Planting trees over material excavated from VIP toilets

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Introduction

*Aquamar-Zimbabwe* has been promoting the concept of recycling the nutrients found in processed or semi processed human excreta into trees for several years. This material is not compost in the strict sense of the word since it contains very little if any plant material in its primary condition. The addition of soil alone starts the process of conversion into a product which is more manageable. Plant material can be added during the process of further treatment which improves the texture and quality of the product.

The *Arborloo* is the simplest and most basic method of recycling the valuable nutrients found in human excreta into trees which can provide fruit, timber or fuel. This simple technique is now used in several countries. The excreta is never touched or handled in any way. The pit material is covered with soil and a tree is planted on top. Placing the converted or processed excreta formed in *Fossa alterna* toilets or urine diversion toilets into the base of “tree pits” is another method. Here the material is physically moved from one site to the next in a way which is safe if carried out by people who are careful. The material is either excavated from shallow pits, or vaults and placed in the base of tree pits, where it is covered with soil and the tree is planted. The “tree pit” is a hole prepared for the planting of a tree, commonly measuring 60cm x 60cm x 60cm. When the human material is added, the lower half contains toilet material which is still in a state of conversion. The upper half holds topsoil which can be a mix of topsoil and garden compost. The young tree is planted in this upper layer, which can be covered with a leaf much to retain moisture. When the young tree is cared for (watered and protected from animals), nature takes over. The young tree roots grow within the soil. The interface between the soil and the human material is biologically very active. The soil organisms and the air introduced during the process acting upon the semi-processed excreta
to convert it eventually into a new nutrient rich material which the tree roots will invade. The tree and its root system take that decision. Different trees react in different ways and some may be more tolerant than others. If the tree holds back, that is known as “hesitancy” on the part of the tree. The tree may remain alive and well for years without moving. But once the physiology of the tree decides it is ready, the tree will move.

This report describes a further step forward in promoting this concept – placing the excavated material from toilet pits (mostly VIPs in our case), placing in “processing pits” nearby, and then moving in bags to the tree pits. The process of excreta conversion and nutrient uptake thus takes place in at least 7 stages.

1. Slow conversion in pit (aided by addition of soil/leaves etc)
2. Excavation from pit into “processing pit.”
3. Secondary processing in processing pit (material is broken up and soil added). This increases area of surface contact between soil and excreta and adds air. May take several months.
4. Removal and bagging of material and conveyance to site where “tree pits” have been dug in preparation. This may be an orchard or a woodlot at a school or in the homestead.
5. Depositing of material into base of pit and covering with topsoil. And garden compost too – it help.
6. Further conversion of human material in the base of the pit.
7. Uptake of the nutrients into the body of the tree, promoting growth and production of increased fruit, timber or fuel.

Now we describe the process in a little more detail. Several other Aquamor publications also describe the process. We now bring it together.
The sources of material
The material can have its origins in pit toilets (eg VIPs), *Fossa alterna* or urine diverting toilets. Manuals and reports describing the processing of material derived all these sources have already been described. This time we concentrate on material taken from the most common toilet in the world – the pit toilet. In this case it will be the Blair VIP, an improved version of the pit toilet. The simplest scenario with filled pit toilets is to knock them down, place a thick layer of soil above the pit contents – up to half a metre – and plant a tree. This may work in areas where there is space (eg in most rural areas). In this case we have chosen to investigate taking material from the pit and processing it further, by a process of mixing and dividing it up so that the value of the nutrients may be distributed amongst many trees.

Methods of extracting material from filled pit toilets
Various methods are available for emptying pit toilets. The techniques are potentially dangerous to health. The methods must be performed by people who are experienced in the various techniques.

These methods include knocking down the toilet, adding soil to the pit, ramming, leaving to partly process, excavating partly processed material, placing in processing pit, mixing with more soil, allowing time to process further, digging out and bagging, transferring to tree pits, planting trees and planting. This process is described in the Chapter 23 of *Teaching Ecological Sanitation at School*.

For other pit type toilets the material can be extracted using an Archimedes screw, into a sides pit, transferring in buckets to a shallow process pit leaving, adding more soil, allowing time to process further, digging out and bagging, transferring to tree pits, planting trees and planting. The pit will be only partly excavated but will provide a few more years of service of the toilet. This method can be used where the toilet structure remains in place. This process
is described in the manual *The Archimedes Screw – its usefulness in toilet pit and tank emptying.*

For further pit type toilets the material can be extracted completely, again by using an Archimedes screw at first and then by manual excavation (using buckets and shovel). If the structure is to remain in place, a trench is dug by the side of the pit and Archimedes extraction takes place at first followed by bucket and shovel extraction. This may mean entering the pit below the slab which is still in place. The material is then transferring in buckets to a shallow process pit leaving, allowing time to process further, digging out and bagging, transferring to tree pits, planting trees and planting. This process is described in the report *The Blair VIP – tank version.*

The exact method depends on the nature of the pit material and whether the structure and slab have been removed. If the material is compacted from the uppermost layer of the pit contents (adding soil prior to excavation will assist this process), and the structure and slab have been removed, the contents can be completely removed using a shovel and a bucket and rope. This process can also be performed if the toilet (eg Blair VIP) has been built with 2 “half-moon” shaped slabs). Once again the pit material is transferred to a processing pit of suitable size, soil added to the mix. A period of processing allowed. Then the material is excavated again and bagged and taken to the final processing site, which is the tree pit. This process is described in *The Blair VIP. A method of emptying the Blair VIP built with removable slab.*

In each case the material, in whatever way it is extracted from the pit is moved to a shallow processing pit of suitable dimension, soil added and the pit totally covered with soil and left to process. After some months, this pit is excavated, bagged and conveyed to the final processing site which is the tree pit. In all cases this process requires space, a trained cadre of artisans and a will by the local community to assist the process.
Excavation methods

Various pit emptying methods, where pit material can be removed from the pit and deposited in shallow processing pits nearby have been described in more detail elsewhere (see the refs on previous page). These include the Archimedes screw, shovels, spades, badza’s and bailers bucket and rope. These methods are used by specialised artisans who practice this skill regularly.

The Archimedes screw has value for looser material

Buckets and spades help too

For harder material direct access to the pit is important
Filling the “processing pit”

The method of pit emptying varies depending on the condition of the pit contents.

Layers of pit contents and soil are laid in the pit.

The pit is filled up and completely capped with soil.
Observations on breakdown of excreta by soil

An important part of the process is the processing of the removed excreta in the nearby “processing pit. This is mainly biological with the soil bacteria being very active. The addition of air into the system also assists the process. If leaves are added they also add air and further beneficial bacteria and fungi. The soil works on the excreta, changing its form and its ease of handling. The breaking up of the solid pit contents also helps to add more air into the system.

Experiments conducted on the reaction of excreta to soil are revealed in these photos. On the right photo can be seen the raw excreta (yellowish) the intermediate material (darker brown) and the soil (lighter brown). The soil and its bacteria slowly move through the excreta, changing its form.

This photo reveals the effect of soil alone (middle) and soil and leaves (right) on raw excreta. The excreta nodules in this case were mixed with an equal volume of soil. The original soil is shown on the left. The rate of change depends on factors which include the volume of excreta the related volume of soil and whether other ingredients like leaves have been added. See report in *An Ecological Approach to Sanitation*
Rates of conversion

The rate of breakdown and conversion of the excreta in the processing pit thus depends on the proximity of the excreta to soil and how much air is introduced into the pile. Adding leaves will add air and beneficial bacteria and fungi which help the breakdown process. Compost could also be added to the mix, either garden or toilet compost. These materials can be added through holes drilled in the mound. It is also very likely (though not yet tested) that the introduction of the black soldier fly, *Hermetia illucens* into these processing pits and mounds will accelerate the conversion process. In all cases the volume of the pit material is reduced as its water content is reduced. For the time being the simplest process is being undertaken – that of adding soil alone – simply re-introduced back throughout and on top of the contents of the compost pit.

Pit size

The size of the pit varies, but should ideally be the same capacity (or slightly more) than the volume of the excavated toilet pit contents - about 3cu.m. is a good size. It should be shallow – about half to 3/4m deep. The pit contents are transferred by shovel or bucket to the pit in layers. After each layer of excreta a layer of soil is added. In the current test a processing pit measuring 3m x 2m x 0.5m deep is in use.

The content of the processing pit can be tested from time to time by drilling small holes into the mound and observing the changes to the material.
Bagging and moving the partly processed material

In current tests the processing of pit material takes a few months. No exact period has yet been estimated, as this may depend on many factors including the state of the weather (wet or dry), the temperature, the relative volumes of excreta and soil, and the state of the pit material when it was excavated. However there is a safety factor involved. That is that the process is undertaken by experienced artisans and the material is unearthed, bagged moved (on a truck etc) and re-deposited in another pit (the tree pit) within a short space of time. The tree pits should have been prepared beforehand. In our study they were prepared in the orchards of two schools.

Digging out, breaking up and bagging the material from the processing pit.

The bagged material is moved from the processing pit to the orchard.
Pit material – safety and nutrients

Early experiments reveal that pit material taken from the processing pit may be almost free of bacteria within 5 months, with elevated levels of certain nutrients. Of some surprise is that the nitrogen levels in very old pit material were shown to be depleted, and reveals that extra nitrogen is required to enhance the growth of trees planted in tree pits. The levels of phosphorus, potassium, calcium and magnesium were much enhanced through. Whilst these results are preliminary they reveal that where old pit material is used (as in the case described here) extra nitrogen should be added to the soil surrounding trees. This can be in the form of garden compost, manure and/or diluted urine.

Levels of bacteria

In a simple experiment 1gm each of natural soil, 5 month old processed pit material and fresh faeces were diluted with the same volume of water and tested for total coliforms and E. coli, using the 3M Petrifilm technique. Numbers were expressed in cfu’s – coliform forming units per ml. As is clearly shown, total coliforms were almost eliminated and E.coli totally eliminated after 5 months. Coliforms are also found in vegetation.

<table>
<thead>
<tr>
<th>Sample type</th>
<th>Total coliforms</th>
<th>E. coli</th>
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</thead>
<tbody>
<tr>
<td>Soil</td>
<td>nil</td>
<td>nil</td>
</tr>
<tr>
<td>5 month processed pit material</td>
<td>2 cfu/ml</td>
<td>nil</td>
</tr>
<tr>
<td></td>
<td>4 cfu/ml</td>
<td>nil</td>
</tr>
<tr>
<td>Fresh Faeces</td>
<td>$10^5$ cfu/ml</td>
<td>$10^5$ cfu/ml</td>
</tr>
<tr>
<td></td>
<td>$10^5$ cfu/ml</td>
<td>$10^5$ cfu/ml</td>
</tr>
</tbody>
</table>

Levels of nutrients

<table>
<thead>
<tr>
<th>Sample</th>
<th>N. before incubation</th>
<th>N. after incubation</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>13</td>
<td>27</td>
<td>10</td>
<td>0.17</td>
<td>2.96</td>
<td>0.71</td>
</tr>
<tr>
<td>Mean Pit (3) 8.66</td>
<td>18.33</td>
<td>172</td>
<td>2.41</td>
<td>26.10</td>
<td>4.26</td>
<td></td>
</tr>
<tr>
<td>Ratio soil/pit X0.66</td>
<td>X0.67</td>
<td>X17.2</td>
<td>X14.1</td>
<td>X8.8</td>
<td>X6.0</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Nitrogen (N) as mineral N ppm (ammonia + nitrate n); Phosphorus (P) as ppm of P2O5; Potassium (K), Calcium (Ca) and Magnesium (Mg) as mg equivalents per 100gm. Mean pit figures from 3 samples.

Note 2. High levels of P, K, Ca and Mg are retained in the excavated and processed pit material, but N is lost. The samples of pit material were extracted after a 25 year period. Nitrogen is far less stable than P, K, Ca and Mg.
Preparing the tree pits

The tree pits are dug 60cm x 60cm x 60cm deep within the orchard.

The tree pits are dug and two bags of bagged processed pit material are added to the base of each pit.

The pit material is levelled off and soil added back, preferably mixed with garden compost.

The tree site is worked into the shape of a bowl and watered.
Planting trees

The young fruit trees were purchased from a nursery contained in plastic bags. The bags are removed and the tree planted.

The soil around the tree is covered with leaf mulch to provide extra nutrients and reduce evaporation, then watered. Trees are best planted at the start of the rainy season. Extra nitrogen can be provided in the form of garden compost, processed manure, diluted urine etc. Several types of fruit tree are growing on tree pits fertilised in this way. It is a simple and productive way of recycling nutrients from human excreta.
Examples of trees thriving on nutrients derived from human excreta

Trees used for building or for fuel *Syringa, Eucalyptus* and *Cedrela*

Mulberry, avocado and banana

Paw paw, fig and orange