Trees as Recyclers of Nutrients Present in Human Excreta

by Peter Morgan
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Harare
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Hundreds of years ago, the Pilgrim Fathers planted trees on their abandoned pit toilets, and Nature also chose the same method when seeds dropping from trees fell into toilet pits which had filled and been abandoned. Planting trees like bananas became common practice in many townships in Malawi and other countries in East and Southern Africa. In almost every case it was noted that the tree growth could be accelerated considerably when its roots could tap the nutrients in toilet pits and the same held true for trees planted near soakaways linked to septic tanks connected to flush toilets. The resulting fruits were large and tasty. Despite the obvious fact that tree and fruit production could be increased considerably by this simple method, very often the production of fruit in this way was often concealed from view, perhaps by some form of embarrassment, or perhaps for fear that the Health Authorities may have condemned the method on grounds of food contamination.

This same principle was adopted within the discipline of ecological sanitation in the form of the ***Arborloo*** – or tree toilet. In the last few years tens of thousands of Arborloos have been built in Africa. The *Arborloo* uses the same principles found in Nature. Combine human faeces and urine with soil and it turns into an enhanced soil. The soil adds soil microbes which accelerate the decomposition process. If ash is also added, this reduces smells and flies and also adds potash to the mix. The reaction also turns slightly alkaline, which can accelerate the biological process. If plant material is added as well, in the form of leaves or plant cuttings, an improved composted product is formed. The addition of leaves adds the activities of fungi to the biological process and also adds carbon and air. In the *Arborloo,* excreta is added to the pit in combination with soil and ash etc. When the pit is almost full the toilet slab and structure are moved to another site. The pit contents are covered with a generous layer of soil. If water is available a young tree can be planted protected and watered straight away. The roots grow at first in the topsoil whilst the material beneath is composting. Root invasion proceeds, as the compost materials is found more acceptable to the roots. If water is not freely available the young tree is best planted at the start of the rainy season.

However in recent years the link between trees and toilets has proceeded further. In later version of the *Arborloo,* the trees were planted in holes drilled around the toilets, so tree growth could begin whilst the toilet was being used. Such trees could be watered with diluted urine added to accelerate growth. Single trees could be planted or even rosettes of trees surrounding the central pit. In later trials trees were planted near pit toilets where soil and ash were not added. These were either simple pit toilets, with no pit lining (like the *Arborloo)* or pit or VIP toilets lined with bricks. Brick lining with holes made in them were also designed to allow the pit nutrients to escape into the surrounding soil.

What has been discovered is that trees planted near to pits, even those where soil and ash have not been added seem to thrive.

Early experiments

Early experiments involved the use of the "tree pit" which became known as the *Arborloo* and also experiments using dog manure in 1 cu.m. pits topped up with soil where a variety of tree species were grown, both exotics and indigenous. Experiments with the *Arborloo* were initially tried in the EcoEd Trust, Mtoroshanga, Zimbabwe. And later by the Mvuramanzi Trust in several locations around Zimbabwe, including Porter farm. Later trials and promotional work were carried out at Kufunda Village Training Centre, Ruwa.

Tree trials at the EcoEd Trust (Mtoroshanga)

Trials at Friend Foundation with both exotic and indigenous trees

Trials at Kufunda Village Training Centre, Ruwa, and Porter Farm Zimbabwe

From there the method was transferred to Kenya in the Kisumu area. The method was then transferred to Malawi (along with the concept of the Arborloo and *Fossa alterna*) where many thousands of units have been built. The method has been used widely in Africa, notably in Ethiopia where over 50 000 *Arborloos* have been built.

Trials in Kenya and Malawi

Trials in Epworth.
Between 2008 and 2010 Aquamor supervised a 3 year study of Ecological Sanitation in Schools supported by the EcoSanRes project, SEI, Sweden. This pilot study included the construction of a variety of simple toilets built by the school pupils, the planting of trees around the toilets, the use of urine to increase production of vegetables, maize and trees. Several other aspects were also studies including hygiene and hand washing and simplifying toilet construction methods. Methods of upgrading traditional wells and collecting urine from school urinals were also studied. Woodlots were also planted using urine as a plant food. Much of this work has already been reported in a series of manuals produced under the title of Teaching Ecological Sanitation in Schools. (*Peter Morgan and Annie Shangwa).*

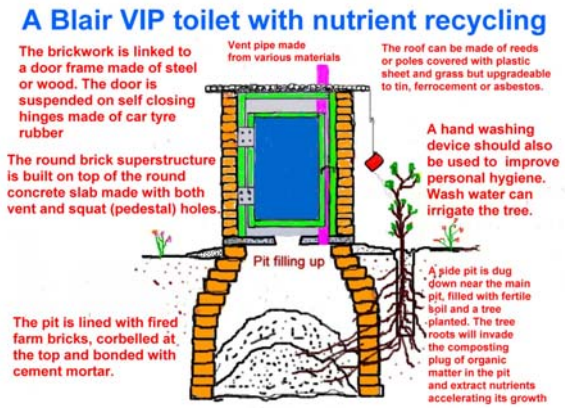
The schools study ended in December 2010, but the work is still being examined and the results are being used to refine technology options acceptable to the Government of Zimbabwe. A large amount of basic research has also been undertaken at the school, and in the surrounding environment (the schools outreach program). Various other reports, manuals and power points describe this work.

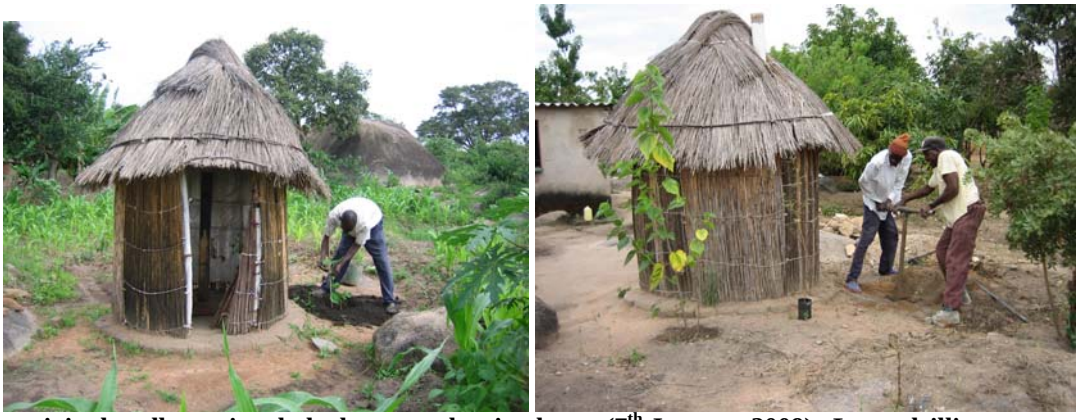
The story of the trees in the Epworth study

Large numbers of trees were planted around toilet structures in Epworth and also a woodlot was planted in the Chisungu school grounds. These were mostly gum trees (*Eucalyptus grandis* and *E. tereticornis*) and also mulberry. Whilst the gum tree does not rank highly on the tree specialists' category, it has many uses. These include fuel and construction. The growth is rapid and the tree can be coppiced up to 5 or 6 times. Once mature it can provide valuable fuel for cooking. It responds to urine treatment very well and is very tolerant of high nutrients levels when planted next to unlined pits filled with raw excreta. There is also a distinct possibility that its tolerance of high nutrient levels and its ability with withdraw water and liquors from high water table areas may have a positive effect on reducing the effect of underground water pollution caused by pit toilets in shallow ground water areas, The mulberry has also been used also responds well to diluted urine treatment and grows well near to toilet pits. The banana has also been used in trials and responds well to urine treatment. The Australian Red Cedar, *Cedrela Toona* has also been tried. This tree is commonly grown in Zimbabwe.

Planting single trees near shallow eco-pit toilets

The Blair VIP (ventilated improved pit toilet) is the standard toilet recommended by the government of Zimbabwe and most trees have been planted around BVIP toilets or variants of the BVIP. These include the ventilated *Arborloo,* and shallow to medium depth variants of the BVIP. In these photos diluted urine was not added to the trees. The tree growth was due to roots tapping nutrients from the pit directly.

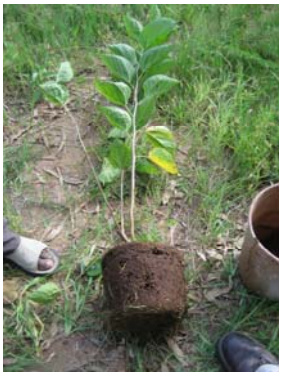




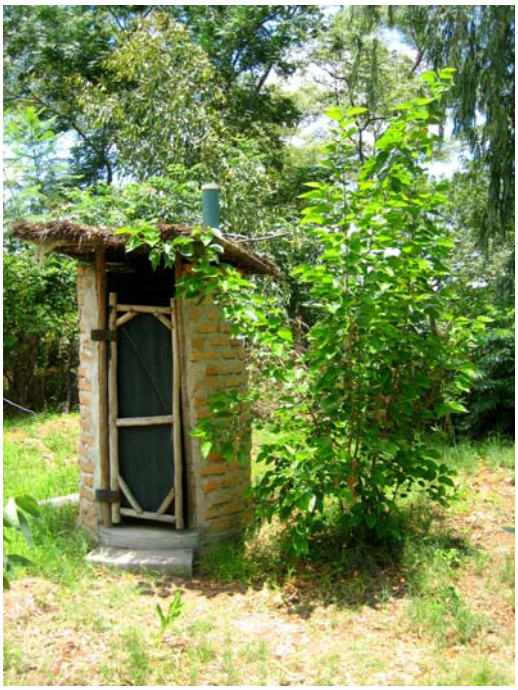
Planting the original mulberry in a hole dug near the ring beam (7th January 2009). Later drilling a second hole near the ring beam and planting a gum tree (13th July 2009).

Both trees have grown well as this photo taken on 16th February 2010 shows
Periodically diluted urine was added to each tree to accelerate its growth. Later pictures 13 Dec. 2011 after the toilet had been moved elsewhere.

Single trees grown next to toilet in the school grounds


A hole is drilled with an earth auger about 1m away from the toilet pit. It is filed with rich well composted soil. The tree can be planted when it is very young, but it is often best to grow the tree first in a bucket so it gains strength and produces a strong root system. Then it is transplanted at the head of the drilled hole. In this case diluted urine was added occasionally to the soil around the tree.



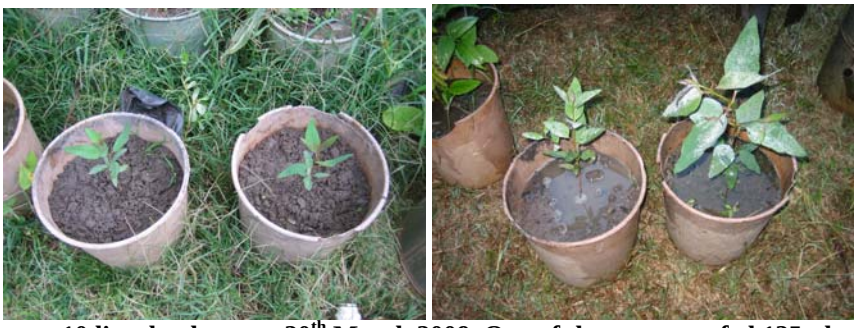

The mulberry is a delicious fruit filled with vitamins. Here it grows next to a simple VIP. Photos taken on 22nd November 2010 and 13th December 2010

The effect of urine on tree growth.

The growth of most trees planted around or near toilets in this study was accelerated by the application of diluted urine. Thus a combination of urine application and the roots tapping nutrients from the pit was taking place. Earlier back yard trials has established that urine copuld have a significant effect of the growth of gum trees as described below.

Urine is known to accelerate the growth of many plants including green vegetables and maize. A great deal of evidence is now available to prove this without question. The urine is best diluted either before it is applied or by water applied following the application of neat urine. Urine also can have a considerable effect on the growth of important trees which provide fruit, timber, fuel or shade. This manual describes how urine can be used to accelerate the growth of trees held in bags before planting in the ground or after planting has taken place.

1. Effect of urine on gum tree *Eucalyptus grandis*



Gum trees planted in two 10 litre buckets on 20th March 2009. One of the trees was fed 125mls urine + 275mls water (400mls) with extra watering once a week after the trees had become established. Right photo on 19th April 2009.

Effect of urine treatment becomes more apparent. Left photo 6th May 2009 and right photo 30th August 2009.

Accelerating the growth of tree before planting near toilets

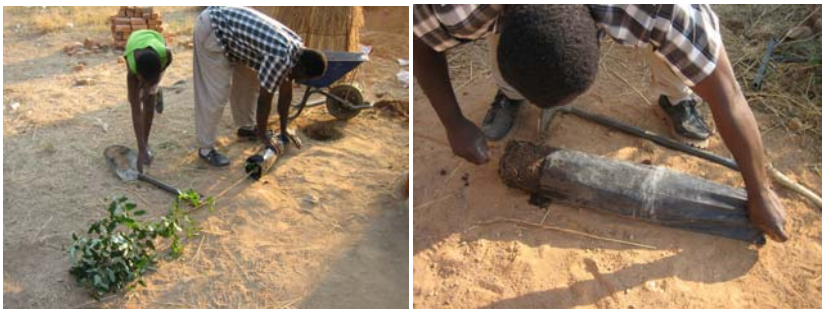
Several trees respond to the application of diluted urine and this can be undertaken before planting the tree in the ground as well as continuing after the tree has been planted in the ground. In another experiment several gum trees (and mulberry trees) were planted in longer planting bags before transfer to the ground during the dry season. The best time to plant trees near toilets (or at any place) if regular watering cannot be guaranteed is during the early part of the rainy season. It is possible to accelerate the growth of trees prior to ground planting by

transferring the seedling tree either into a bucket or into a deeper planting bag, which can be placed in a position where more regular watering and urine application is possible.

A series of gum trees (*Eucalyptus grandis*) were planted in deeper planting bags half a metre in depth filled with compost from *Fossa alterna* toilet and treated with urine every week. This considerably accelerated the growth of the trees compared to trees held in the original seedling bags. Left photo dated 9th July 2009 and right photo 6th October 2009.

Left: Original trees in smaller bags. Right: Original trees in smaller bags compared to transplanted trees in larger bags and urine fed.

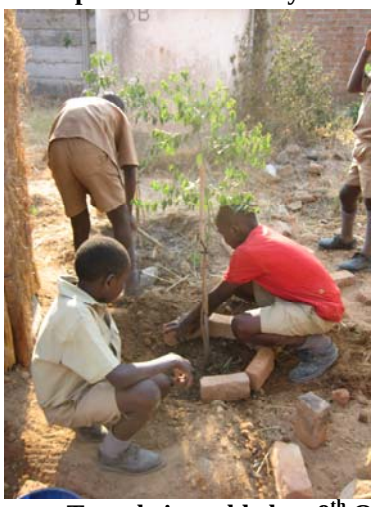
The accelerated trees were taken on to site. The trees were carefully extracted from its bag by cutting the bag open with a knide and carefully lowering the 50cm column of composted soil in which the roots were growing down into the hole. Gathered compost was then place around and below the tree to fill the hole. Note that at first the trees were extracted by pulling the column of compost out of the bag from the end, but this method damaged some of the roots. The ideal method is to keep the column of compost in tact and carefully introducing it down the hole and surrounding by rich compost soil. The aim is to plant the column of compost and enclosed roots without disturbing the roots of the tree. This column is surrounded by compost to fill the hole. The soil within covered with mulch made of leaves or grass.



The method of extracting the column of compost by pulling from one side was not satisfactory.


The best method is to cut the bag and take out the full column of compost in tact. Compost is first added to the hole Then the full column of compost surrounding the tree roots is carefully lowered into the hole.


Once the tree is positioned correctly in the hole compost is carefully added to fill the hole around the tree.



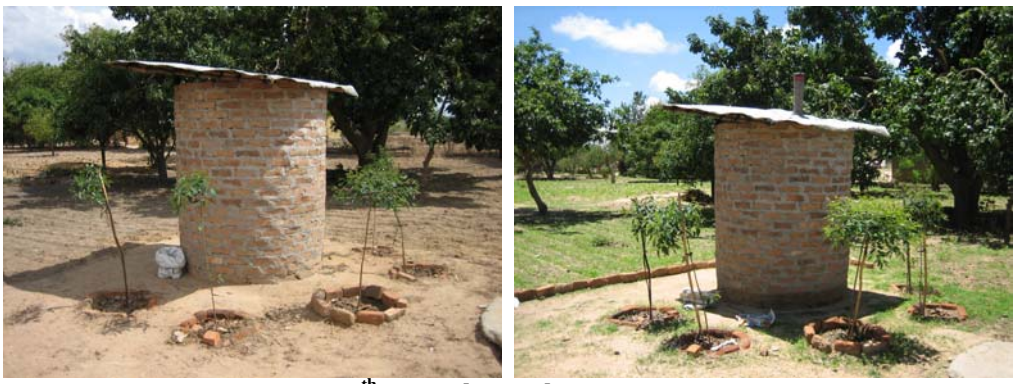

Trees being added on 9th October 2009. Right photo on 16th February 2010
Each hole is planted and protected in turn around the pit. A ring of bricks is added around each tree and covered with grass or leaf mulch. Each tree is thoroughly watered. Diluted urine was added weekly.

Later views of these trees

Trees on 25th May 2010. The trees had grown tall, but several had been attacked by termites. Termite attack appears to be a serious problem in some areas. See later notes. Note that earlier simpler toilets made with grass had been replaced by brick toilets during the experimental period.

Another example of planting several trees around a toilet

Several toilets have been surrounded by a ring of trees to extract nutrients from the central pit. In this case the trees were planted on 5th October 2009. The trees were fed diluted urine, once a week.



19th November and Dec 8 2009


15th February and March 12th 2010


13th December 2010 and 31st May 2011. In these photos the toilet had been rebuilt in a new location. The toilet was taken apart and rebuilt in a single day. Note considerable growth of trees, a combination of toilet compost below ground and diluted urine treatment above ground.

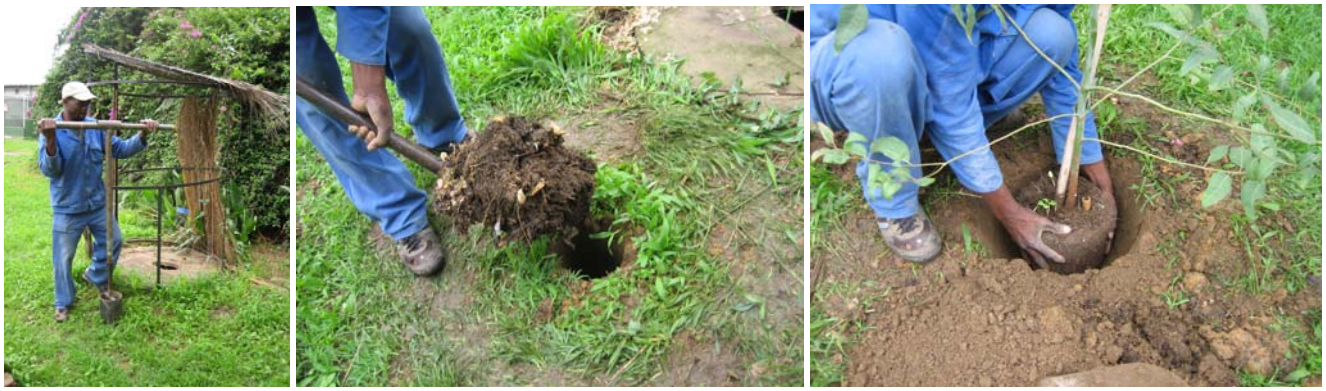
Pruning the trees

In this case the gum tree *Eucalyptus grandis* has been used. When the tree reaches the height of the toilet or just beyond it is best to prune the lower branches of the trees to promote upward growth. The foliage will then quickly rise above the level of the toilet and vent pipe. Vent pipes work better if the air flow around them is not disturbed by trees.

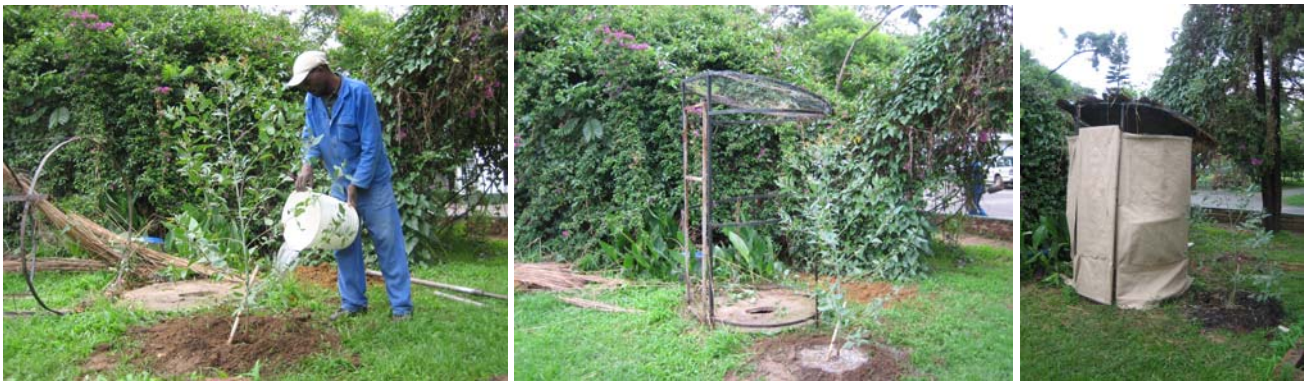

The lower branches are carefully pruned to a level just below the green new growth of the tree trunk.

Growing a gum tree near to an unlined pit toilet filled with raw excreta only

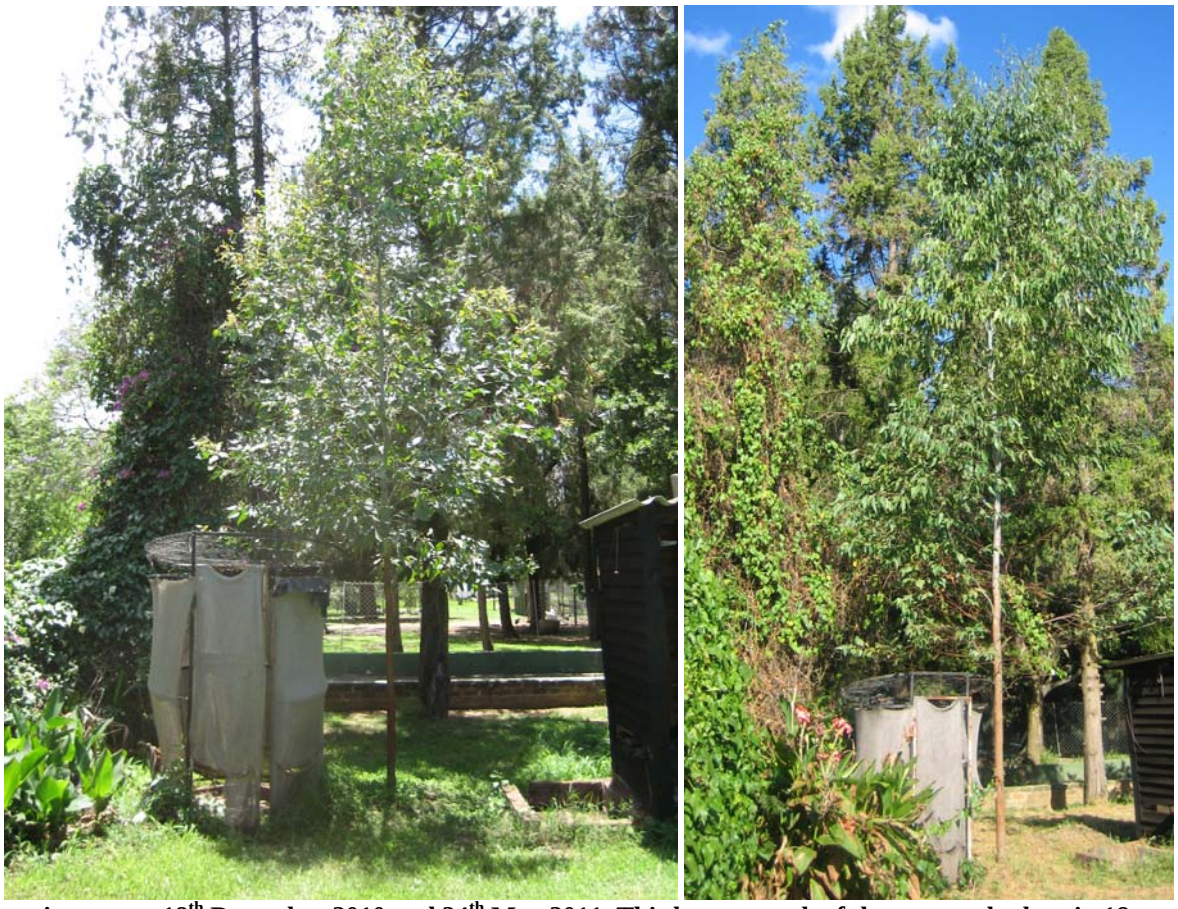
Most *Arborloos* have soil and ash added regularly to the pit contents as well as excreta. This promotes composting and also reduces flies and odours. This is the normal method with *Arborloos.* In this case a gum tree was added near to a pit filled with raw excreta only to see if the tree could tolerate the high nutrient levels near the pit and also be able to tap the nutrients without tree stress. No urine was added to the tree in this experiment, which was undertaken at the Friend Foundation, Harare.



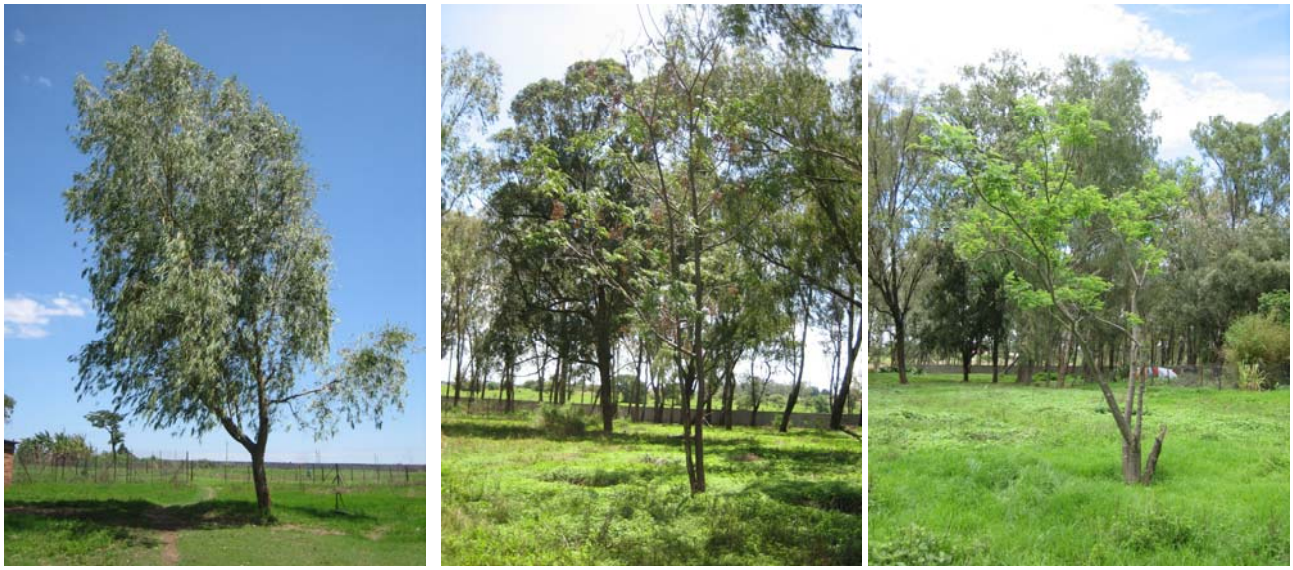
A hole was drilled about a metre away from the toilet pit, which was an unlined *Arborloo pit.* The drilled hole, about one metre deep was filled with compost from a *Fossa alterna* pit. The gum tree growth had been accelerated from seedling stage in a bucket by the application of diluted urine once a week. Thus on planting in this location it has d become established with a strong root system, Planting took place on14th December 2009.



The planted tree was watered. The wall covers of the steel frame portable structure were rebuilt in hessian material. The pit was protected by a concrete ring beam only with faeces in direct contact with the soil of the put walls.



The tree pictures on 18th December 2010 and 24th May 2011. This huge growth of the gum took place in 18 months. Tree growth in this case was accelerated without the use of diluted urine. Nutrients derived from excreta seeping directly through the pit wall into surrounding soil led to this remarkable growth.

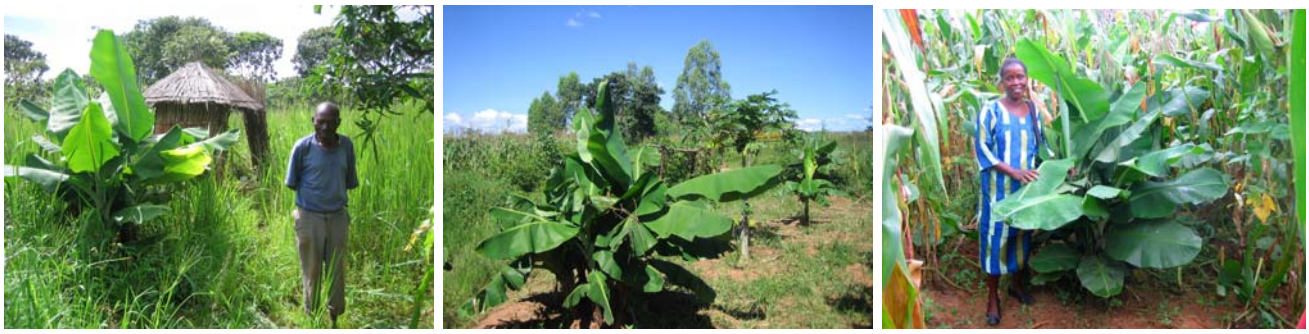


Eucalyptus sp, and *Cedrela toona* and planted on organic pits filled with dog manure years before. Trees planted directly on top of the pit contents covered with soil

Toilets and banana

The banana is perhaps the most commonly used fruit tree which is used to recycle human excreta in traditional practice within Eastern and Southern Africa. Most commonly placed on used and abandoned toilet pits, it is also planted around soakaways attached to septic tanks. It freely accepts the high concentrations of nutrients present in human excreta. Valuable trees in recycling human excreta also include the gum tree, the mango, paw-paw and avocado. Citrus trees are less tolerant but popular nonetheless in countries like Malawi, Kenya and elsewhere.

Banana growing vigorously – each linked to feeding from human excreta.
Left photo directly from an abandoned toilet pit in Epworth. Centre, fed by urine taken from the boys' urinal at Chisungu school, Epworth, at the end of the hand pump run-off. Right feeding off a soakaway linked to a "tank version" of the Blair VIP in Epworth.



Bananas planted on *Arborloo* pits in Malawi

Left, banana tapping urine from urine diverting pedestal within the toilet. Centre, one of many designed for portable toilet structure in Malawi. Right bananas planted in a row of earlier *Arborloo* sites.

Planting a woodlot of gum trees and accelerating the growth with diluted urine

The rapid growth rate of gum trees treated with diluted urine weekly, in both the school and the outreach environments provided sufficient evidence for extending this concept to woodlots. Fuel is in short supply in Epworth, as it is in most parts of Zimbabwe and an effective and simple method of growing more timber, using excreta as a source of nutrients seemed like a viable and practical concept.

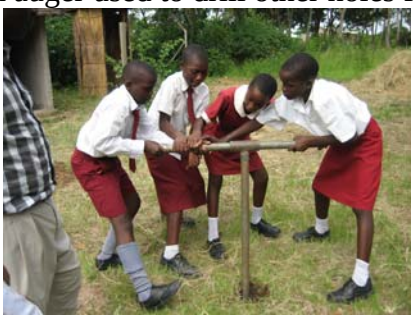
Choice of tree species

Many species of gum trees are available for this type of work. The project had used the fast growing *Eucalyptus grandis* in its first trials. This had proved very successful. However another fast growing and drought resistant species *Eucalyptus tereticornis* was more easily available at the time of planting and was chosen. Whilst gum trees are known to take up large amounts of water from the soil, they are valuable in many ways – not least for building and for fuel. Their use around toilets helps to reduce the flow of fluids from the pit and thus helps to reduce the potential of underground water contamination.


The trees were purchased from the Forestry Commission Nursery

Site selection and drilling holes for tree planting

School staff chose the most suitable site for planting and holes were drilled with the 170mm diameter earth auger used to drill other holes for trees. Holes were drilled 0.6m deep and 1.5m apart.



The earth auger fills up with soil and this is removed after each filling and placed back in the hole to drill deeper. Soil is removed by knocking the auger with a bar to loosen the soil then emptying by hand or with a stick. Each hole is filled with rich soil or a mix of compost and excavated soil. This helps the plant roots penetrate more quickly into the soil.

Tree planting

Each tree is carefully taken out of its planting bag and placed in a hole made in the soil within the drilled hole. The soil is pressed down around the tree. The tree is thoroughly watered. It is a good idea to place a “mulch” of leaves or grass over the soil around the tree to reduce the loss of water by evaporation after watering.

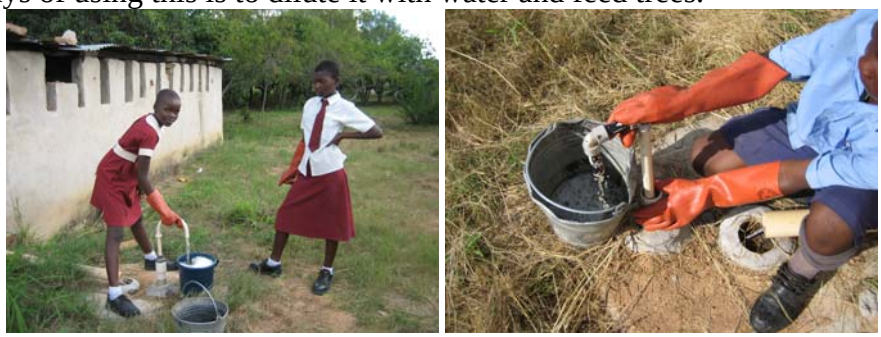
Photos on planting day. March 2010

Each tree is carefully planted and watered in each planting hole

The trees are watered regularly if there is no rain. Gum trees in woodlots like all other planted trees are best planted during the rainy season, especially if sources of water are distance or scarce. In this case water is taken from the school well fitted with a hand pump. Urine application starts about 2 weeks after planting to allow the trees to establish.

Collecting urine

In this trial urine was collected from the urine tank connected to the boys urinal. A modified plastic "Blair pump" is used to pump out the urine. Large amounts of urine can be collected from the tank and one of the best ways of using this is to dilute it with water and feed trees.



Collecting the urine from the urine tank

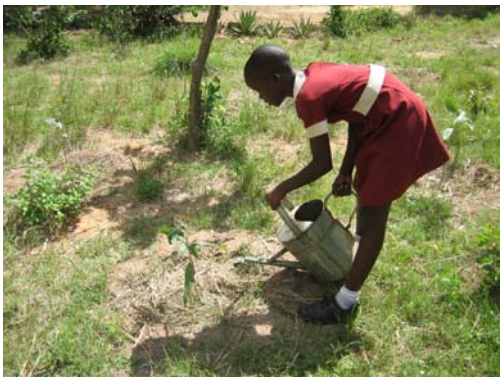
Urine application

Urine is diluted with water before being applied to the trees. 2 litres of water are diluted with 8 litres of water in 10 or 12 litre bucket or watering can. This is a 4:1 dilution and is enough to treat two trees. Thus each tree is given one litre of urine. The urine is applied once a week. After the urine has been applied each tree is given a further 5 litres of water.

A 2 litre plastic milk bottle (opened up) serves as a measure. The bucket or watering can is filled up with water. Each tree is fed individually with the diluted urine either from a bucket or from a watering can

Watering

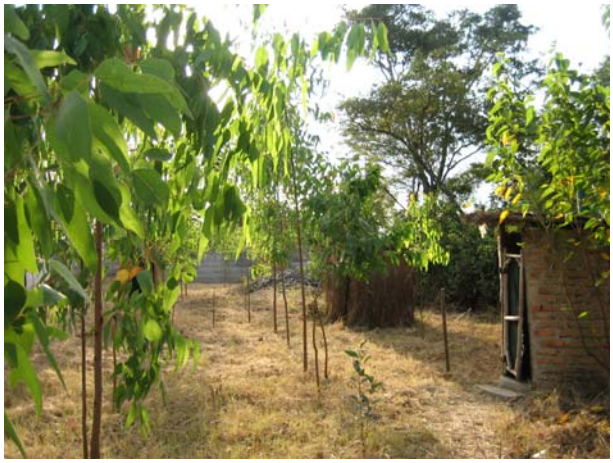
When the trees are young they need to be watered regularly, especially if the rains are poor or if the trees are not planted in the rainy season. As the roots penetrate more deeply they rely less on watering. If a tree shows signs of dying it should be replaced.




Liberal watering helps a lot in the first few weeks and in the dry season of the first year.

Photos of woodlot December 2010


Photos of woodlot May 2011

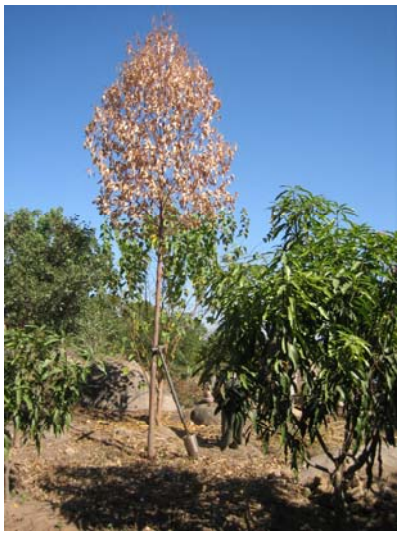



All the gum trees are healthy. Urine application became less frequent, but had contributed to the early growth. Further diluted urine application would accelerate the growth.

Problems areas

In the first year a tree, like most plants, requires a lot of attention including watering and protection from animals. There may be other problems

Protection from termites

These sad trees were totally killed by termites. If there is early evidence they should be treated with chemicals. The application of wood ash may help. Dead trees should be removed and the soil treated and new trees planted.

Goats

Goats can eat trees and suitable protection should be provided if goats roam the area

Trees and vent pipes

The leafy part of younger or shorter trees can interfere with the air flow of vent pipes in VIP toilets. However if trees like gum are chosen the trunk can grow fast and the foliage lies well above the level of the pipe whilst the pit contents are still low in the pit. Trees can be trimmed and pruned after the first year so that air flow is not interrupted.

What have we learned?

This report clearly indicates that trees of various types can benefit greatly from the nutrients derived from human excreta and the methods of transferring the nutrients can vary somewhat. These vary from direct uptake from an unlined pit, a lined pit, by various methods of urine application and also from the seepage from soakaways linked to septic tanks of various types. The trees, in their early stages and up to at least one year old require protection from animals like goats (if these are common in the area) and most importantly a regular supply of water. It is often best to plant the tree just after the start of the main rains, if water is scarce or if regular watering cannot be guarantees. If trees die, from what ever course, they can be replaced. Trees fare better if they have been pre-grown in containers just after purchase form the nursery. Here they can be planted in rich soil, water regularly, and when established the growth can be accelerated by the weekly application of diluted urine.

One of the greatest problems faced in the Epworth study was attack of the tree roots by termites and ants. This had the effect of killing of the tree completely. This can be a serious problem. Interviews with tree nursery people revealed that this problem can be overcome by the application of product known as Confidor which contains Imidacloprid. The trees should be well irrigated before application. 5 litres for smaller trees and 10 litres for larger well established trees. Doubtless traditional methods also exist. Wood ash is known to help reduce termite problems.

Other potential problems related to trees linked to toilets are the disruption of air flow across the top of VIP vent pipes. In the literature it is commonly stated that VIP toilets should not be built close to trees, as the tree vegetations spoils the air flow in the pipe. This is true. However if gum trees are used, the tree should grow above pipe level within 2 years and the foliage can be trimmed so the trunk of the tree only stands by the toilet with the foliage above pipe level. Also there is the possibility that the roots may damage the substructure brick construction. This may be true after a decade of growth, but within the lifetime of the normal pit (10 – 15 years) there may be minimal damage to the pit. Time will tell on this aspect of the work. Eventually the tree will outlive the pit toilet, and probably those who first use it.

One potential advantage of planting trees near pit toilets, especially those placed in relatively high water table areas is the ability of the tree (particularly gum) to withdraw water and possibly liquors from the soil surrounding and under the pit (particularly medium depth pits). This may have the benefit of reducing pollution of underground water sources by pit toilets placed in such situations.

Looking ahead

A much wider variety of trees should be considered in these experiments, particularly indigenous trees. There are several species which have merit, including Acacia and both exotic and indigenous nitrogen fixing trees. Linking the Toilet and the Tree as partners makes good sense and as time passes this will become more evident. Trees can provide benefits like an income in cash, fuel, fruit or building material. And trees have time. Amongst their numbers are the oldest living things on Earth.

Acknowledgements

The studies described in this report were supported by the EcoSanRes Project of the Stockholm Environment Institute in Sweden. Many thanks to Madeleine Fogde and Arno Rosemarin and SEI staff for their support. Many thanks also to Annie Kanyemba and Jim and Jill Latham of Eco-Ed Trust.