported to the vegetable garden of choice.

The “long cycle” alternating compost VIP toilet

In the ***Fossa alterna*** unit so far described the period of alternating is about 12 months. The pit is relatively shallow (max 1.5 metres) which has several advantages. These advantages include ease of digging, reduced compaction, better composting, more distant from water table etc. However it is also possible to build a pit toilet of this type where the pit is a little wider or deeper (max about 2 metres) so the period of alternating pits can be extended to between 2 and 5 years depending on usage. Composting is encouraged as before by the generous addition of leaves to the base of the pit before use and then regular addition of soil, ash and leaves during use. When fitted with a vent pipe, this becomes a variant of the VIP toilet.

Where the alternating period is longer, recyclable superstructures made of brick can be used. These are best linked to a steel frame fitted with “sprags” which are bonded into the brickwork. Such frames can be fitted with hinges made of car tyre rubber. Also the option of fitting lighter doors mounted on the door frame is possible. In this case the bricks are mortared together with a weak cement mortar (20 parts pit sand to 1 part Portland cement). Experience has shown that such brickwork can hold firmly for years, but is also easy to take apart and rebuild. Roofs and vent pipes are best built in materials which will last for a very long time and can cope with being dismantled and reconstructed. The ideal is asbestos. Asbestos vent pipes last much longer that PVC pipes. With good bricks and asbestos roofing and vent, a brick superstructure can be recycled periodically for many years.

Pit volume can be increased by enlarging the cross section of the pit from 0.7 sq.m. (in the model described earlier) to 1.2 sq.m or more. A pit with an upper cross section of 1.2 sq.m. and a depth of 2m will have a total volume of 2.4 cu.m. This is nearly three times the capacity of a pit with a cross section of 0.7sq.m and a depth of 1.2m (0.84 cu.m.). The larger ring beam (external measurements 1.2m X 1.4m and internal measurements 1m X 1.2m) will require a larger and heavier slab. This will have dimensions of 1.2m X 1.4m and will be 1.5 times as heavy again as the smaller slab(1.2 X 0.9m) and will use 1.5 times the volume of cement and sand to make (15 litres cement + 75 litres river sand). Experimentation is required.

Once again the type of superstructure mounted over one of the two pits is optional. But where the recycling time is longer, bricks can become a serious option. Where the steel frame version with sprags is used, the entire structure can be taken apart, bricks cleaned, slab relocated and structure completely rebuilt within 6 hours by an artisan. This relatively easy process is possible because the entire brickwork is mounted on the slab itself and no separate foundations are required. The brickwork for this system is built on edge, to reduce weight and the number of bricks required. A steel frame superstructure covered with any suitable material (such as grass) to provide privacy is also a good option. Where heavy brick structures are used both pits must be lined with bricks to the base. A good ring beam is probably adequate for lighter structures. It is desirable to dig and line both pits at the same time, using one immediately and retaining the other for future use. The second, as yet unused pit can be filled with leaves to make leaf compost. Whilst this procedure (digging and lining both pits at the same time) may seem unnecessarily laborious, experience has shown that if both pits are not built at the time of the toilet programme, a second pit may never be dug and lined, or dug and lined poorly. For the ***Fossa alterna*** concept to be successful it is essential that both pits be available for use from inception.

Photos of a fully recyclable "alternating compost VIP toilet"

Durable and yet completely recyclable!

For long life, the vent pipe and roof are made of asbestos. Inside, a home made pedestal using a plastic toilet seat and plastic bucket. For those who do not use pedestals, the squat hole is equally as effective. A bucket of soil easily available. A cup full is added to the pit after use. Wood ash should also be added and plenty of leaves. With a good vent pipe in place the facility should be almost odourless.

Sequence of building, dismantling and rebuilding the recyclable brick superstructure.


One of the two pits is dug and lined with cement mortared fired bricks. The steel frame (with door frame) is erected at the "door" end of the slab and the brick walls are built. "Sprags" of steel welded to the frame link the steel component with the brick and mortar work.


The roof is fitted after completion of the brickwork and door fitting. An asbestos pipe will also be fitted. Photo on right shows first stage of dismantling. The pipe, pedestal and roof have been removed. Now the brickwork is taken apart.


All the brickwork has been taken apart. The bricks are cleaned up. This is easy because the mortar is weak (20:1 sand and cement). On the right the same slab, having been removed from the original pit, is relocated on the second pit and mounted over a bed of weak cement mortar.

The steel frame is mounted again on the slab and the same bricks are used to rebuild the structure.

After the brickwork is complete, the roof, asbestos pipe and pedestal can be put back in place. The operation takes about 6 hours. If the pits are changed once every 3 – 5 years, this is not a huge expenditure of time and effort. Everything is recycled, even the material in the pit, which is dug out once the time has come to change sides again.

Closer views are parts of the frame. In this case the frame is made from 40mm X 40mm X 5mm angle iron. In this case the hinges are steel, but a more durable hinge can be made from car tyre. This is shown in the chapter on special construction techniques later in this book.

Potential problems of the *Fossa alterna*

No account of the ***Fossa alterna*** would be complete without a discussion of problems that may be encountered and how they can be overcome**.**

1. Pit overused.

Use of three or more "alternating" pits!

If the "family" size is very high (including visitors, lodgers and tenants etc) a 1.2m deep pit will fill up in much less than a year. Under these conditions the rate of composting will not keep pace with the rate of new additions to the pit. It will be essential in this case to dig another pit or even another two pits to cope with the loading. In this case the structure rotates around the three or four pits, thus allowing each pit of contents more time to "convert." Making each pit deeper, say to 1.5m will also help. By doing so the same conversions can take place in the pits, but the need to evacuate a pit "ahead of time" will be unnecessary. There will be more time for the full formation of humus. The longer the period of compost formation the higher the quality of the end product, and also the safer it will be to handle. So with a little extra space being allocated for the inclusion of a third or fourth pit there will be increasing flexibility. This may be the preferred option in some locations where there is some space but where the households are very full and the "family" is extended. Thus a family of 6 will find the double alternating pit entirely suitable for its needs at the pit depth of 1.5m. But if the number of users rises to 15 or 20, two shallow pits or vaults will not be adequate. A third or fourth must be built.

This *Fossa alterna* is actually used in a heavy duty communal setting. Three pits have been built to cope with the use.

2. Inadequate soil added to the pit.

Adding soil into a pit is not the most natural way of using a pit latrine. Many users may think the pit will fill up very rapidly and may reject the idea. In fact much of the volume of excreta is made up of water and a proportion of this can be absorbed into the dry soil which is added. ***Fossa alterna*** pit filling rates are often less than anticipated by users unaccustomed to these ecological latrines. If too little soil (or no soil at all) has been added to the pit, the conversion from excreta into compost will take a long time - even years. Adding just a small sprinkling of soil from time to time will not help the process at all. Fortunately it is possible to compensate by adding bulk soil/leaves/humus from time to time to the pit. And soil can be rammed into the pit at the time of changeover to increase the proportion of soil to excreta. These various methods help. It is far better, however to add the soil, ash and leaves as the pit is filling up.

3. Right type of soil

The best soil to add is crumbly humus like soil which is fertile and healthy. This will contain a high content of living organisms like beneficial bacteria and fungi which will help to break down the faeces. Less fertile soil like sand or clay will not be so effective at converting the excreta. During the first year of operation it is wise to look around for good soil to add to the pit. After this period, some of the compost taken out of the first pit can be used to help convert future pits. However it is accepted that for most areas where the ***Fossa alterna*** will be put to use, the soil will be naturally poor. This is where the addition of leaves will help. The best ingredients for the ***Fossa alterna*** pits are excreta, soil and leaves. Ash also helps to control flies and odours and adds potash.

4. A good distribution of soil

The soil should be added often so it is well distributed in the pit and some soil is near to the excreta wherever it may be in the pit. By adding lots of excreta without soil and then adding a bag of soil later is not the ideal. Add soil often to get a well distributed mix.

5. Pit Flooding

This can happen if rain flows into the pit if there is no roof on the structure. In this case a roof will solve the problem. It can also happen if the water table rises very high in the ground on a regular basis. In this case the problem may be solved by building the pits above ground level. That means basically converting them into brick lined vaults. This method involves raising the vault completely above ground level as shown in the picture below. In this case the above-the-ground vault is used in the wet season and the latrine is placed on a ring beam placed at ground level during the dry season. Two above-the-ground vaults might also be used. It is not the ideal - then areas which are permanently flooded are not the best for human occupation, let alone the proper functioning of toilet systems.

Vault above ground and pit below the ground – used alternately.

6. Too much bathing!

Too much water from bathing can also lead to flooding of a pit. In fact it is not recommended that either the ***Arborloo*** or the ***Fossa alterna*** be used as a bathroom as this adds an excessive amount of water in to the pit, which disrupts the composting process. If bathroom facilities are attached to the eco-toilet, the wash water should be drained away to a separate soak pit.

7. Adequate pit drainage

Adequate drainage is important to the ***Arborloo*** and ***Fossa alterna*** concepts. The conversion of excreta into compost will not take place in flooded conditions. Where flooding is known to take place regularly, shallow pit methods of eco-san may not be suitable. If the soil has a high clay content and the seepage of water and excess urine from the pit will be slow, a difficult situation is created. The addition of larger amounts of dry soil and leaves from above will help. But if the pit is permanently wet with water or urine, a "dry system" like the urine diverting method (described in the next chapter) may be more successful.

8. Climate

The ***Fossa alterna*** was designed to work in a warm climate and specifically for countries in East and Southern Africa. Its operation does depend on ambient temperatures in the pit being in the range 15 – 24 degrees Centigrade for most of the year. In colder climates the rate of humus formation will be slowed down and the system may not be effective. As always when a new technology is used for the first time in a new country, it must be built somewhere on an experimental basis and examined closely for a period of at least one year, and preferably more. Only after successful trials in a new country should more wide spread promotion begin.

A sunny climate is ideal for the *Fossa alterna*

Examples of the *Fossa alterna* from different countries

The *Fossa alterna* in Kenya

Delegates at eco-san workshop in Mombasa construct concrete ring beams within wooden frames for *Fossa alterna* at the Mtomondoni Primary School (left). On the right the two pits of a *Fossa alterna* are lined with coral limestone blocks from the base in very loose sandy soil near a beach site at Mombasa.

School children at the Mtomondoni Primary School learn how to make concrete slabs for eco-toilets

On the left adding semi composted "makuti," the leaf of the palm tree, to the base of a *Fossa alterna* to promote composting. On the right a finished *Fossa alterna* at Bengala Village. Both pits, dug down to 1.5m are fully lined with coral limestone blocks in loose soil. The second pit has been left empty and covered with a tin lid. The addition of soil, wood ash and leaves to excreta promotes composting in the pits. It is this promotion of the composting process which makes the *Fossa alterna* concept possible.

The *Fossa alterna* in Malawi

The ***Fossa alterna*** is becoming very popular in Malawi and is being promoted by WaterAid in Salima and also in Embangweni by CCAP with WaterAid Assistance. It is also being promoted by COMWASH in Phalombe and Thyolo districts. The Malawians as well as the Mozambicans have chosen to enclose both ***Fossa alterna*** pits within a single permanent superstructure rather than move a portable superstructure from one pit to the other. All these units use round slabs and ring beams or pit linings mounted over circular pits. In Embangweni and Thyolo the soil is firm, whereas in Salima and Phalombe the soil is loose and unstable. These areas require different approaches to construction.

Round concrete slabs are commonly used on pit latrines in Malawi and the *Fossa alterna* also uses a round slab. Many of these are domed and use on reinforcing. Some are flat and use a small amount of reinforcing. The flat slab on left is 1 metre in diameter using a 3 to 1 mix of sharp river sand and cement and 2.5mm or 3mm wire as reinforcing. It is left to cure for 10 days. The twin pits are normally lined with fired bricks and bonded with traditional mortar. Photo taken in Phalombe district. On the right two pits dug prior to brick lining. Photo taken in Thyolo district. Thanks to COMWASH.

Simple grass superstructure for the *Fossa alterna* on the left in Njerema Village, Salima. On the right a view through the entrance showing one pit covered with a squatting slab and the second pit awaiting a cover. The *Fossa alterna* pits in loose sandy soils are lined from the bottom with bricks. Thanks to WaterAid.

On the left a grass structure for the *Fossa alterna* in Salima district with support from WaterAid. Both pits are placed within the superstructure. On the right a permanent brick structure is built over two pits lined with bricks in Thyolo.

The interior of the structure shown above on right showing the two brick lined pits within the brick structure. On the left a demonstration structure showing one pit covered with a squatting slab and the other covered with a plain slab. Photo on left taken in Thyolo, photo on right taken in Phalome. Thanks to COMWASH


Very neat *Fossa alterna* constructed in peri urban settlement near Lilongwe with support from WaterAid. The roof has still to be added. On the right a view of the interior with round domed slab.


Excavation of *Fossa alterna* pit in Embangweni. In this case the structure is a simple bamboo portable unit which is moved from one pit the other. The ground is very firm in this locality and no ring beam or pit lining was used. The pit took less than 30 minutes to excavate and the entire operation of excavating and moving the slab and structure to the newly excavated pit took less than one hour. On the right dried leaves are being placed down the new pit. These help to compost the excreta like the soil which is added.


Using the *Fossa alterna* humus. On the left the pile from the *Fossa alterna* has been brought to the vegetable garden. A shovel is used to spread the humus over the vegetable bed. On the right a hoe is used to dig in and mix the new humus into the topsoil prior to planting vegetables at the onset of the rains.

An example from South Africa

A *Fossa alterna* built at Mbaswana, Maputaland, Kwazulu Natal, South Africa, by Partners in Development. Thanks to Dave Still and Stephen Nash.

Some work on recycling the existing pit contents of VIP toilets is also being carried out in Maputaland. On the left a previously full pit toilet, to which soil and leaves were added from the top is being dug out three years later. Previously it would have been impossible to dig out by hand. In Maputaland and elsewhere in South Africa, large numbers of VIP toilets were built years ago and many are now full.

In a new series of experiments leaves are added to the bases of dug out pits and the users asked to put plenty of soil, ash and leaves into the pit as they use it. And not to use the pit as a garbage dump. It it thought that this refinement in the way pits are used will make hand excavation easy in the future. Where twin pits are used, the family alternates the use from one pit to the other. The pits under investigation are lined with concrete rings. Each concrete ring is 1m in diameter and 40cm deep. Up to 6 rings are used to line a pit. Pits of this size (1.8 cu.m.) can last a family up to 5 years.

An example from Zimbabwe
Changing pits in the Epworth peri-urban settlement near Harare

This ***Fossa alterna*** was constructed in September 2001. It is used by a family on a plot in Epworth, where the soil is very poor. When the toilet system was first built, the second pit was filled with leaves and soil to make leaf compost. In September 2002 the leaf compost was removed from the second pit and added to a trench in which maize was late planted. The slab and structure were moved from the almost full first pit onto the empty second pit. The pit filled with a mix of excreta, soil, ash and leaves was topped up with more leaves and soil. This was left for another 12 months. In September 2003, the second pit change was made. This involved excavating the composted excreta from pit 1, adding leaves to the base of this pit and moving the slab and structure from pit 2, which was almost full, back to pit 1. The second pit was topped up with leaves and soil in preparation for a 12 month composting period. The photos below show the sequence. The pit excavation took 30 minutes and was easy work since the composted pit soil was loose. Moving the structure and topping up the used pit with leaves and soil took less than 20 minutes. The whole operation was completed in less than on hour. This attention is required once a year. The humus removed was completely converted and is a valuable resource in places like Epworth where the soil is very poor. (see later plant trials and soil analyses)


Starting to excavate the pit which has been composting for 12 months. This pit was brick lined in loose sandy soil. It was 1.1 metres deep with a cross section of about 1m X 0.7m. The pit was filled with a mix of excreta (faeces and urine) together with local soil, some wood ash and some leaves. At first the soil and leaves added on top of the excreta is removed. Further down the soil becomes darker and richer as the effect of the excreta on the soil becomes more visible. On the right photo, the richer soil is being removed.


The used pit has now been fully excavated and the compost can be seen on the side. The now empty pit has a generous layer of leaves added to the base. This helps to start of the composting process in the new pit. The addition of leaves helps a great deal to improve texture and nutrient value to the final compost.


The layer of leaves at the base of the pit. Note that small roots have invaded the pit, even through the brickwork to find the nutrients available in the composting excreta. On the right, the superstructure is now moved from the now almost full pit and placed on one side. The home made pedestal can be seen.


The concrete slab is now removed using the four handles and this is immediately placed over the now empty pit nearby. The slab is levelled and best laid on a bed of weak cement mortar laid over the pit lining brickwork.


Finally the superstructure (with pedestal and vent pipe in this case) is placed over the slab. The toilet can now be put to use immediately. On the right the pit used during the previous 12 months is not yet full, but a 12 month cycle of change is easy to remember. The pit contents are now covered with a generous layer of leaves and then topsoil is added. The mixed contents of the pit are then allowed to make compost for a further 12 months, while the used pit fills up again with a mix of ingredients. The whole process is then repeated every year. With this technique the pits are re-used repeatedly and every year a valuable supply of humus is produced. It is a simple technique which has great value.

It is wise to leave some written instructions on the inside of the toilet to remind the users how to manage the *Fossa alterna*. The regular addition of soil is essential if the process is to work properly, and also some leave and ash help to improve the compost. It helps if the time of changing pits is earmarked for a particular month of the year. In this case it is September, a good month as conditions are very dry. On the right, the composted pit contents can be bagged in preparation for the rainy season and planting. Alternatively they can be dug into the soil of vegetable gardens. A mix of half pit compost and half local topsoil is best. This mix enhanced the growth of vegetables considerably.

Satisfied customers at Epworth!

The *Fossa alterna* - a summary

The ***Fossa alterna*** is a relatively new concept introduced into the world of low cost sanitation and experimentation is still continuing with this principle. Clearly there is still a lot to learn of the process of excreta conversion in shallow pits and also how this concept will be accepted by communities in Southern and Eastern Africa and possibly elsewhere. It is possible that the ***Fossa alterna*** concept may represent an important step forward in sanitation technology and a valuable addition to the eco-san concept. Whilst low in cost and simple and adaptable in concept, it provides a system that is easily built by the family. It controls flies and odours, and also reduces the risks of ground water pollution. Because the pits of compost are easily excavated it offers potential for a permanent solution to home sanitation, whilst at the same time providing an annual supply of valuable fertile compost for the home vegetable garden. The testing and application of the pit compost is described in a later chapter. For these reasons the ***Fossa alterna*** may have widespread application throughout Africa.

***Fossa alterna* or *Arborloo* ?**
The two concepts are related – both make humus to enhance the growth of trees or vegetables. Both are specialised pit toilets – the link has been made between sanitation and agriculture.

6. The urine diversion toilet

Urine diversion

In a third range of latrine designs, the concept of **urine diversion** is used. This is a well established method which is being used successfully in many parts of the world. Countries in Europe like Sweden, use it a great deal in the new era of ecological sanitation which is taking off in the northern hemisphere. It is being strongly promoted by the Swedish EcoSanRes group and also GTZ. The concept of **urine diversion** is also being used widely and successfully in Mexico, Central and South America (El Salvador, Guatemala, Ecuador), India, Japan and also in China, where the recycling of human wastes has been practised for generations. It is also being promoted on a relatively large scale in South Africa (Austin and Dunker, 2002) and Uganda by the Ministry of Water, Lands and Environment (MoWLE, 2003). The use of this method is well documented. A book entitled *Ecological Sanitation* (1998) first written by Esrey et.al. is particularly valuable and the second updated edition (editors Uno Winblad and Mayling Simpson-Hebert - 2004) is now available. For a list of suitable references see the bibliography at the end of this book.

Urine diverting toilets use a special pedestal in which the urine enters the front part of the pedestal and is then diverted through a pipe and is thus separated from the faeces. In China and a few other countries where the squatting position is favoured, urine diverting squat plates are used. These are very successful. The urine can either be collected in plastic or concrete containers of some sort, or it can be led into a soakaway system. Considering the value of the urine, to allow it to soak away, unless on to a mature tree like a banana, is somewhat wasteful of a valuable resource. The faeces fall down directly into a brick lined vault beneath the pedestal. Some dry soil and wood ash (or lime in some countries) is added to cover the faeces after every visit. This covers the deposit and helps to dry out the surface of the faeces and makes them easier to handle and transfer. The distinct advantage of this method is that the urine can be collected separately, making it available as a liquid fertiliser. Also the solid component, being in a semi dry state, is much easier to handle and is safer from the beginning, even if it does initially contain pathogens. Being semi dry, it does not smell so much and its potential as a fly breeding medium is much reduced compared to the mix of urine and faeces. Eventually the faeces become completely desiccated.

Semi dryness is essential for the success of the urine diverting system. There must be no malfunction of the urine diverting pedestal. In other words, urine must always go down the front and faeces down the back. If there is an error made in this use, the system can malfunction badly. Blocked pipes carrying urine need unblocking. It is possible that soil thrown down the pedestal may enter the urine pipe, and sometimes even faeces if used by children. Thus the pipes used must be wider rather than narrower, and easily washed out. Also if urine (or water) finds its way into the above ground “dry” vault, the result can be messy and unpleasant. Meticulous use is rather an essential component of the urine diverting concept. This is one reason why alternatives are also recommended in Southern and Eastern Africa, as they are simpler and cheaper, being more forgiving of misuse. The writer has used an above-the-ground single vault urine diverting toilet for several years in his garden and this experience is reported in this chapter. Both home made and commercially made urine diverting pedestals have been used. Initially urine was taken to a seepage area, but this was modified so that urine was collected in a 20 litre plastic container for use in the garden. This system has proved to be an excellent asset to the homestead and has given far fewer problems than the conventional water born system used in the house.

The single vault urine diversion system

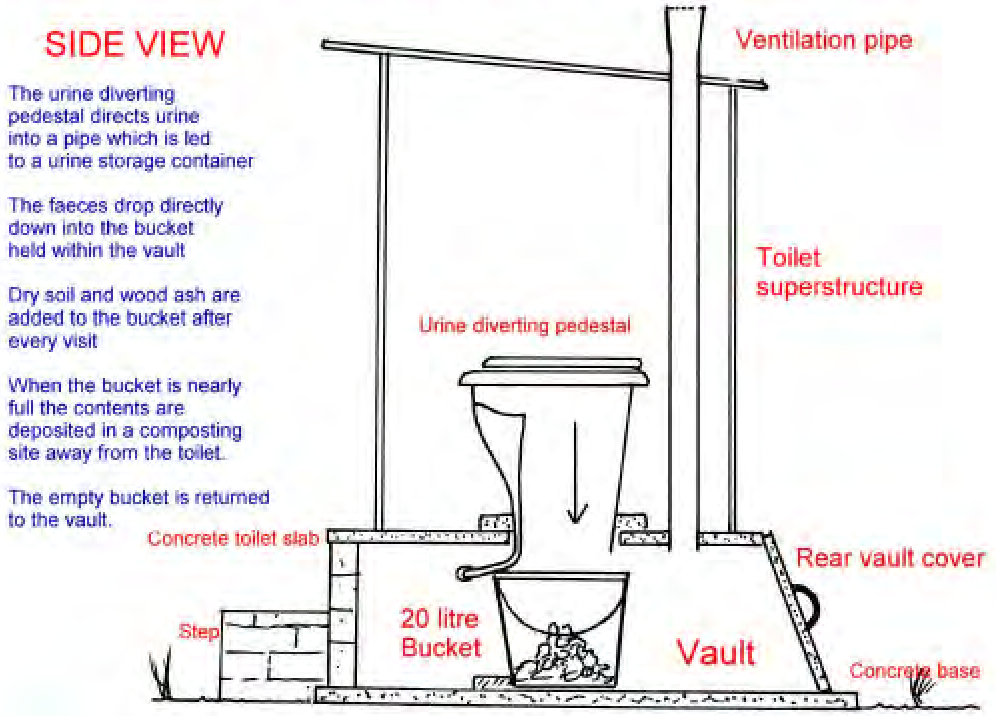
In this system (sometimes referred to as the ***Skyloo***) the faeces are collected in a single small vault built above the ground. Whilst faeces can accumulate directly in the single vault for periodic removal, the preferred method in this case, has been to contain them in a 20 litre plastic bucket (together with toilet paper, soil and wood ash). The bucket contents are held within the vault only for a relatively short period, until the bucket is nearly full. Then they are transferred to a "secondary composting site" for further processing. These sites may be in the form of cement jars or buckets or shallow pits or trenches and even garden compost heaps. In each case the formation of humus is encouraged by combining the various ingredients in the bucket with more soil and also some water to add moisture to the mix. Some leaves can also be added. The mixture of ingredients is converted into a pleasant smelling humus-like soil within a few months. This humus can be used to grow a variety of trees, vegetables and flowers. Nothing has gone to waste. Once again the recycling of human excreta is made as simple and convenient as possible. Natural processes are involved.

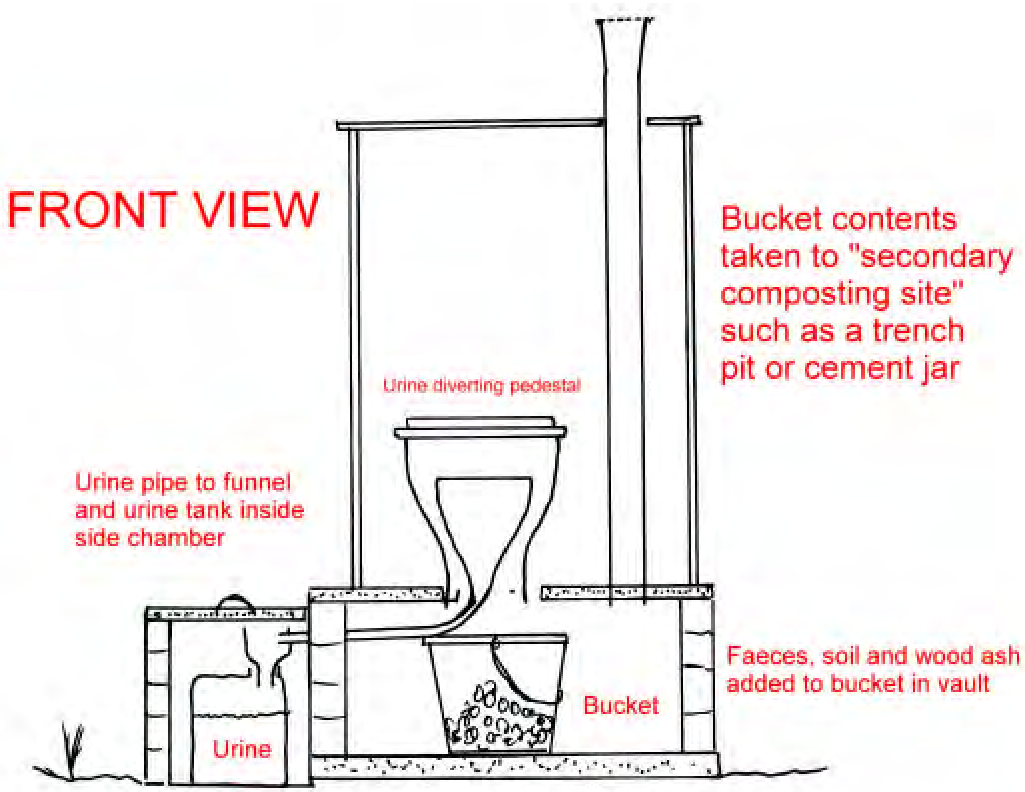
The humus resulting from composted human faeces makes an excellent soil conditioner and is rich in nutrients as the soil analyses revealed later shows. The important lesson that comes out of this experience is that human faeces, once composted into humus, have a considerable value of their own, not only in providing extra nutrients, but also by improving the texture of soil. The resulting humus can be used directly for growing trees, vegetables and flowers or it can be mixed with less fertile soils to improve the overall quality of the soil. The use of garden and leaf compost generated in the garden is also important so that a combination of these various plant growing media can be encouraged. Thus those practising ecological sanitation should also be familiar with the methods of making garden and leaf compost so that all these fertile materials can be mixed to form a good planting material. The human fraction enters the system and becomes part of it. Such humus when properly used in agriculture helps to improve food yields and also food quality and hence provides more food security and improves the nutritional status of the beneficiaries.

A general description.

The toilet is built upon a base made of concrete cast on the ground. Above this concrete base is built a shallow "vault' made of bricks and cement mortar. The vault only needs to be a little deeper than the bucket which will be fitted inside it - that is less than 40cm deep. A concrete slab is laid on top of the vault with openings for a vent pipe and urine diverting pedestal. An additional slab is made to fit on the rear of the vault for easy access into the vault and removal of the bucket. A urine diverting pedestal is fitted over the hole in the concrete slab. The urine pipe from the pedestal can direct the urine into a soakaway or preferably through the wall of the vault into another brick built chamber which contains a 20 litre plastic container to receive the urine. Next, a suitable superstructure is built or mounted on top of the latrine slab. This can be made of wood, bricks, plastic sheets attached to a frame or in any way that affords privacy. All hardware in direct contact with urine should be made of durable plastic – not metal - urine is very corrosive.

How the urine diverting toilet works





Stages of construction

Stage 1. Making the base slab

This is a concrete slab laid on level ground which will form the base of the toilet. This forms the foundation for the whole toilet. A concrete mix is made using five parts clean river sand and one part cement (or 3 parts river sand, 2 parts small stones and 1 part cement). The concrete is cast within a mould made of bricks, the dimensions being 1.35m long X 0.9m wide X 75mm deep. An area for the step is also made 450mm long and 335mm deep. Some steel reinforcing wires are placed in the concrete. It is left to cure for at least 2 days before any brickwork is built on top of it. It should be kept wet for several days to cure properly

On the left the brick mould for the toilet base slab. This is cast on level ground at the toilet site. The whole structure is built on top of this. On the right the mould for the toilet slab. This is cast with the same mix of ingredients as the base slab and is 1.2m long and 0.9m wide and about 40mm deep. Holes are cast in the slab for both the pedestal and the vent pipe. The exact method of making the concrete slab is described in the toilet construction chapter. In fact the same basic slab can be used to make an *Arborloo*, a *Fossa alterna* or this urine diverting toilet. Using the same slab it is therefore possible to upgrade the system over time. Money spent on making concrete slabs and other concrete structures is well worth while since they usually last for a lifetime and are a good investment in both money and time.

Stage 2. Making the latrine slab

This is made with a mixture of 5 parts of quality river sand and 1 part of cement or three parts river sand, two parts small stones and one part cement. It is reinforced with 3 or 4mm steel wire - 4 lengths in each direction. The slab is made 1.2 metres long and 0.9 metres wide and about 40mm deep. Holes are made for the vent pipe and the pedestal. The pedestal hole is made about 30-35cm from the rear end of the slab and the vent pipe hole (110mm in diameter) is made about 15cm in front the rear and side of the slab. The hole for the pedestal is made using a plastic basin or 20 litre bucket and this is laid in the final position. The hole size must match the pedestal being used. The vent hole is made using a short 75mm length of the pipe which will be used for the vent. This may be a PVC vent 110mm diameter. The slab is cast on flat ground on a plastic sheet. Bricks can be used as a mould, or timber. Half the mix is made first, then the wire reinforcing is added, followed by the remaining cement. The concrete work is made flat with a wooden float, then finished off with a steel float. About 10 litres of cement (quarter 50 kg bag) mixed with 50 litres good river sand (or 30 litres of river sand and 20 litres small stones) is a good mix . The slab is best cast in the late afternoon, left to harden overnight, then watered and covered with plastic sheet. It is kept wet for at least one week before moving. Whilst the slab is curing, the rest of the toilet structure can be built. Such a slab, well made will last indefinitely.

Stage 3. Making the vault, step and lintel

The vault is built up in fired bricks and mortar to the required height on the base slab. If a 20 litre bucket is used the vault should be about 40cm high. This will require about 4 courses of bricks built on edge or about 6 courses built normally. The walls are built so that the outer measurements of the top are 1.2m X 0.9m and the base 1.35m X 0.9m. This allows for the slope at the back of the vault over which the vault access slab at the rear will be fitted.

Stages in making the vault. The brickwork

Since the rear end of the latrine slab will not be supported on a brick wall it is desirable to make a reinforced concrete lintel which spans the rear end of the vault. This is made with 3 parts river sand and one part cement and reinforced with 3 or 4mm wire. It should be 0.9m long and be 225mm X 75mm wide. Once cured after 7 days it can be carefully mounted on the rear wall of the vault as shown in the photo above.

Stage 4. Making and fitting the vault access slab

This is made in thin high strength concrete using 2 parts river sand and one part cement with 15mm chicken wire as reinforcing and two wire handles inserted for lifting. The dimensions are about 90cm X 45cm high (the exact dimensions must match the vault). This is cured for a week and will be rested against the sloping rear side of the vault. A neat, almost airtight fit is required. This is made by applying strong cement plaster to the vault brickwork and grease to the adjacent cement panel side and bringing the two together. After curing the panel can be withdrawn leaving an exact impression on the vault. This is shown in the photo below. The concrete slab is then fitted and bonded on top of the vault in cement mortar.

The vault access slab and the toilet slab have now been fitted. The superstructure must now be made.

Stage 5. The urine diverting pedestal

Urine diverting pedestals can be home made (see chapter 13 for various methods of home made urine diverting pedestal and squat plate construction), purchased commercially or modified from commercial non urine diverting pedestals which are more commonly available. The toilet described in this chapter used a home made urine diverting pedestal at first. Later this was replaced by a urine diverting pedestal made from a commercially available non urine diverting pedestal. This was modified by adding a urine diverting wall and a urine outlet pipe.

Home made urine diverting pedestals can be made from off-the-shelf plastic buckets and cement. The photos below show one possibility. The plastic bucket forms the inner shell of the pedestal and it is surrounded with cement mortar. Another plastic bucket is cut and trimmed to fit inside the first. The urine is channelled down and led off through a pipe to a soakaway or preferably into a urine storage container.


Stages in making one "home made version" of a urine diverting pedestal. Urine in this case ran down through the hole into another plastic bucket held within the vault and then to a soakaway.


On the left the home made urine diversion unit is fitted over the slab. On the right the improved urine diverting pedestal, fitted with wooden seat. Note also the vent pipe fitted behind the pedestal to the right.

Stage 6. Mounting the pedestal.

Pedestals are mounted over the hole in the slab and cement mortared in position. It is important that this joint is watertight, so that any water falling on the slab (from rain or washing water) does not drip into the bucket below which must contain faeces, paper, soil and wood ash only – absolutely no water.

Stage 7. Adding a urine collector.

Urine is a valuable plant food and is best collected in a container. The best method is to build an extra brick side-chamber on one side of the vault. This will house a plastic container of about 20 litres capacity which will receive and store the urine. A plastic pipe is led from the urine outlet of the pedestal through the side wall of the vault into the brick side chamber so that the urine can be caught by a small funnel which directs it into the urine storage container. The brickwork of the side chamber is built up to enclose and protect the container and the piping. The chamber is covered with a concrete lid with handles. It is important to ensure that the plastic pipe leading from the urine outlet to the container falls continuously and does not pass through a loop which will act as a water trap or air lock. The side wall chamber must be big enough to house the container so that it can easily be withdrawn. Since urine is very corrosive, the piping and container must be made of stout plastic. Metal parts will corrode.

A plastic pipe is led down from the urine diverting pedestal through the side wall of the vault into a plastic container held within a small brick built side vault. A home made funnel is used to guide the urine into the container. The side vault is built up on soil so that any urine overflow can drain away.

Stage 8. Making the superstructure

Many types of superstructure are possible for urine diverting toilets. They are built in one location and thus can be made from bricks or timber, metal sheeting, asbestos sheeting, reeds, grass or of any material that offers privacy. In this case, the vent pipe is placed within the structure and the roof must have a hole made for the ventilation pipe to pass through. Structures are fitted with a door of some sort. A roof is essential as this prevents rain water entering the interior and the pedestal. Water must not be allowed to penetrate into the vault.

The superstructure

The superstructure in this case has been made from a frame of polyethylene pipe covered with plastic "shade cloth." This is not very robust, but has proved very adequate over a four year period. The urine diverting pedestal is smart and comfortable. A mixture or soil and wood ash (4:1) is stored in one container, with dispenser. Toilet paper is held in another container.

Finished structure with side vault for urine collection. The rear vault access door is neatly fitted. A 20 litre bucket has been fitted within the vault. Two bricks cement mortared to the floor locate its best position directly beneath the pedestal chute.

Stage 10. Finishing off

Make sure the rear access door fits well at the rear of the vault. The vent pipe will function better if the vault is well sealed. Two bricks can be mortared on the base slab to locate the best position for the bucket which is directly under the pedestal. The vent pipe is fitted into the toilet slab and through the roof. A latch is fitted to the door to hold it closed. A mix of dry soil and dry wood ash (4:1) is provided in a container. It is best to mix bulk dry soil and ash first and hold in a sack, or dust bin, then bring to the toilet in small lots.

Use and management of the urine diverting toilet

Since the faeces from the UD toilet will be used to make humus, it is essential that soil and wood ash are added after every visit to the latrine. The bucket then fills up with a mixture of materials which compost easily - faeces, paper, soil and wood ash. It is wise to premix the soil and the ash first (mix of four parts soil to one of ash), when these materials are in the dry state. This can be stored for use in a larger container or sack and brought and stored in smaller containers within the toilet. The ash and soil can be applied down the chute using a small cup or home made dispenser – the one used on the toilet is made from the upper part of a plastic milk bottle. Half a cupful of the mix is added after every deposit made. When the bucket of contents is nearly full, its contents are transferred to a "secondary composting site" for further processing. The rate of filling obviously depends on the number of users and the amount of soil/ash added. Weekly transferral may be required for a family of about 6. For a single user, the bucket may take 4 – 6 weeks to fill up. The urine accumulates in the plastic container until it is nearly full. This urine can be used in various ways as described later in this book.

Processing the faeces

The faeces (without urine) fall directly into the bucket, and it is wise to put some humus or leaves in the base when it is empty to avoid sticking and to help start the composting process off. In this unit the bucket is removed and its contents transferred to a "secondary processing site" quite regularly. The frequency of moving the bucket and its contents depends on how quickly the bucket fills up and this is related to the number of users. Fresh excreta does not remain in the toilet system itself for long. It may be just a few days or a week or two at most. However, at the ambient temperatures found in Harare (the temperature of faeces held in buckets hovers around 18 degrees C.), the combination of faeces, paper, soil and wood ash does start to degrade. Thus in practice the toilet can be considered the "primary processing site" (in so far that the ingredients are placed together and start to change their form) - but the period is brief. When the bucket is nearly full, the rear vault access slab is removed and the bucket withdrawn and its contents tipped into a "secondary composting site" nearby. Some soil is placed back into the empty bucket and then it is placed back in the vault beneath the pedestal. The rear vault slab is replaced and the toilet can be used again. This transferral of materials from primary to secondary composting sites is quick and easy.

The bucket is withdrawn from the vault and its contents tipped into a shallow pit composter or a split cement jar as shown above. The 30 litre split cement jar is ideal for processing human faeces. Fertile soil is added on top of the excreta and a strong lid placed over the top for protection. More deposits are made when the bucket fills again. After 3 or 4 months the contents are pleasant to handle. Naturally it is always wise to wash hands after handling humus of any type – including this variety. The conversion is a *Miracle of Nature*.

Secondary composting sites.

Several "secondary processing sites" have been tested over the last three years with the UD toilet. These are sites where the raw excreta is converted into a product which is best called humus. The humus has the appearance of loam like soil and smells pleasant. These sites include shallow pits (tree pit or fertility pit or twin shallow pits), trenches, compost heaps and also buckets or split cement jars where the composting process can take place. Plastic bags have also been used. The tree pit is a shallow pit covered with a lid into which the bucket contents are placed and then covered up with fertile soil. When the pit is almost full it is topped up with a good layer of topsoil and a young tree is planted in the topsoil. This works like the ***Arborloo*** **–** in fact this method preceded the ***Arborloo*** which evolved from it. A similar method is used with a trench, which is filled up in stages with buckets of the mixed composting ingredients.

What system to use as a secondary composting site?

This will depend on the number of users. If the number of users is small, a series of small jars described later is ideal. If the family is medium to large say between 5 – 10 persons or more it is best to build a twin pit composter where the contents of the bucket are added to one shallow pit until it is nearly full, then to a second shallow pit which fills whilst the contents of the first pit are composting. A composting time of at least 6 months should be allowed. A single user will completely fill a 20 litre bucket with a mix of faeces, paper, soil and ash in about 4 - 6 weeks. Thus a family of about 6 persons will fill a 20 litre bucket in approximately one week. This means that the bucket must be removed and its contents placed in a "secondary composter" every week. The actual rate of filling will be quickly established. In this case the best composter is the double shallow pit type. This can be built near the toilet.

Use of split cement jars as a "secondary composting site"

When nearly full, the bucket of contents (faeces, toilet paper, dry soil and wood ash) are tipped into the jar, levelled off with a trowel and covered with a layer of good fertile soil. The soil is full of life forms which digest and convert the excreta into humus. Two or three bucket loads may enter the jar before it is nearly full. After the last filling the excreta is levelled off again and topped up with about 5 cm layer of soil. This jar of contents should be watered, then covered with a lid and left to decompose. The various ingredients will decompose within three or four months to form humus which can then be removed and used much in the same way as the eco-humus taken from the ***Fossa alterna***. Tomato growing is the best option. The empty jar can then be reused time and time again.

When made properly, the cement jar can be used time and time again - being made of concrete. It is also cheap. The jar has a wider base than top so the contents held within it are well drained. That is important if a good conversion from excreta to humus is to be effected. During the period when the faeces are converted into humus, which may be as little as three or four months with this method, there is no (or very little) temperature rise within the jar. The conversion is rapid because the conditions seem to be ideal. There is a relatively high ratio of soil to excreta, and the conversion is made "in small lots" where no pocket of excreta is large and all excreta is relatively close to some living soil. As the mass is converted, it also contracts as the water content of the original excreta (which may be as high as 70%) is absorbed into the soil within the jar or drains away under the jar. In practice the level of the plug of soil held within the jar drops as its volume decreases. Also the diameter of the "plug" is reduced and this can leave a gap or small air space between the soil and the jar, which obviously retains its original dimensions. The soil near this air space is very active biologically. Thus the core of converting matter is moist, well drained, well aerated and close to the living soil - all ideal conditions for an effective conversion of faeces into humus.


Tipping the contents of the bucket from a UD toilet into a small shallow pit for processing. The shallow pit is covered with a concrete lid with hole which is itself covered. On the left three cement jars are shown. The one actively being filled is covered with an attractive painted concrete cover.

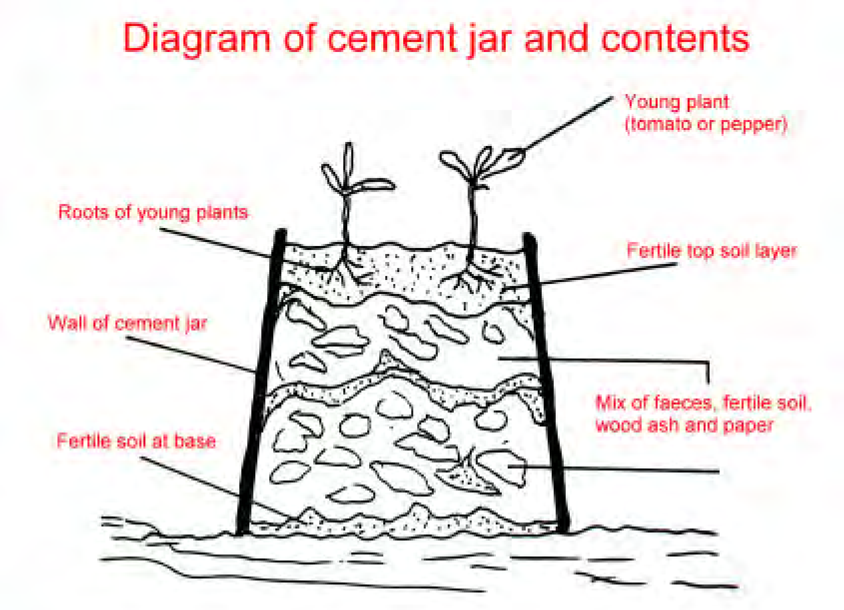
Biological activity within the jar

The contents of the jar are biologically very active during the conversion stage and thereafter. The process is aided by adding a layer of fertile topsoil to the container and planting young plants of various types into this upper layer. The conversion process whereby faeces are converted into humus is the result of the activity of bacteria and fungi present in the added soil which thrive under ambient temperatures (that is temperatures which are close to the surroundings). Many other beneficial organisms, including worms, insects and many other life forms also thrive at their best at ambient temperatures. These animalcules and microbes appear to digest the excreta and may also considerably reduce the number of pathogenic organisms, such as bacteria which carry disease. In tests carried out on jar humus, pathogenic bacteria such *Escherichia coli, Salmonella sp, Shigella sp, and Staphylococcus sp*. were absent after only 3 months of composting (From tests carried out by Clinical Laboratories, Harare - Frank Fleming. pers.comm.). This aspect is further discussed in the chapter on Health. Care is obviously required when handling any compost of this type.

The process is an entirely natural one leading to the formation of humus. The process may best be described as "*Ambient Temperature Composting*" since it takes place at a temperature close to the natural surroundings. The soil added should ideally be fertile and contain living organisms for the process to take place at its best. These fertile soils and leaf moulds also absorb much of the moisture content of the excreta, and the process is normally associated with a reduction of volume of the mass. Remarkably however the process still takes place where poor soils are added to the excreta, albeit less efficiently, and the final product may lack the texture of the best humus – but it certainly is high in nutrients, which come from the faeces.

In addition, the roots of the plants invade the body of the container as the plants grow and this provides an extensive biological structure within the decomposing materials which assists the process of converting the faeces into a friable and acceptable humus like soil. The extent of the root invasion depends on the plant type. Not all plants will send their roots down the entire depth of the jar. Certain types of flower are very effective at invading the contents of the jar (or bucket) and penetrate the entire space occupied by decomposing matter. The giant "*crackerjack*" marigold is a good example. Within 3 months its roots invade the entire contents of the jar or bucket and provide an extensive biological surface which assists in converting the faeces into soil. Obviously in doing this the flower is taking nutrients away from the humus.

The absorbing root-soil interface is called the rhizosphere. It is within this thin microscopic layer that surrounds the roots and root hairs that much biological activity takes place. There are many living organisms present in soil and around the rhizosphere - bacteria, fungi, protozoa, slime moulds, algae, soil viruses which together with nematodes, earthworms, millipedes, centipedes, mites, snails and other small animals, compete for water, food and space. The roots provide a multitude of surfaces for microbial colonisation. The roots also provide oxygen, essential for effective biological processes and also other nutrients that the micro-organisms require. These include carbohydrates, organic acids and many other substances essential to the life within the rhizosphere. The abundance of life in this active biological zone form micro-cavities where the micro-organisms live. In nature, decomposing vegetable matter within the soil helps to make conditions optimal for these organisms. The plant itself takes up water, nitrates, phosphates, potassium, sulphates, and many trace elements. Thus as the roots of plants invade the decomposing materials in the bucket, they greatly assist in the natural processes which lead to the conversion of faecal material into humus simply by generating enhanced biological activity throughout the root zone.



The final texture of the humus formed very much depends on the type of soil added. If the soil is a lifeless sandy soil, the final texture of the humus will be more sandy. If the soil added is fertile and humus-like itself, then the final product will be more crumbly and humus like. Thus the texture of the end product depends on the soil added. It is also possible to add leaves to the mix and this will greatly improve the texture of the humus. In all cases the combination of soil and human faeces considerably enhances the level of nutrients in the final soil produced. The increase in nutrient levels is dramatic and can transform even the most barren soils into soils which are fertile and able to sustain plant growth. The following charts show the levels of major nutrients in the 30 litre "secondary composting jars" combining human faeces, wood ash and soils.

The twin pit secondary composter

Stages of building a twin pit composter for single vault urine diverting toilet


Stage 1. Choose a level site near the toilet and caste two ring beams from concrete on the ground. The internal measurement is variable but in the case shown here the internal measurement was 0.8m X 0.8m. The width of the ring beam was 15cm and the depth 7.5 cm. A mix of 5 parts river sand and 1 part cement was used. The two ring beams were placed about 0.75m apart. The concrete was allowed to cure for a period of 3 days under plastic sheet. In the photo on the right the bricks and timber shuttering have been removed from the ring beam and each filled with water to loosen the soil beneath.


After a day and night soaking the soil is easier to dig. The photo on the right shows the two pits dug down to about 0.5m metres. The removed from the twin pits has been laid around the ring beams and rammed in place. This makes the pits more stable. The pit which will not be used first can be filled with leaves to compost, whilst the other pit will be filled with a mix of faeces, paper, soil and ash from the toilet. The area around the ring beams is smoothed down and made neat.


A wooden lid is made for the twin pit composter and placed over the pit which is being filled with excreta, soil, paper and ash. The almost full bucket is removed from the toilet vault and tipped into the shallow pit. The deposit is covered with more soil.

On the left a motivated pensioner tips his bucket of contents into the shallow pit. The photo on the right shows the first deposit made into the pit. Many more will be added until the pit is almost full. Since the excreta is close to the soil and is surrounded by soil and the additions are made in "small lots," the composting process is quite efficient. The pits are called secondary composting sites because the actual composting process starts off in the bucket itself and the process continues in the shallow pits. Leaves can also be added to the shallow pit. These add more air into the system and also further organisms which help to break down the excreta. The final humus is more crumbly in texture if leaves have been added.

Photo showing first addition (left pile) and second addition a month later (right pile) in the composter. The conversion to humus is already well advanced in the first pile. Note how the toilet paper has disintegrated. The new additions to the shallow pit are covered with a layer of soil and the wooden lid is laid over the pit for protection and safety. Water is added periodically to keep the composting ingredients damp. The two pits are used alternately. Once the first pit has filled up which should take rather more than 6 months, the second pit is used. When the second pit is full, the first pit can be emptied. And the process started again on the original pit.

Routine maintenance of the urine diverting toilet.

Routine cleaning and maintenance of the 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 chute is desirable. During normal use, the dry soil/ash mix will cover any side wall fouling, dry it out, and make it less objectionable.

The great advantage of the UD system described here, where the faeces are contained in a removable bucket and not a static vault, is that the system can be washed down completely once the bucket and the urine container have been removed. It is desirable that the vent pipe, pedestal and urinal pipe are washed down and cleaned from time to time. First the bucket 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 vault can then be cleaned out with a small tree branch. The whole unit can then be thoroughly washed down and cleaned out. The pedestal is cleaned entirely from top to bottom including the side walls. The urine pipe is also flushed out with water. The toilets floors and vault can also be washed down with water. The ventilation pipe must also be washed down and cleaned out 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 bucket, urine container and vent). The dry soil/ash container inside the toilet is constantly being recharged from a larger stored stock elsewhere.

During the wet season, it has been found that Culicine mosquitoes (which do not carry malaria) can hide in the vault and emerge up the pedestal chute during use. Attempts at controlling these mosquitoes have been made by introducing springs of the wild basil *Ocimum canum*, which is know to be a mosquito repellent. No flies have ever been seen.

The interior of the *Skyloo* can be completely washed down once the urine container and the bucket containing the faeces, soil and ash have been removed. In the middle the wild basil, *Ocimum canum*, can be used to chase mosquitoes away. On the right a spider – fortunately they rarely travel up the pedestal!

Flies have never been seen in the single vault urine diverting system (*Skyloo) described here,* but spiders and mosquitoes do invade during the wet season. Spiders do no harm but can block vent pipes. Mosquitoes in this case are the culex type and not malaria carrying. They look for dark places to hide – they do not breed there – there is no water. Effective fly and odour control is maintained by using a screened vent pipe (with corrosion resistant stainless steel or aluminium screen), and near airtight sealed vault, regular addition of a dry mix of soil and ash to the bucket, a water tight seal between pedestal and toilet slab (to stop rain or other water entering the bucket), and the toilet seat lid closed when not in use. The unit is "spring cleaned" three or four times a year by removing vent, bucket and urine collector. The vent is cleaned out and washed down. The pedestal is washed down, the vault washed clean and cobwebs removed. The urine pipe is flushed out with water. The bucket is cleaned and allowed to dry. The toilet slab is cleaned down. When parts have been cleansed they are fitted back together and allowed to dry out. The unit is then put back to use.

7. Upgrading the toilet system - *Start simple and improve over time*

The ***Arborloo*** is an excellent entry point for householders who wish to consider using ecological toilets and recycle their excreta. It is simple, cheap and the excreta is never touched. But the ***Arborloo*** can be upgraded to a ***Fossa alterna*** and this is a trend which is being followed in several programmes. Also toilets can be upgraded by fitting pedestals and vent pipes. The advantages of upgrading the ***Arborloo*** to a ***Fossa alterna*** is the permanence of location and a regular supply of compost. It is also possible to upgrade the ***Fossa alterna*** (or even ***Arborloo)*** to urine diversion. This brings with it extra cost and complexity. But the pit contents will be drier, with less potential for odour and fly breeding. Also the urine can be led to a sunken plastic container for collection. The urine can also be led to a seepage area planted with a nitrogen hungry tree (e.g. banana,) or a garden compost pit or some other seepage area. The pit contents will be drier which will be an advantage especially if the soil does not drain well. In those cases where a urine diverting pedestal is fitted to a shallow pit composting system, it is best that the urine pipe is led off above the base of the pedestal. Underground piping can be complicated to fit to pit structures. 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.

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 container, 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.

Example of upgrading the toilet system using the 1 metre diameter round slab and matching ring beam

The 1 metre diameter concrete slab and matching ring beam can be made cheaply and is normally used to construct an Arborloo. But the same slab can be used on a *Fossa alterna* system (see earlier chapters). The same concrete slab and ring beam can be used to make a urine diverting toilet, as this sequence of photos shows. The ring beam has been laid down on level ground and backfilled with soil. A round brick wall is then built up on the ring beam to form a vault, with an opening at the rear, and high enough to accept a 20 litre bucket for containing the faeces, ash and soil.

The one metre diameter slab has been fitted and bonded on top of the round vault in cement mortar and a urine diverting pedestal fitted. This could also be a squatting type urine diverting platform. The bucket is located in position under the urine diverting pedestal with some bricks.

A concrete vault access door has also been made and fitted to the rear of the vault

Toilet paper and is the dry soil/ash mix are held in separate plastic containers.

A simple structure is built around the vault for privacy and the urine pipe is led off to a banana plant close by. Structures can also be upgraded.

Example of upgrading the toilet system using a 1.2m X 0.9m rectangular concrete slab.

The 1.2mX 0.9m rectangular concrete slab has been used to build this Arborloo (left) and *the Fossa alterna* (right). Most Arborloo and *Fossa alterna* toilets use squat holes rather than pedestals. But they can be upgraded by adding pedestals and vent pipes. The vent pipe helps to remove smells and excess moisture from the pit

This *Fossa alterna* (using a 1.2m X 0.9m slab) has been upgraded first by adding a non urine diverting pedestal (left) and later by adding a urine diverting pedestal (right). When fitted to a shallow pit system the urine diverting pedestal is easier to install if the urine pipe lies above slab level.

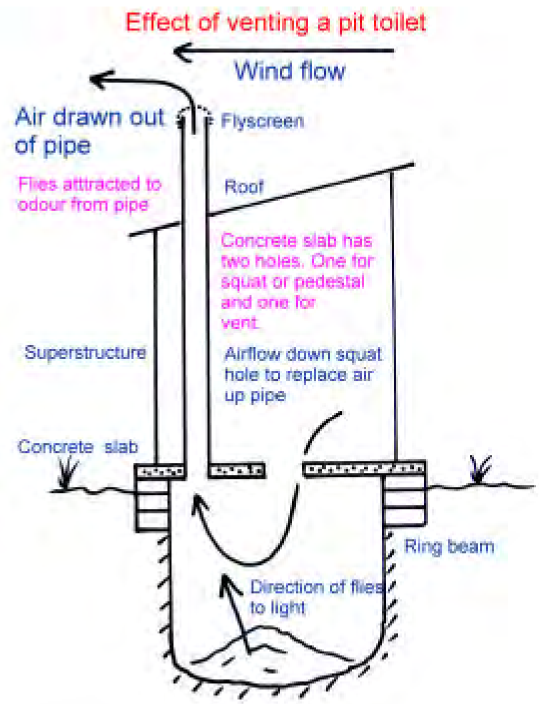
This urine diverting pedestal has been mounted on a 1.2m X 0.9m concrete slab mounted on an "above the ground" vault (see earlier chapter). In this case the urine pipe can be led off below slab level. The urine pipe is shown on the right leading to a plastic container. The two bricks which locate the bucket (not in place) which contains the faeces, soil and ash, are also shown.

8. Odour and fly control

The control of insects and odour are important issues to deal with in improved toilet facilities. The elimination of odours makes the toilet far more pleasant to use, and the control of insects, particularly flies is important for health reasons. Too many flies are also a nuisance.

Odour control.

A screened ventilation pipe can reduce odours and flies in all the compost making toilets described in this book. The vent pipe (e.g.110mm PVC) draws out air from the pit or vault, mostly by the action of air passing across the top of the pipe. The air that flows out of the pipe is replaced by air passing down the squat hole or pedestal. This is most efficient when the slab and pit collar are sealed and airtight and the head of the pipe is not surrounded by trees. Any foul odour from the pit or vault does not escape into the superstructure, but is diluted by air and passes out of the pipe into the atmosphere. The effect is that the toilet becomes almost odourless. The vent also helps to remove moist air from the pit or vault which helps to reduce the moisture content of the excreta.



Left: Diagram showing effect of vent pipe on controlling odours and flies. Right: A urine diverting pedestal with above slab urine take-off. This type is suitable for upgrading shallow pit composting toilets like the *Fossa alterna* to urine diversion. Pits under urine diverting pedestals are drier and this helps to control flies and odours.

Also a urine diverting pedestal which separates urine from faeces will also have the effect of reducing odours, since the faeces are drier when not mixed with urine. The drying effect is increased by adding wood ash or dry soil to the deposit. This will also control flies. But PVC pipes and urine diverting pedestals may be too expensive to fit to very low cost pit toilets. In this case the regular addition of soil, wood ash and leaves to the pit will help to reduce odour. Keeping the toilet clean and covering the squat hole can also help. It is possible to upgrade a simple pit toilet by adding a vent pipe or urine diverting pedestal or both at a later date. The urine diverting pedestal should ideally be one where the urine off-take is above slab level. This makes plumbing arrangements on pit toilets easier.

Fly control

In urine diverting toilets, the faeces are deposited separately and covered with dry soil and ash. Flies do not breed well under these conditions. But if soil and ash are not added, fly breeding can begin. However fly breeding is easier to control in urine diverting toilets, simply by adding more dry ash and dry soil to the deposit. It is essential that the urine diverting vault is not flooded with water or urine added. This will make things very messy. User education is required on the proper use and maintenance of UD toilets.

The method used in the VIP latrine effectively controls flies as well as odours if the conditions are met, such as fitting a screened vent pipe (corrosion resistant aluminium or stainless steel screens must be used). The toilet house must be kept in semi darkness (open doors allow flies to escape through the house and a roof is essential). Where the interior of the toilet is kept semi dark, flies will enter the pipe from the pit or vault and become trapped by the screen. This is because flies are attracted to light when they leave the pit and enter the pipe which is the most obvious light source. From the outside, flies are attracted by odours coming from the pit or vault and most of these are expelled through the head of the vent. If the head of the pipe is screened, flies cannot enter the pit (see diagram). This simple effect can dramatically reduce fly breeding in the pit toilet or vault and thus reduce the passage of fly-born disease. This is the principle of the VIP toilet (see diagram).

Fly breeding will also be reduced if the pit contents are drier. Thus adding a urine diverting pedestal to a shallow pit system will help reduce fly breeding. But for lower cost shallow pit composting toilets a vent pipe and/or urine diverting pedestal may be too expensive to fit. Then fly breeding, which is a natural phenomenon in pit toilets, must be controlled by some other means. This is because the mix of faeces and urine is far more fluid than faeces alone produced in urine diverting toilets. Flies breed most in pits which are moist and also during the warm wet season in Southern Africa (December – March). The liberal addition of wood ash is known to reduce the potential for fly breeding in pit toilets. But it may not eliminate them altogether. So if flies build up, it helps to add ash liberally if it is available, especially during the hotter wetter months when the fly problem is worst. The liberal addition of ash will also reduce odours. Where soil, ash and leaves are added in combination, the pit gets a mix of soil organisms, potash and composting matter which helps to make better pit compost for later use in agriculture and tree growing. So the more of these additional materials is added the better the final compost and the greater the degree of fly and odour control. Obviously pit filling time is reduced, the more soil, ash and leaves are added and a balance must be struck between adding too much or too little soil. In rural projects, homesteaders are often reluctant to add too much soil or ash at first, but soon learn that flies and odours are controlled better if more is added. Also a lid or cover added over the squat hole helps to reduce the entry of flies into the pit. If a superstructure is fitted with a door it is wise to also place a cover over the squat hole, in case the door is left in the open position. There is no fly control, even in VIPs if the toilet door is left open. If the toilet is also used as a washroom, a squat hole cover also prevents the soap falling down into the pit

In this pit, wood ash as been added over freshly deposited faeces to control fly breeding. During the hotter wet months it pays to add plenty of ash if it is available.