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Comparison of plant nutrient levels between compost from *Sky loo* and *Fossa alterna* toilets

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Recent scholars have highlighted the benefit of harvesting compost from eco-san toilets for application as plant nutrients. However, levels of nutrients in eco-san compost may vary depending on the type of toilet and also the type of top soil in a particular geographical region. This study compared levels of nitrogen, phosphorous, potassium, calcium and sodium between compost from *Sky loo* and *Fossa alterna* toilets. Samples were collected from Zimora and Ng'ombe villages in Chikhwawa district, southern Malawi. Statistical analysis using SPSS showed significantly higher levels of nitrogen, calcium and moisture in compost from *Fossa alterna* toilets than in *Sky loo* ($p < 0.05$). However, there were no significant differences in the levels of potassium in the two types of eco-san compost studied. This study has revealed that compost from *Fossa alterna* is generally a richer source of plant nutrients than that from *Sky loo* thereby presenting poor, local communities in sub-Saharan Africa with a cheaper alternative to commercial fertilizer.

Key words: Eco-san toilets, compost, Malawi, plant nutrients, soil quality.

INTRODUCTION

With a Human Development Index rank of 171 out of 187 countries, Malawians living in rural areas face numerous challenges that include lack of access to safe drinking water, rising poverty, rapid population growth and poor sanitation (United Nations Development Programme, 2012). The growing numbers of poor households means that the majority of smallholder farmers cannot afford commercial fertilizers due to high prices. Such poor communities suffer from periodic famine due to persistent drought, and depreciating soil quality among many other external factorsg (Sugden, 2009). Eco-san compost has the potential of improving soil quality thereby increasing food security for poor households. Eco-san technology provides a safe way of recycling human excreta through composting. However, meaningful and comprehensive knowledge on variations of plant nutrient composition between compost from different eco-toilets is still scare.

There are three types of eco-san latrines, namely: Arborloo, Fossa alterna and Sky loo. Arborloo, sometimes known as "fertility pit", does not provide mechanism for harvesting manure; instead, a tree seedling (preferably a fruit tree) is planted on the spot when the pit

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becomes full. Sky loo, which is also known as “dry toilet”, has a permanent super structure and it is a urine diversion system. The urine and stool are collected separately. Fossa alterna is a kind of toilet in which urine and faeces are mixed in one vault (Snel and Smet, 2006).

Although, eco-sans toilets provide an environmentally friendly waste management technology for disposing of faeces and urine and their recovery through composting for possible use as manure, it faces some resistance due to socio-cultural issues. Adoption of eco-san technology has made little progress in Malawi despite a decade of advocacy and promotion by non-governmental organizations such as Water for People (Malawi). Such negative attitude stems from a general reluctance of people to use of their excreta as a valuable resource. Traditionally, issues of human excreta are considered a taboo in most parts of the world and are not usually discussed in public. For this reason, sharing of information and willingness to learn practical and environmental benefits of recycling nutrients in excreta back to soil seem remote.

Across the world, eco-san is increasingly being seen as an alternative for providing safe sanitation, reducing health risks associated with poor sanitation, protecting water resources, soil fertility and optimizing resources management at the same time (Water for People, 2009). Eco-san technology can improve social and economic conditions especially for impoverished communities. Similar technologies or ‘dry box toilets’ have been used successfully for many years in a number of countries, such as Vietnam, China, Mexico, El Salvador, Guatemala, Ethiopia, Zimbabwe and Sweden (Esrey and Anderson, 2001). In Asia, containers of untreated human excrement are set outside residences during the night and taken to crop fields. The contents of these containers are called ‘night soil’ because the boxes are collected at night for application (Nawab et al., 2006).

Soil is the primary natural resource base for agriculture, but most of the soils in Malawi have low levels of nitrogen. This means that they cannot support crop production without supplementation of key nutrients such as nitrogen, phosphorous and potassium from external sources. Nitrogen, potassium, phosphorous, calcium, magnesium and sulphur are collectively known as macronutrients. These macronutrients are vital for the rapid growth of plants, increased seed and fruit production and improving the quality of leaf and forage crops. Ferrallitic soils are widely prevalent in Malawi. These soils have levels of both nitrogen (0.05 - 0.12 %) and organic matter (0.4 - 1.6 %) in low amounts; indicating poor soil fertility. Available phosphorous is between 0 - 22 ppm while potassium ranges from 0.11 - 0.36 mE/100g). Enhancement of soil productivity is very important to the sustainability of agriculture and to meeting basic food needs of the growing population.

Commercial inorganic fertilizers in Malawi costed about US$40 for a 50 kg bag in 2012. This is a huge expense in a country where almost seventy percent of the population live on less than 1US$ per day (United Nations Development Programme, 2012). Conversely, human excreta are a freely available resource in all societies. They can be utilized as soil amendments to boost crop production. Eco-san technologies are important in econo-mic emancipation of poor masses because compost from eco-san toilets is an alternative to commercial fertilizers and have potential to reduce reliance on inorganic fertilizers. Compost has the ability to improve the soil structure and water holding capacity and is comparatively better off than commercial fertilizers (Centre for Community Organisation and Development, 2011).

The concept of eco-san technology was first introduced in Malawi in 2001 by Water Aid in Salima district and the Church of Central Africa Presbyterian (CCAP) at Embangweni, in Mzimba district, before being taken up by Community Water Sanitation and Health (COMWASH) in Phalombe and Thyolo districts (Morgan, 2010). Despite attaining a decade since its inception, it is still not widely used. Recent reports indicate that 50% of the communities in Ng’ombe and Zimora villages in Chikhwawa district have adopted eco-san toilets as a result of promotion activities by Water for people in Malawi (Water for People, 2012). However, this progress is minimal and there remains a lot of work to be done before a real paradigm shift in sanitary provision can occur whereby people do not simply equate sanitation to toilets but rather to total and ecologically sound sanitation with an agronomic and economic perspective. This study was therefore conducted to compare levels of essential plant nutrient between compost from *Sky loo* and *Fossa alterna* toilets in Chikhwawa district, southern Malawi.

MATERIALS AND METHODS

This study was conducted between May and August 2012. Three *Sky loos* and three *Fossa alternae* which had been in use for at least one year were identified in the area as sampling points. Samples were collected from well decomposed and harvested compost (approximately 500 g of compost was collected in triplicates into sealed plastic zipper bags) and were transported to Polytechnic Chemistry Laboratory in Blantyre City, Malawi. Samples were air-dried by thin spreading on clean sheets of paper in the laboratory for five days. Dry samples were sieved over 2 mm mesh and then stored in air tight polyethylene zipper bags for further analysis. The standard analytical methods used were from American Public Health Association series of Standard Methods of Examination of Water and Effluent (APHA, 1998) and AOAC Official Methods of Analysis (AOAC International, 1998).

Data analysis

The data collected were subjected to student’s independent t-test (two tailed) using SPSS to validate the hypothesis that the two

Table 1. Comparison of plant nutrient levels in *Fossa alterna* and *Sky loo* compost.

Compost type	mc (%)	N (%)	P (%)	K (%)	Na (%)	Ca (%)	S
Sky loo	5.03 ± 0.21	0.06 ± 0.00	0.05 ± 0.01	0.04 ± 0.00	0.01 ± 0.00	0.16 ± 0.02	BDL*
Fossa alterna	11.39 ± 0.44	1.88 ± 0.08	0.06 ± 0.00	0.05 ± 0.00	0.01 ± 0.00	0.10 ± 0.03	BDL*

*BDL = below detection limit.

Table 2. Nutrient levels in natural topsoil, compost from *Fossa alterna* and *Sky loo for studies done in Zimbabwe.* Source: Morgan, 2002.

Source	N (mg/kg)	P (mg/kg)	K (mEq/100g)
Natural dry land topsoil	38	44	0.94
Fossa alterna compost	275	292	4.51
Sky loo compost	232	297	3.06

Table 3. Chemical properties of natural soils in Chikhwawa district, Malawi. Source: Ministry of Agriculture and Food Security, 2001.

Agro-ecological zone	N (%)	P (ppm)	K(mEq/100g)
Chikhwawa Escarpment	>0.12	6 - 18	>0.2

types of eco-san compost had the same level of nutrient content.

Null hypothesis (H_0): $\mu_{FA} = \mu_{SL}$
Alternative hypothesis (H_a): $\mu_{FA} \neq \mu_{SL}$

Where μ_{FA} represented *Fossa alterna* compost mean values and μ_{SL} represented *Sky loo* compost mean values. The test was carried out at 95% confidence level (p-value = 0.05). If p-value computed was less than 0.05, the null hypothesis was rejected and alternative hypothesis accepted instead. With a p-value < 0.05, it meant there was a significant difference in the means of nutrient levels of *Fossa alterna* compost and *Sky loo* compost.

RESULTS AND DISCUSSION

Results obtained from the analysis of the two types of eco-san compoat are summarised in Table 1. There was a significant difference in levels of nitrogen for *Fossa alterna* and *Sky loo* (1.88% ± 0.08; 0.06% ± 0.00 respectively with $p \leq 0.05$). There was a lower amount of nitrogen in *Sky loo* compost than *Fossa alterna* compost probably because of the urine diversion design in the *Sky loo* latrine. Urine has a high content of readily available nitrogen. Nitrogenous wastes in the body, which result from ingestion of proteins, are excreted as urea after they have been converted from amines and ammonia (Chasseaud, 1970). Moisture content was also significantly different (11.39% ± 0.44, for *Fossa alterna* and 5.03% ± 0.21 for *Sky loo*; with $p \leq 0.05$). High amounts of water in compost from *Fossa alterna* result from urine inclusion because its principal component is water.

Levels of calcium were also significantly different such that *Fossa alterna* compost (0.10% ± 0.03) had lower level as compared to the *Sky loo* compost (0.16% ± 0.01) and p = 0.04. In humid soils, presence of ammonium sulphate may lead to loss of calcium from the soil because clay particles act like ion exchange resins. Calcium ions are exchanged for ammonium ions and are easily leached from the soil (Gardiner and Miller, 2004). This might explain why levels of calcium were lower in *Fossa alterna* compost than *Sky loo* compost.

However, there was no significant difference in levels of phosphorous for *Fossa alterna* compost (0.60% ± 0.00) and *Sky loo* compost (0.05% ± 0.01); $p = 0.17$. No significant difference was observed in levels of potassium for compost from *Fossa alterna* (1.88% ± 0.01) and compost from *Sky loo* (0.04% ± 0.03); $p = 0.34$. There was also no was no significant difference in levels of sodium for *Fossa alterna* (0.007% ± 0.00 and *Sky loo* (0.007% ± 0.00); with $p = 0.94$.

The results obtained in this study are comparable to findings in Zimbabwe (Table 2) which were reported by Morgan (2002) to compare major nutrient levels in samples of naturally occurring topsoil and compost from *Fossa altena* and *Sky loo-toilets*.

The natural soils which are found in the study area (Chikhwawa district, southern Malawi) are classified as eutric cambisols and haplic luviso (Food and Agriculture Organisation, 1999). Table 3 shows major natural occurring plant nutrient levels of these soils.

The levels of plant nutrients in eco-san compost from Chikhwawa district in Malawi are however lower those of eco-san compost from Zimbabwe. This phenomenon underlines the fact that amounts of nutrients in excreta differ from person to person and from region to region (Vinneras, 2002).

It is also important to note that eco-san compost can be a source of microorganisms such as salmonella, especially if the compost is harvested within a period shorter than 4 weeks. Studies done by Lemunier et al. (2005) indicated that compost may support long-term survival of *Escherichia coli and Listeria monocytogenes* but proper long-term (over 12 months) composting may prevent the presence of such microorganisms in compost and therefore pose low health risks to consumers of food plants grown using eco-san compost.

Conclusion

The findings from this study show that *Fossa alterna* produces compost richer in nitrogen than the *Sky loo* therefore more valuable nitrogen based organic fertilizer. The levels of other nutrients such as potassium and phosphorous did not vary between *Fossa alterna* compost and *Sky loo* compost.

The study has increased an understanding on the variations in nutrient levels of human compost depending on the type of eco-san technology used. It also contributes to the existing knowledge on the key factors which influence adoption of eco-san technology to improve soil productivity. Nitrogen is an essential plant nutrient which influences production of most cereals such as maize. Therefore, *Fossa alterna* compost can serve as good alternative for the relatively expensive inorganic fertilizers. However, nitrogen is highly labile and a single analysis is not sufficient to predict its sustainable supply to the crop over the growing season. it is therefore recommended that further extensive studies on crop productivity should be based on long term data of crop response to the two types of eco-san compost.

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