7. The eco-toilet and agriculture

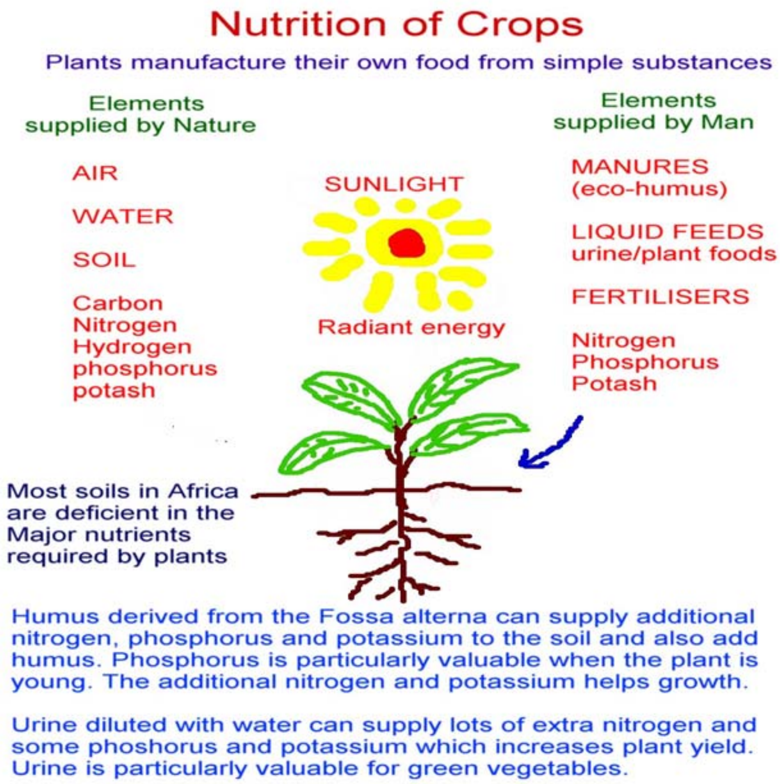
So far we have talked about toilets – how they are built and managed. We have arrived at the point where, in the Arborloo, we have a pit filled with excreta and soil etc ready for tree planting. In the case of the Fossa alterna we have arrived at the point where we have a pile of fertile humus next to the toilet.

But at that stage we have only reached the first part of our story The best part is still to come! We must now plant trees to make use of the nutrients in the Arborloo pits and also use the Fossa eco-humus (and urine) to best advantage to grow better crops of vegetables.

The simple eco-toilets described here fit in well with the sound principles involved with organic gardening where organic materials of many types, like composted kitchen and garden wastes and animal manure etc, are recycled for the benefit of food and tree production. The use of eco-humus derived from human excreta is an extension of this idea, and there is nothing particularly new about it. Human waste, suitably composted, has been used by Man for a long time.

The importance of nutrients in plant growth

Plants require certain chemical elements for plant growth – these are called plant nutrients. Most of these are non-mineral elements such as carbon, hydrogen, and oxygen. These elements are mainly taken up as carbon dioxide from the air and water by the roots. Sunlight also plays a major part. Increasing the supply of sunlight, carbon dioxide and water through photosynthesis also increases the growth rate and crop yield of plants.



The nutrients are classified in two groups, macronutrients and micronutrients. The major uptake by plants falls in the macronutrient category. Macronutrients include nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca) and magnesium (Mg). These nutrients are mainly taken up from the soil by the plant roots in ionic form. Micronutrients include boron, copper, iron, chloride, manganese, molybdenum and zinc.

Each major nutrient, nitrogen (N), phosphorus (P) and potassium (K) plays a different role in plant growth and development. Each also plays a vital role, and plants grow best when there is a good balance of these essential nutrients. It is useful to record here the value of the different nutrients in plant growth and development.

NITROGEN

Increases size of leaves
Increases rate of growth
Increases final yields
TOO LITTLE - Poor pale green or yellow leaf
TOO MUCH - Delays ripening, causes lush but soft growth. Can block uptake of potassium.
VERY GOOD for green leafy crops and maize

PHOSPHORUS

Stimulates early root and shoot growth
Hastens leaf development
Encourages early maturity
TOO LITTLE - Poor growth
TOO MUCH - No harmful effect
VERY GOOD - All plants need generous supply

POTASSIUM

Improves health and quality of crop
Encourages fruit production
TOO LITTLE - plants less healthy and poor fruit production
TOO MUCH - Few harmful effects
VERY GOOD for potash-responsive crops like potatoes, tomatoes, tree fruits & legumes

- **Nitrogen** (available as nitrate) is the most important nutrient involved in vegetative plant growth and leaf building – it also helps to increases the final yield of crops. It is required in relatively large amounts. Plants deficient in nitrogen have pale leaves and look weak and the lower leaves gradually turn yellow, as the plant transfers the vital nutrients to where they are most needed in the formation of new leaves. However nitrogen cannot do its work unless phosphorus, potassium and other elements are also present in the soil in sufficient quantities. An excess of nitrogen can also reduce the uptake of other important nutrients like potassium which is important for the general health, fruit formation and disease resistance of plants. Most soils in Zimbabwe and surrounding countries are very deficient in nitrogen. Nitrogen is quickly washed out of the soil after heavy rain or watering, and needs to be replaced fairly often.

- **Phosphorus** is important because it gives a good start in life for plants by assisting strong root growth and shoot formation. It is also a good fruit builder and encourages early maturing and ripening. It hardens stems and vegetative growth and increases resistance to disease. Unlike nitrogen, which is easily flushed out, it is held by the soil and does not need to be replaced so often. Also unlike nitrogen and potassium, it does not burn plants. Generally phosphorus is deficient in most top soils in this part of Africa. A deficiency in phosphorus results in poor root growth which is revealed later by slow plant growth in general. One indication of deficiency is the purpling of leaves. There is seldom an excess of phosphorus in any soil. It is a very precious mineral in short supply unlike nitrogen which is available in abundance and potash which if needs be can be taken from wood ash. Most soils in Zimbabwe and surrounding countries are very deficient in phosphorus.

- **Potassium** (potash) builds fibre & skeletal growth in the plant and also helps to promote good fruit development. It promotes the general vigour and health of plants. A balance must be maintained between potassium and nitrogen as they interact with each other. Many important plants are "potash hungry" like tomato, potato, onion, runner bean – so potassium is important in our story. Potassium is not washed out of the soil as easily as nitrogen but is not held as strongly as phosphorus. Most soils in Zimbabwe and surrounding countries are very deficient in potassium.

Most garden fertilisers have a balance of nitrogen, phosphorus and potassium for use on vegetables. The ratio of the "NPK" in fertilisers, with phosphorus predominating, indicates that on the phosphorus deficient soils in Zimbabwe, most require more phosphorus than nitrogen overall. As the plants mature, more nitrogen may be required. Most leafy vegetables respond very well to the application of nitrogen after they have become established and this is available in large quantities in urine. Fruiting vegetables and root crops require far more potassium as they mature, and an excess of nitrogen may retard fruit growth, favouring lush leafy development. But each vegetable or crop has its own specific requirements. Also different soils vary greatly in what nutrients they can naturally provide for the plants. So the application of ***Fossa*** humus and urine to plants may result in a variable reaction, depending on the soil used and the type of plant grown. The ***Fossa*** humus improves soil texture and a good balanced supply of additional nutrients to the soil and most plants respond very favourably to its application.

Fruit and trees.

All plants have the same basic requirements, whether they are vegetables or trees. Thus in the early stages of a trees growth, phosphorus will be required for good root and early shoot growth. Nitrogen once again will be required for vegetative growth. But fruit bearing trees do require plenty of potassium to produce of their best. Perhaps this is why young tree grow well on composted human excreta – it does contain generous supplies of phosphorus.

All fruit trees need adequate fertilisation to produce their best yields. Feeding of some sort is required every year, with manure, compost, diluted urine or other fertilisers. The amount of plant food required increases as the tree grows larger. In the case of citrus trees about 10 kg of manure or compost is required per tree per year for the first two years. This increases to 15 kg in the 3rd year, 20 kg in the fourth year, 25 kg in the 5th year, 30 kg in the 6th year, 35 kg in the 7th year, 40 kg in the 8th year and 50 kg between the 9th and 14th years. 10 kg is a wheelbarrow full or 150 gms ammonium nitrate, 200 gms single super-phosphate and 200 gms potassium chloride. For guava about 15kg manure or compost is required in the first year, 20 kg in the second and 45 kg from then on. Similar amounts are required by mulberry and avocado. Mango requires 10 kg manure or compost spread out through the year during the first year, 16kgs from the 3rd to 4th years, 18kgs for the 5th and 6th year and after 11 years about 60 kg. For Bananas about 15 kg manure or compost are required every year for each banana clump.

In ecological sanitation, the ***Arborloo*** is the closest link between the toilet and the tree. The nutrients present in the composted excreta, will be enough to start the tree off and a good quantity of phosphorus will be present and sufficient nitrogen and potassium to feed the tree for a year or two. The analysis of compost from a few ***Arborloo*** pits and from those ***Fossa***

alterna pits analysed (see below) show that even after a year of composting the nutrient level is high. Once the tree is planted, the nutrients held within the pit compost will start to be used up. So after two years, annual feeding of the fruit trees will be required to gain the best fruit yields. Urine can supply plenty of nitrogen, but less potassium. So the best way of applying urine is to dilute the urine (5:1) and add wood ash. The exact amounts required are still being worked out. As the tree grows larger, more will be required. A single charge in a watering can will be a mix of 2 litres urine to 10 litres water with a mug full of ash added and stirred in. Once the young tree is 2 years old, a mix of 2 litres, urine diluted with 10 litres water with a mug full of ash mixed in can be applied twice a month during the rains and with additional watering at other times. As the tree grows much larger quantities are required. It is important to keep the level of potash high in relation to nitrogen for best fruiting. The annual application of manure or compost will also help to sustain fruit output from trees.

Soil pH

For most crops the pH of the soil is best at a value of around 6.0 to 6.5. That is just slightly acid. At such a pH bacteria of the helpful kind will enjoy good conditions. The various soil nutrients will be kept in an optimum state of availability, various fungi that cause disease will find unfavourable conditions and the soil will tend to granulate to a more favourable size. If the pH drops too much below 6.5 or 6.0 then phosphoric acid ceases to be available. If the pH goes up to high, that is towards alkalinity, then certain trace nutrients will become entirely unavailable eg manganese, iron, copper, zinc, boron, and such a condition would be very hard to correct. There is therefore a serious danger in the over use of lime.

Special requirements

We have already mentioned that some plants require increased amounts of certain nutrients to give their best yields. All young plants require generous phosphorus and perhaps that is why the amount of phosphorus available in most general fertilisers contains more phosphorus than the other main nutrients. ***Fossa alterna*** humus does contain quite a generous supply of phosphorus. Most green vegetables and maize respond to a good supply of nitrogen, and diluted urine has much nitrogen. Indeed most plants respond positively to diluted urine if applied carefully during their main phase of vegetative growth. Several important plants like tomato, onion, potato and some types of bean need more potassium to give their best yields and this can be supplied by applying wood ash. Wood ash can also be applied in a liquid feed with diluted urine, or with water. Alternatively a liquid feed made from composted leaves in which comfrey leaves are included provides a good mix of nutrients including potassium. Most plants respond positively to soil to which compost has been added. As the plants use up nutrients for their growth, the soil requires replenishment, from whatever suitable source is available.

Nutrient levels in *Fossa alterna* humus

It is interesting to record that the balance of available nutrients in humus derived from the ***Fossa alterna*** is well spread between nitrogen, phosphorus and potassium, as they would be in commercially available general compound vegetable fertilisers. By comparison, urine has a very high level of nitrogen in relation to both phosphorus and potassium. Thus the effect of applying urine is much like applying a rich nitrogen fertiliser. Urine is particularly useful for promoting the growth of leafy vegetables like rape, covo and spinach, once they are established. Maize also responds very positively to the application of urine.

Soil analysis of ***Fossa alterna*** humus shows it is rich in the main plant nutrients as can be seen from the following table. The figures below show the pH and levels of nitrogen (ppm - after incubation), phosphorus (ppm), and also potassium, calcium and magnesium (ME/100gms.) in twelve samples of the ***Fossa alterna*** taken from the Friend Foundation (10 samples), Epworth (one sample) and Woodhall Road (one sample), all in the Harare area. Later these figures are compared to various naturally occurring top soils in Zimbabwe in the Harare area.

NUTRIENT LEVELS IN *FOSSA ALTERNA* HUMUS

Soil source	pH	N	P	K	Ca	Mg
Sample 1. (Friend Foundation)	6.5	269	317	1.59	20.77	11.28
Sample 2. (Friend Foundation)	6.1	246	330	4.64	5.53	5.41
Sample 3. (Friend Foundation)	6.6	174	374	3.74	8.59	5.74
Sample 4. (Friend Foundation)	6.2	222	422	2.22	3.60	3.57
Sample 5. (Friend Foundation)	6.5	319	196	3.26	13.70	7.26
Sample 6. (Friend Foundation)	7.7	316	242	3.84	9.96	3.42
Sample 7. (Friend Foundation)	7.6	355	258	7.14	8.97	6.26
Sample 8. (Friend Foundation)	6.9	305	230	6.65	12.00	10.32
Sample 9. (Friend Foundation)	7.7	354	257	9.18	9.26	3.46
Sample 10 (Friend Foundation)	6.3	197	299	2.94	26.64	4.77
Sample 11 (Epworth)	7.1	240	194	2.80	5.22	3.65
Sample 12 (Woodhall Road)	7.8	285	228	2.80	9.24	2.33
Mean value (*Fossa alterna*)	6.86	273	278	4.22	11.11	5.61

Enhancement of deposited soil

The quality of the humus derived from ***Fossa alterna*** pits varies depending on what extra ingredients are added to the pit in addition to excreta (urine and faeces). The texture, nutrient levels and water holding capacity, for instance, are improved if fertile topsoil and leaves are added in addition to the excreta. The texture of the excavated humus is similar to the soil added to the pit. However, even when poor soil is added alone, significant improvements can be achieved in nutrient levels as the results below show. In the cases cited below, soil analyses were made on the soil added to the pit as well as the soil (humus removed).

Example 1.	pH	N	P	K	Ca	Mg
Soil added to FA pit (cemetery topsoil)	4.9	50	13	0.18	2.95	0.78
Humus removed from *Fossa alterna*						
Sample 4	6.2	222	422	2.22	3.60	3.57
Sample 6.	7.7	316	242	3.84	9.96	3.42

Examples 2, 3 and 4	pH	N	P	K	Ca	Mg
Soil added to FA pit (kennels site. pit soil)	5.5	27	5	0.29	10.23	4.11
Humus removed from *Fossa alterna*						
Sample 7.	7.6	355	258	7.14	8.97	6.26
Sample 8.	6.9	305	230	6.65	12.00	10.32
Sample 9.	7.7	354	257	9.18	9.26	3.46

	pH	N	P	K	Ca	Mg
Example 5 (Epworth sample 11)						
Soil added to FA pit (Epworth topsoil)	**4.1**	**23**	**54**	**0.07**	**1.72**	**0.50**
Note local dried leaves and some wood ash were also added to the pit)						
Humus removed from *Fossa alterna* Sample 11 (Epworth)	**7.1**	**240**	**194**	**2.80**	**5.22**	**3.65**

	pH	N	P	K	Ca	Mg
Example 6 (Woodhall Road sample 12)						
Soil added to FA pit (Woodhall Rd soil).	**6.2**	**27**	**32**	**0.63**	**9.68**	**2.30**
Note dried guava and avocado leaves were also added to the pit)						
Humus removed from *Fossa alterna* Sample 12 (Woodhall Road)	**7.8**	**285**	**228**	**2.80**	**9.24**	**2.33**

We can now compare the nutrient levels found in ***Fossa alterna*** humus and mixed soils with a series of samples taken of naturally occurring top soils taken in the Harare area.

Examples of naturally occurring top soils

Soil source	pH	N	P	K	Ca	Mg
Harare (Tynwald 1.)	**6.1**	**32**	**68**	**1.59**	**6.42**	**4.02**
Harare (Tynwald 2.)	**5.5**	**27**	**5**	**0.29**	**10.23**	**4.11**
Harare (Marlborough Vlei)	**5.1**	**72**	**30**	**0.99**	**22.88**	**18.06**
Harare (Epworth 1**)**	**4.0**	**18**	**9**	**0.08**	**1.46**	**0.32**
Harare (Woodhall Road**)**	**6.2**	**27**	**32**	**0.63**	**9.68**	**2.30**
Ruwa (Knuth Farm 1. veld**)**	**7.5**	**30**	**30**	**0.12**	**3.79**	**0.56**
Ruwa (Knuth farm 2. pit soil)	**5.1**	**14**	**23**	**0.01**	**1.12**	**0.48**
Ruwa (Knuth farm 3 - garden soil)	**6.7**	**96**	**143**	**0.73**	**15.23**	**1.96**
Harare (Epworth 2)	**4.1**	**23**	**54**	**0.07**	**1.72**	**0.50**
Mean value (local soils)	**5.5**	**38**	**44**	**0.49**	**8.05**	**3.58**

According to the Chemistry and Soil Research Institute, many naturally occurring top soils found in Zimbabwe reveal very low levels of nutrients available for plants. This is caused by weathering, lack of tree cover, and the effects of rain on badly eroded soils. A nitrogen level in soil of less than 20ppm is regarded as low, 20 – 30 as medium, 30 -40 adequate and 40 plus is regarded as "rich". So the soils produced from the ***Fossa alterna*** are rich indeed, with those in our range of naturally occurring soils being in the adequate range.

For phosphorus, less than 7 ppm is regarded as low, 7 – 15 marginal, 15 – 30 medium, 30 – 50 adequate and 50 plus "rich." Thus once again the natural soils tested were in the adequate range. Once again the ***Fossa alterna*** humus is rich in P, which is a valuable component. It can be mixed with local top soils to get an enhanced production of vegetables, which is what this story is all about. Critical ranges for Ca are 15 – 20ppm, and 0.3 – 0.4 meq/100g for Mg and 10 – 15ppm for K.

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. Nitrogen, phosphorus and zinc, amongst other minerals were 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 production without meaningful inputs of both humus and nutrients (Farai

Mapanda (pers.comm). Thus any form of fertile humus which can be locally produced and mixed with the poor local topsoil can only be seen as advantageous.

Summation of levels of nutrients in *Fossa alterna* soil compared to local top soils

Soil source	pH	N	P	K	Ca	Mg
Mean value (local soils)	**5.5**	**38**	**44**	**0.49**	**8.05**	**3.58**
Mean value (*Fossa alterna*)	**6.86**	**273**	**278**	**4.22**	**11.11**	**5.61**

The value of leaves as an additive to *Fossa alterna* pits.

Constant reference is made to the considerable benefit which can be derived by adding leaves to ***Fossa alterna*** pits. Leaves help the composting process considerably, by adding more air into the mix, and by adding a composting process undertaken by fungi to the already existing bacteriological process undertaken by soil micro-organisms. Leaves also increase the organic proportion of soil and thus improve its humus content.

During the first year of operation, the second pit of the ***Fossa alterna***, which must be built at the same time as the first pit, can be left empty and covered with a wooden lid. This will be the standard procedure. However it is possible to take advantage of the second pit during the first year of operation. One of the best methods is to make leaf compost within this pit for the first year of operation. This is carried out by adding dry leaves to the pit, together with thin layers of soil. More leaves and soil are added once the initial batch has condensed in volume. Water is added from time to time to keep the contents slightly moist.

At one site in Epworth close to Harare, leaves were gathered and emptied into the second pit of a ***Fossa alterna*** interspersed with thin layers of the local topsoil. Water was added from time to time. After 12 months the leaf compost was excavated and proved to be much richer in nutrients than the original soil. In fact plants grew in this leaf mould far better than in the original soil. The second pit acted like a pit composter and was well worth the simple effort involved of adding leaves, soil and water. The following table shows the increase of nutrient levels in the leaf compost made in the second pit compared to the local topsoil

The figures below show the pH and levels of Nitrogen (after incubation), Phosphorus, (ppm) and also Potassium, Calcium and Magnesium (ME/100gms.) in the leaf compost formed in the second pit of a ***Fossa alterna*** compared to the surrounding topsoil which was added together with local leaves.

Soil source	pH	N	P	K	Ca	Mg
Local topsoil (Epworth)	**4.1**	**23**	**54**	**0.07**	**1.72**	**0.50**
Leaf compost from second pit	**7.7**	**81**	**130**	**1.86**	**9.31**	**1.88**

Composted leaves clearly have a considerable nutrient value of their own and no doubt greatly enhance the final quality of ***Fossa alterna*** humus, if added. The results of four soil analyses of leaf mould formed in wire baskets and a variety of containers is given below. A description of these leaf mould makers is given later in this book. As we shall see later, the addition of leaves also improved the efficiency of composting in shallow pits.

Analysis of leaf mould

Soil source	pH	N	P	K
Leaf compost in wire basket	8.2	256	344	3.92
Leaf compost formed in plastic bag	7.8	267	294	8.50
Leaf compost formed in steel drum	7.6	239	255	0.60
Leaf compost formed in brick moulder	7.4	540	266	9.00

Overall comparisons of soils and composts

Soil source	pH	N	P	K
Mean value (local top soils)	5.5	38	44	0.49
Mean value leaf mould	7.75	325	290	8.00
Mean value (*Fossa alterna*)	6.86	273	278	4.22

Physical properties of excreta, soil, leaf mixes.

One interesting property of excreta or mixes of excreta and soil, both in jars and pits is that the volume is considerably reduced over time. Even with abandoned full latrine pits the volume may decrease considerably over time. In urine diverting toilets the urine is channelled away and the faeces dehydrate or compost and loose their initial volume due to loss of moisture. In shallow pits the combination of urine and faeces also loose volume over time with the urine being absorbed into the soil added to the pit and also into the soil surrounding the pit. The bulk and volume of the faeces is also reduced over time with the liquid fraction of the faeces being absorbed into the soil added to the pit. It is known that the water content of the faeces is variable but always high. It is this larger water fraction of the faeces which can be absorbed into other ingredients added to the pit (soil, ash, leaves),whilst the remaining smaller solid fraction of the faeces is converted into humus, which forms part of the final total volume of the humus formed in the pit or jar.

But what are the fractions?

The following experiment was carried out to calculate the percentage water content of faeces by combining a known weight and volume of faeces with a known weight and volume of dry soil. Since the dry soil would loose neither weight of volume, any change in the final volume and weight of the mix would be caused by changes in the properties of the faeces.

A sample of faeces was collected in the ***Skyloo***. This sample weighed 357gms, had a volume of 340mls and a density 1.05 gm/ml. This was mixed with a near equal volume of dry soil with a weight of 352gms, a volume of 310mls and a density of 1.135 gm/ml. Therefore the total weight of the mix was 709gms having a volume of 650mls and an overall density of 1.084 gm/ml.

This was allowed to slowly compost over a period of 24 days. Fly larvae developed in the mix, which also attacked by ants. Slowly the mix changed into soil. Another mix was made with an approximately equal mix of faeces, dry soil and crushed dry leaves. This mix was also allowed to compost for the same period.

On the left, raw faeces and soil being mixed prior to composting. On the right a mix of leaves, soil and raw faeces prior to mixing and composting

After the period of composting both samples were laid out in the sun to substantially dry out, but not to full dessication status. The final weight of the dried soil/faeces mix was 420gms, with a volume of 405 mls and a density of 1.037gm/ml.

Thus the weight of the "new soil" formed had increased from 352 to 420g (about 19%), compared to the original soil in the mix and the volume of the "new soil" had increased from 310mls to 405mls (about 30%) compared to the original soil in the mix. Since the volume and weight of the dried original soil cannot change, the faeces weight had therefore been reduced from 357g to 68g (420 - 352g) - 19% of original. **So the water content of faeces was 81%.** The faeces volume had therefore been reduced from 340mls to 95ml (405 - 310ml - 28% of original). So the final density of the mix was less than the original soil. The mix was also darker in colour. The overall weight of the combination was reduced from 709g to 420g (59.23% of original). The overall volume of the combination was reduced from 650 ml to 405ml. Thus the composting process of soil and faeces reduced the volume to **62.3%** of the original combined volumes.

The processed combination of "NEW SOIL" was very similar in appearance to the original soil since 76.5% of its new volume and 83.8 % of its new weight consists of the original soil.

Samples of original soil (left), and "new soil" made from faeces and soil (centre) and from faeces, soil and leaves (right)

In the case of the faeces/soil/leaf mix a final weight of 270gms was measured with a volume of 405mls. This gives a density of the combination of 0.66gms/ml. This is a much lower density compared to the faeces/soil mix (1.037gm/ml). Clearly the addition of leaves lowers the density of the mix, a result no doubt of less compaction and more air in the mix due to the presence of leaves. These properties would encourage far more efficient composting. Composting is far more effective as the air content increases. This is a very important finding.

Density trials on *Fossa alterna* humus

The results shown above would explain why a mix of excreta, soil and leaves appears to compost much faster than a mix of soil and excreta only. To test this theory the humus taken from a ***Fossa alterna*** which had a mix of excreta, soil and leaves was compared for weight and volume to the humus taken from another ***Fossa alterna*** which had a mix of excreta and soil only. The initial comparisons (for volume, weight and density) were made in crumbly (not dried) ***Fossa alterna*** humus. These samples were then dried out in the sun to obtain new parameters.

***Fossa alterna* soil (crumbly, not dried)**

Soil /humus type	Vol. ml	Wt.gm	density
FA kia (excreta, soil, leaves)	410 (jam jar)	370g	0.90g/ml
FA FF (excreta & soil only)	410	402g	0.98g/ml
Garden soil	400	443g	1/10g/ml

***Fossa alterna* soil (sun dried)**

Soil/humus type	vol. ml	Wt.gm	density
FA kia	325	278	0.85g/ml
Fa FF	370	338	0.91g/ml
Soil	368	392	1.06g/ml

These results reveal that where leaves are added to the ***Fossa alterna*** pit the resulting density of the humus is lower. The density of the humus is related to both the moisture content and the air content. The more air (with some moisture) the better the conditions for composting. Thus a mix of excreta, soil and leaf in the ***Fossa alterna*** pit is more effective and leads to a faster and more efficient composting process than the mix of excreta and soil alone.

Thus leaves are an important ingredient in this process, not only because they provide extra nutrients, but also because they lower the density of the mix and provide extra air, thus increasing the efficiency of composting. They also add a process of fungal decay in the mix as well as composting based on bacteria. They also provide a larger surface area for the composting process to take place and allow for better pit drainage. All these combined beneficial effects of leaves enhance the composting process considerably.

Consequently the addition of leaves to the shallow pit composting process in both the ***Arborloo*** and ***Fossa alterna*** has been greatly encouraged in programmes of implementation. Similarly leaves are now added to the buckets holding faeces, ash and soil in the ***Skyloo*** and also to the jar and shallow pit secondary compost sites.

Adding leaves to shallow pits

Adding dried leaves to shallow pits used in the *Arborloo* and *Fossa alterna* helps the composting process considerably.

Adding leaves to *Fossa alterna* pits. On left at Woodhall road, on right at Epworth.

Adding semi composted palm leaves to the base of a *Fossa alterna* pit in Mombasa, Kenya (left). Two sacks full of leaves at the base of a concrete lined pit in Maputaland, South Africa.

Conclusions

These various results show that the ***Fossa alterna,*** when well managed, offers the family a valuable asset, which is not only an effective toilet system, controlling both flies and odours, but also provides an excellent source of humus for the vegetable garden. Soil analysis reveals why the addition of humus derived from the ***Fossa alterna*** pit every year helps to enhance the fertility and nutrient levels of an existing vegetable bed. This can greatly enhance back yard vegetable production (see plant trials later). By combining these advantages with its low cost and relative ease of use and management, the ***Fossa alterna*** may hold much potential for future use in many parts of Africa. Since the same ingredients are also added to the ***Arborloo*** pit, it is logical to suppose that young trees will also gain much benefit, in their early life. Many generations of experience in countries from all over the world can vouch for the improvement of tree growth in old toilet pits. Even the Pilgrim Fathers used the idea when they arrived in the New World. The same method is practices in many countries in Africa today. The ***Arborloo*** concept is an extension of a well established and widely used traditional method. The formation of humus by mixing soil, leaves and excreta was invented by Nature itself.