

PAVING THE WAY TO SCALING - UP

FACTORS CONTRIBUTING TO THE ADOPTION OF ECO-SAN TOILETS AND SAFETY OF HUMANURE IN MALAWI



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April 2013

ACKNOWLEDGEMENT

We wish to thank Sue Cavill of WaterAid for asking us to prepare this report. Also to the Share Consortium, who are working in Malawi and in many parts of the world in an effort to encourage research which will benefit the poor and underprivileged, particularly in the great challenge of improving their sanitation.

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1. INTRODUCTION

1.1. BACKGROUND

In Malawi, access to improved sanitation is estimated to be 51% (49% in urban and 51% in rural areas) (WHO/UNICEF, 2012). Disaggregated urban rural data point to some key trends. Access to improved sanitation has almost stagnated showing a mere 1% increase in 2010 from a reported 50% increase in 1990. Open defecation and the use of unimproved facilities are on the rise while toilet sharing is on the decline in urban areas (MoAIW, 2012). However, these figures might further understate the critically dire state of the sanitation situation in the country given the existing disparities in reported figures from different sources particularly due to lack of consistency and general agreement as to what represented an “adequate” sanitation.

Traditional pit latrines are the commonest facilities for defecation in Malawi, and in Africa in general. At times in urban Malawi the use of traditional pit latrine is considered synonymous to poverty and lower societal status (The Nation, online archive). They are often constructed with a ten years' expected service period. Nonetheless, the reported average pit latrine life is 3.9 years in Malawi (MoIWD, 2008). Up to several households share a single latrine. Hence latrines fill-up quickly requiring new investments from households for building new ones. Sanitation services are almost non-existent in the slum areas as their development is every so often unplanned and not included in government's limited service provision plans. Water-borne diseases are among the major causes of death in young children. School latrine to pupil ratios in schools could be as bad as 1:134 for girls and 1:136 for boys (Unicef, 2002) although schools without a functioning toilet are uncommon in Malawi.

A significant proportion of Malawians, particularly in growing urban slum settlements, and the poor in the rural areas live under dismal sanitary standards. Progress towards expanding sanitation service is offset by rapid urbanization (5.2% in 2005-2010), which fuels the growth of slums by annual rate of 3.6%. Slum population in 2010 accounted for 66.4 % of the urban population (UNHABITAT, 2010). The massive exodus from rural areas over to crowded and newly forming slums in densely populated big cities is believed to be exacerbated by the decline in food production in rural areas due to draught, deterioration in soil fertility and insufficient landholdings (less than 1ha for 55% of rural population) which do not match household food demands. High population growth in rural areas, spreading extreme poverty in slums, weak government capacity to address most of the social and economic problems further compound the already desperate sanitary situation in Malawi.

It is within such background that WaterAid in Malawi (WAMA) introduced ecological sanitation (eco-san) philosophy and technologies in 2001 to start a process that might help overcome some of these challenges. The philosophy focusses partly on making simple risk-free toilets more permanent, and partly to remit for the aforementioned environmental degradation and poverty nexus by promoting the use of human excreta-derived soil nutrients. These nutrients can potentially boost food production and help gain extra income for poor households. However the gains to be had are dependent on several external determinants such as climate, soil nature, access to land as well as governance, institutional line ups and collaboration and sector prioritization and financing, to mention a few.

Since 2001, over 10,000 households in the key WaterAid project areas (Lilongwe, Salima, Machinga, Nkhosakota, Mzimba and Blantyre) have been introduced to ecological sanitation philosophy. Church of Central Africa Presbyterian (CCAP) at Embangweni in the Mzimba district with support from WAMA was also an early promoter of eco-san in Malawi (WSP, 2007). Soon after, eco-san would spread to other districts such as Thyolo, Phalombe, Dwangwa Salima, Lilongwe, Blantyre and Ekwendeni attracting interest from local and international organizations. Some of the other promoting actors included the

Malawi Wildlife, and Environmental Society, Salima District Assembly, InterAid, Cowater International in partnership with the Community Water, Sanitation and Health Project (COMWASH), Centre for Community Organisation and Development (CCODE), and Water for People (WFP).

Currently an important weight is placed on eco-san technologies, at the national level, as the main driving factor to boosting widespread demand among the 49% of the unserved Malawian Population, and to enhance local and private sector investment to reverse the negative trends in meeting the sanitation linked MDGs (MoAIW, 2010).

UNICEF-led CLTS initiative also put emphasis on eco-san technologies to lever the open defecation free initiative in post triggering step villages. Sanitation marketing activities and hygiene promotion are also to go hand in hand with the current eco-san movement. The Ministry of Education has included eco-san as a teaching subject, and schools are also expected to integrate sanitation in their curriculum, particularly eco-san along with “permaculture”. Improved agricultural production in school gardens using eco-san toilet driven composts is believed to provide the required finance in addition to investments sought from the private sector to increase school sanitation coverage.

However scaling-up is a complex process itself and requires prior experience of both promoters and recipients in the chosen intervention areas, in the basic principles of eco-san, including technical aspects, processing, marketing and the application of the resulting “humanure” (processed human faeces). The key message here is that the various aspects of scaling up (horizontal, vertical, and functional) must be taken into consideration before the eco-san concept is scaled up to cover more people across a wider geographic areas. Inevitably, this requires working in collaboration and partnership with higher-level (provincial, national, regional, and even global) institutions and political forces. It may also be a serious setback to the long-term success of eco-san toilets if the health, environmental and economic aspects are not given equilibrated due attention in the scaling up process. This report attempts to partially fulfill the knowledge gaps needed to promote the functional scaling up of the eco-san concept in Malawi in line with the concerted efforts of SHARE and WaterAid to concretize the knowledge base in this respect.

1.2. PURPOSE OF THE REPORT

The present report is mainly centered on the findings of recent research carried out by Bunda Agricultural College, in partnership WaterAid and SHARE. The research was carried out from August 2011 to March 2012, and aimed to set some building blocks towards scaling up ecological sanitation in urban and rural Malawi. The basic idea was to draw lessons from households’ experiences of eco-san toilets promotion so as to understand what factors were appealing or deterred them from adopting the technologies. The goal of informing future standards and guideline developments for the safe management of ecological sanitation and human compost in Malawi was also in the realm of the research.

In view of the above mentioned objectives it sets out to:

- identify factors that motivate and/ or demotivate urban and rural households to adopt ecological sanitation;
- examine appropriateness of ecological sanitation promotional messages and methods;
- investigate eco-san management practices and assess their implications on human health and plant nutrient value;
- assess the levels of thermo-tolerant coliform and helminth eggs in human compost and
- measure levels of Nitrogen, Phosphorus and Potassium in sampled human compost.

While the authors of this current report acknowledge the importance of the findings of the research towards shedding light on its stipulated objectives, a substantial gap remains in making use of these results to answer most of the important questions surrounding the current dilemmas in the move towards scaling-up eco-san toilet technologies at a national scale in Malawi. Therefore an attempt has been made by the current authors to fill some of these lacunas (gaps) through further exploration of the literature and most importantly by enriching it with experiences not mentioned in the initial research report. Surveys of published literature available on websites and personal communication reveals a huge amount of information and further research is yet to be put together to form a fully coherent picture of the full extent of ecological sanitation practice in Malawi.

1.3. BASIC PRINCIPLES OF ECOLOGICAL SANITATION AND ECO-TOILETS.

The major principle of eco-san is to use systems where human excreta, after suitable processing, is free of health risks, and nutrients contained in it are freed to be used in agriculture and/or forestry to increase crop, fruit or timber output. The human excreta is known to contain valuable nutrients, notably nitrogen (mostly found in the urine), phosphorus and potassium. Eco-san toilets are also expected to be ecologically sound, reducing contamination of the environment, and use a minimum of water to operate.

1.4. ECO-SAN TOILETS PROMOTED IN MALAWI

Three main types of ecological toilet are known in the WASH sector, the *Arborloo*, *Fossa alterna* and urine diversion (UDDT). The *Arborloo* (Fig 1.1a) consists of a shallow (1.0m deep) pit with a movable slab and superstructure. Soil and ash are added to the pit after each use preferably with some leafy matter. When nearly full, the slab and structure are moved to another pit and a tree is planted on the filled pit in a layer of soil. The *Fossa alterna* (Fig 1.1b) operates in a similar way to the *Arborloo* but has two shallow (1.5m deep) pits which are used alternately. When one pit is full, it is covered with soil and left to mature and the second pit is put to use. When the second pit is full, the contents of the first pit are emptied and the use of the toilet reverts to the first pit. The removed pit contents are then stored in bags for later use or applied on gardens or trees. In Malawi most *Fossa alterna* toilets are built with both pits housed within a single superstructure. The third type, *Skyloo* (fig. 1.1c) is different from these two. In *Skyloos* urine and faeces are collected separately, using a urine-diverting pedestal or squat plate. The faeces (together with soil and/or ash) build up in a vault or bucket, whilst the urine is collected in a suitable plastic reservoir. The end products are also used or applied separately.



Figure 1-1 a: *Arborloo*



Figure 1-1 b: *Fossa alterna*

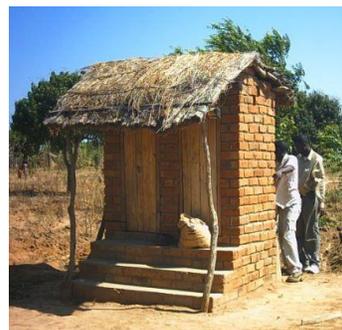


Figure 1-1 c: *Skyloo*

The organic matter in faeces is converted into stable humus-like products by a complex mix of bacteria, fungi, and other microorganisms present in the soil in both the *Fossa alterna* and *Arborloo*. In the case of *Fossa alterna* and *Arborloo* the governing biodegradation process is largely of aerobic nature (as it is the case for all composting processes). Composting in these types of eco-san toilets is affected by physical and chemical factors such as the carbon to nitrogen ratio, climate and temperature, moisture content, oxygen concentration, and pH. Wood ash and soil are added regularly to the excreta (urine and faeces) entering the *Arborloo* and *Fossa alterna* pits. This reduces the potential for odour and fly breeding and also hastens the conversion of raw excreta into a safer and more manageable product by acting on moisture, nutrient, and pH factors of the pit contents.

In urine diverting toilets dehydration or desiccation is the domineering agent for waste stabilization and pathogen kill-off in detention vaults. The separation of faeces and urine results in a significantly reduced moisture content in UD vaults compared to *Arborloo* and *Fossa alterna* pits where both urine and faeces are added. In the case of urine diversion, soil and wood ash (or often ash alone) are also added to the deposited faeces, assisting further dehydration, drying, and stabilization. Aeration is also one factor which could accelerate drying through evaporation in UD vaults. The addition of a vent pipe to a urine diverting toilet also draws out vault moisture, hastening dehydration of the vault contents, as well as controlling odours.

1.5. EARLIER ASSESSMENTS OF MOTIVATING AND DEMOTIVATING FACTORS FOR ECOLOGICAL SANITATION IN MALAWI PRIOR TO THE BUNDA REPORT.

Motivating and demotivating factors for ecological sanitation in the rural areas have already been partly assessed in earlier studies (Gremu, 2004; LSHTM, 2004; Morgan, 2007; Tsirizeni, 2004) and the strengths and weaknesses of ecological sanitation in urban areas in Malawi documented by CCODE in both published and unpublished material.

The major motivating factor on the part of households who adopted them, and perhaps the most promoted aspect of eco-san toilets are the potential advantages to be gained by the production and use of valuable soil conditioners and/or composts. These have the potential to improve household income and livelihoods. The much desired results from this can be summarized as harvesting of soil conditioners and nutrients which would otherwise be lost, assisting soil fertility restoration and improve food production, especially where soil nutrients are depleted. For landless and poor households however the main motivational drive, in this regard, comes from a reduced need to purchase commercial fertilizer and possibly the potential to bring-in extra cash to the household through compost sales. Whichever of these end results motivated them, the households who conferred interests in eco-san toilets, often times, exhibited high level of poverty and low social and economic profiles. Other motivating factors are also entrenched within the quest of poor households' to solve persistent problems surrounding access to proper sanitation facilities. Defecation is a fact of life that any conscious being would want to perform in private and in dignity. Such access however is far from the reach of a significant part of the poor, due to space limitations for toilet installation, lack of access to initial capital, limitations in hygiene related knowledge, and deficiency in technologies which offered options optimized to respond to their particular contexts and precincts, among others. Eco-san toilets emerged to address parts of space, cost and efficiency issues in urban and rural Malawi, where sharing of a single facility by several households, accidents from collapsing toilets (Nalivata and Matiya, 2008) and long queues behind toilets are common places.

The promotion of the eco-san toilets, particularly the *Fossa alterna* as a permanent structure, requiring little space, and cheaper (where subsidies were made and loans were facilitated) in contrast with

traditional pit latrines had captured the interests of households both in the rural areas and also in peri-urban slums.

The versatility of these advantages linked to resource recycling however, come with additional management and maintenance responsibilities beyond those often associated with traditional waste containment oriented approaches to sanitation like pit toilets. Reinforcement of both the resource base, institutional lineup and interaction, and good governance are required so that eco-san toilets do not stay constricted to the traditional functions of drop and seal sanitation facilities.

A number of disadvantages could emerge from insufficient considerations of the elements needed to make eco-san toilets function to attain their objectives. All eco-toilets require far more attention, than the squat and forget type of pit toilet. At times adoption and adherence is not accompanied by a willingness on the part of families to look after their ecological toilets properly. These include but not limited to the potential health threat of handling and using poorly processed toilet compost in gardens and on the lands which are not completely rid of pathogenic bacteria or the ova from parasitic helminthes. In worst case scenarios insufficiently treated pathogenic micro-organisms and unsafe disposal of excess nutrients contained in human faeces and urine can rather be threats to human health and cause environmental degradation problems such as buildup of nutrients in surface water bodies. However the health risks decline with time after the application of the compost on agricultural land as pathogen die off due to further exposure to the soil and also exposure to further heat from the sun.

In an undocumented number of cases, families have reverted back to the use of simple pit toilets, having been exposed to ecological toilets. Consequently, the use of human compost in agriculture is limited in Malawi to areas where eco-san has been introduced and sustained and backed by some sort of financial support system. The lack of space in many high density urban areas also limits its use.

2. MATERIALS USED FROM THE BUNDA/SHARE REPORT

The methodology as undertaken by Bunda College included a synthesis of demographic data, socio-economic and biological processes and drew important lessons from people's experiences. A total of 77 households, who implemented the eco-san toilets and 42 households who failed to do so were interviewed in the study. Compost and soil samples were taken from all the 6 districts and the eco-san toilets visited and analyzed for different parameters at Bunda Agricultural College, the undertaker of the research. A combination of quantitative and qualitative methods of data collection was used in the research to collect first hand and secondary data relevant to answer the research questions.

2.1. SOCIO-ECONOMIC SURVEY AND DATA SAMPLING, AND ANALYSIS TECHNIQUES

Key informant interviews were conducted at the district and organizational levels in order to complement interviews carried out with households. At the community level, local leaders and the masons trained in producing slabs and charged with the dissemination of eco-san technology practices were interviewed as key informants. At the district level, the key informants included health surveillance officers, project staff and local leaders. Members of same communities in the study area not using human compost manure were also interviewed to get their perceptions on the human compost. Focus Group Discussions with similar interest groups comprised of 4 – 7 people (men and women), in each village were conducted. These included toilet owners and compost users with converging perceptions and current stands vis a vis the production and utilization process of compost. This helped shed light on prevailing influences, which propelled and/or constrained current eco-san interventions. Quantitative data for the study was collected through a questionnaire which covered a total of 77 randomly

selected households of eco-san toilet owners and 42 households which did not own one. It was noted that statistics obtained from head offices of eco-san implementing organizations did not match in numbers with what had been witnessed during the field visits.

Additional observation was made by the study, at each of the interviewed households on the status and utilization of the toilets. These included cleanliness of the toilets, the availability of cover material, presence or absence of flies and odour. The visits to households also helped acquire information on the composting process and the management of the toilets while practiced. Data collected through the questionnaire was entered into SPSS software, analysed for descriptive statistics and comparative changes in some of the indicators. Genstat statistical software package was employed for biological data analysis.

Secondary data collection encompassed a review of published documents and relevant reports from WaterAid and its partners. Additional data is also available from CCODE and WFP on their websites. These documents, in combination can assist in comparing the approaches applied by the different actors to promote eco-san toilet, the advances made as well as the constraints met.

2.2. FIELD SAMPLING AND ANALYSIS OF TOILET COMPOST AND SOIL

Human compost was collected from households owning and using eco-san toilet to establish the biological safety and chemical quality of the compost derived from the toilets. These samples were analysed for levels of thermo-tolerant and faecal coliform, helminth ova count and viability as well as levels of nitrogen, phosphorus, potassium and organic carbon. Soil samples were also collected from sites near eco-san toilet which were representative of soil added as dehydrating and cover material in corresponding eco-san toilets.

2.3. PROCEDURES FOR BIOLOGICAL SAFETY ANALYSIS

For helminth ova determination, according to data emanating from Bunda College, 3g of the human compost sample were placed in a stoppered bottle containing 42 ml of distilled water; Exceptions were made for samples from compost found to be hard by replacing distilled water with 42 ml of 10N NaOH as dilution agent. The bottle was shaken vigorously until the compost was completely broken down aided by glass beads placed inside the bottle. 100 μ l of the mixture was pipetted on a microscope slide and covered with 22 mm cover slip. The sample on the slide was examined and all the eggs observed were counted. The number of eggs present in 1 g of compost was calculated from this.

2.4. FAECAL COLIFORM DETERMINATION

According to the recent report of Bunda College, 50g of the compost sample was mixed with 450 ml of sterile 0.1% buffered peptone water in a sterile blender bag. The mixture of the sample and the diluent was blended for 60 – 120 seconds in a VWR star lab blender (400 series). The mixture was further diluted using serial dilution method from 10⁻¹ to 10⁻⁷. Sterile tubes containing 9 ml of 0.1% buffered peptone water were prepared. Using aseptic technique and a separate sterile, 1 ml was pipetted for each dilution step, 1 ml from the blended sample, transferred to the first tube of 9 ml of sterile peptone water to make a 10⁻² dilution. Using a new, sterile 1 ml pipette, 1 ml was transferred from the first dilution (10⁻²) to the second tube of sterile peptone water to make a 10⁻³ dilution in the second tube. The procedure continued until a 10⁻⁷ or appropriate dilution was reached.

Three sterilized fermentation tubes with inverted Durham's tubes were prepared and filled with 9 mL of sterile lauryl tryptose broth (Oxoid) just to a volume partially covering the inverted Durham's tubes. These were incubated at 30°C for 24 hours. Then tubes were observed at the end of the 24 hour

incubation period for signs of gas in the upper top part of the Durham's tubes un occupied by the lauryl tryptose broth. Tubes manifesting gas clouds were kept as positive presumptive tubes indicating possible presence of coliform group bacteria (Total Coliforms). All positive presumptive tubes were transferred to EC broth fermentation tubes for further 24 hours incubation at 44.5°C. At the end of this further incubation the presence of gas in the upper parts of the Durhams tubes confirms the presence of faecal coliform bacteria (Harrigan, 1998).

2.5. THERMO-TOLERANT COLIFORMS USING MPN

For enumeration, plates were prepared as in total coliforms using MPN but this time incubated at 44o C for 24 – 48 hours. Faecal coliforms were detected by aseptically transferring 1 ml of inoculate from the positive presumptive tubes (one from each dilution showing positive results for total coliforms) to 9 ml tubes of sterile lauryl tryptose broth and Durham's tubes. Positive tubes showed gas production after incubation at 44° C for 24 hours.

2.6. HUMAN COMPOST SAMPLES PROCESSING FOR NPK

The soil and compost samples were analyzed in the Soils and Plant analytical laboratory (SPAL) at Bunda College of Agriculture. These samples were air dried (at 40oC) for 24 hours and then ground and passed through a 2 mm sieve. The sieved material was analysed as follows:

- Total organic carbon using the Walkley-Black acid digestion method.
- Total Kjeldhal nitrogen levels (i.e. levels of combined organic nitrogen, ammonia, and ammonium)
- Total phosphorus by digestion in concentrated nitric acid followed by colorimetric analysis.
- Soil pH in 1:2.5 water to soil suspension read on a previously calibrated electronic pH meter (Rhoades, 1982).
- Available P, K were analyzed through Mehlich III method (Mehlich, 1984)

3. FINDINGS AND DISCUSSION OF RESULTS FROM VARIOUS SOURCES

3.1. FINDINGS FROM DEMOGRAPHIC, SOCIO-ECONOMIC ASPECTS AND MANAGEMENT ISSUES OF HUMAN COMPOST

3.1.1. DRIVERS FOR USE OF ECOLOGICAL TOILETS

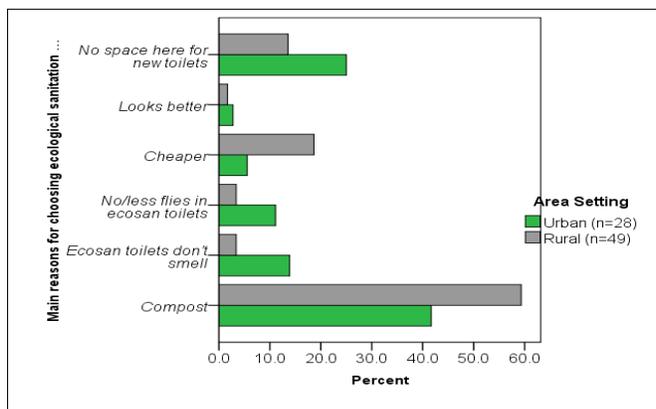


Figure 3.1: The Reasons Why People Choose Ecological sanitation toilets in Malawi

The Bunda survey found that about 60% of rural and 40% of urban respondents prefer eco-san toilets over traditional latrines principally for the latter's added value in yielding compost. This was especially true for households from low income rural and peri-urban groups who relied largely on subsistence farming. These groups constitute the majority of the adopters. Optimizing the use of scarce space related to eco-san toilet technologies appeared to be of high interest particularly in the squatter settlements (in urban areas) and small communal/village

setting (in rural areas) where available land for the household was absent or limited. Also of great interest was the fact that a well-managed *Fossa alterna* can operate for years without the need for reconstruction or re-siting. The offer of material or financial support would also have played an important factor. The *Fossa alterna* can work in a peri-urban environment if there is enough space to either reuse or dump the pit compost safely and if the unit is not shared between families.

Other enticing factors for eco-san toilet adoption are linked to comfort and esthetic quality including reduced smell and flies as well as pleasantness to the eyes of the owners and onlookers. However, over 31.5% of visited toilets were found to have flies and a significant emitted bad odor. Other studies highlight the striking effects the type of toilet that a household owns has on how it is perceived by the society it is part of. A household's adoption of an eco-san toilet could earn it a better place in its social status that some households were observed to "disguise" pit latrines with eco-san superstructures (Mtafu A. Manda, 2009).

Studies carried out at the LSHTM (2004) aimed to understand what drives demand for an ecological sanitation programme run by the Church of Central Africa Presbyterian and WaterAid in Embangweni, Malawi. The study found that the main driver for the uptake of ecological sanitation was not the control of diarrhoeal disease, but the ability to obtain manure, namely the financial benefit that came from saving money on fertilizer costs, which is very expensive by local standards. Through proper management and storage, participants realized the value of their own excreta in that they themselves could transform it from a harmful product into a productive asset. This asset not only saved them money in the short-term, but often was responsible for increasing their income in the long-term by improving their soil fertility and increasing their crop yield.

3.1.2. MAIN DISINCENTIVES FOR USE OF ECO-SAN TOILETS

A number of factors are said to act as disincentives for the use of eco-san in Malawi. These include the extra precautions needed to be taken for their maintenance and new responsibilities which come with adopting an eco-san toilet such as frequent pit emptying or compost removal of on a regular basis. Where the pit contents are not matured, due to reduced period of composting, there may be doubt about the safety of the product, in the mind of the user. The squat and forget philosophy is very appealing. Also not all potential recipients are farmers or practice any form of agriculture. A lack of land, particularly in the urban areas may limit the usefulness of the compost particularly the choice to put it in a market and earn a revenue is absent. One cycle which appears to be emerging is the cycle of use of – 1. traditional pit – 2. *Arborloo* – 3. *Fossa alterna* – 4. back to traditional pit. Many may favour the use of the deeper pit toilet, simply because of its simplicity of use and maintenance. Those that maintain the use of eco-san toilets have not only seen but appreciated the value of the concept in its entirety (that is use of a single toilet unit which provides valuable soil conditioner).

The shallower depth of pits specified for the eco-san toilets (1.5m) compared to the deep pit of traditional pit latrines is the main reason for wide spread skepticism among the non-adopter groups. In Malawi "a squat and go" types of pit latrines can be appealing in the short term, where sharing a single latrine is common and the management and maintenance of the shared latrine is thinly spread among several users. Toilet sharing is widely practiced in densely populated areas of Malawi in general (MoIWD, 2011). In most parts of Malawi pit latrines are intended to last for 10 years, whereas the actual time may be less than 4 years. Most traditional pit latrines fall out of service or fill up in less than 5 years (Vasquez, 2008) due to over sharing and at times due to technical and environment related faults. According to JMP data, in 2010, 27% of Malawian households (42% of urban and 24% rural households) used shared latrines (WHO & UNICEF, 2012). A 2008 survey on 10% of the households in nine low-income settlements of Malawi's three largest cities, Blantyre, Lilongwe and Mzuzu, shows strong income and access to land

and property causal relationships. 78% of overall households surveyed shared toilets for lack of space. Of those households 15% shared with one other household, 13% with two other households and 3% with more than 15 households (Mtafu A. Manda, 2009). Similarly (Kappauf, 2011; Maoulidi, 2012) find that the wide spread toilets sharing phenomena is a major cause of early filling-up of eco-san latrines in Malawi. However (Nalivata and Matiya, 2012) records an average family size for the use of eco-san toilets as 5.7.

Yet, the *Fossa alterna*, currently popular among adopters, in the form in which it is known in Malawi, was designed for use by a single, small to medium sized family and not for communal use. The two alternating pits were designed with an optimum period needed for a complete composting and service time of 12 months (Morgan, 2004). The concept completely breaks down, when the *Fossa alterna* is used communally by large numbers of people. This is because filling time is reduced and since an alternating pit system is used between two pit, the period available for composting and pit content processing is also reduced. This directly relates to the safety of the product when it is withdrawn from the pit.

The *Fossa alterna* and the other varieties of eco-san toilets are implemented in areas where traditional pit latrines were the customary sites of defecation or where no other proper defecation sites and practices existed before. Hence the newly introduced or adopted eco-san toilets are also susceptible to suffer similar fates particularly the abridged life of pits. In circumstances, where the number of users are not regulated and communal use of toilets threaten to continue post eco-san toilet adoption, the "Long Cycle *Fossa alterna*" (Morgan P.R. (2013) Website <http://aquamor.info/>) may be a better choice.

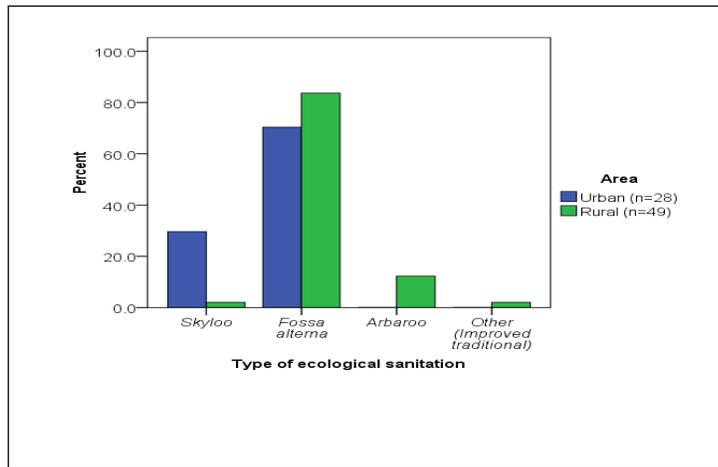
Furthermore, attentiveness to the construction design parameters and the principles governing the distinctive functional properties of the eco-san technologies are paramount to whether or not the generally promoted benefits of compost related livelihoods advantages and extra sectorial investments from the eco-san toilets are to be gained.

Rectangular pits built in Zimbabwe had a cross section of 1m x 0.7m and were 1.5m deep, providing a pit volume of 1.05cu.m. for each pit. Circular pits had a diameter of 1m and were also 1.5m deep, providing a pit volume of 1.17cu.m. per pit. Those pits observed by one of the authors in Lilongwe, and Embangweni in 2003 (ref Morgan 2003) had circular pits which were 0.6m in diameter and 1m deep, providing a pit volume of 0.282cu.m, one quarter of *Fossa alterna* pits built in Zimbabwe. Recommendations were made at the time to increase pit size for the *Fossa alterna*, but may never have been acted upon. The small size of *Fossa alterna* pits in Malawi may have been the result of the common use of the 0.8m diameter dome shaped slabs used on SanPlat toilets, commonly used in Malawi. Also fitting both pits within a single structure may have placed a limiting factor on pit size. However a small increase in superstructure dimensions could have solved this problem.

The way eco-san toilet construction costs were regarded differed in urban and rural samples owing to the type of promotional approaches used by the implementing organizations. While low cost as a driving factor was reported in the rural samples, directly linked to subsidies received by the rural households to cover all or part of eco-san toilets (hardware) costs, the no subsidy approach in the urban areas meant eco-san toilets were not attractive in terms of initial price. However there is also disparity in terms of access to finance within the urban setting itself. In Lilongwe, adopters were responsible for the overall building costs of their toilets while in Blantyre (urban) building materials for the toilets were facilitated as part of the loan for building houses under the CCODE-Federation agreement. Consequently in urban areas, financial constraints along with murky property rights rated as the major hindering factor for the adoption of the technologies. Eighty percent of the urban respondents were not property owners and resided in rented homes. This meant that either their landlords prohibited them from building toilets or they themselves withdrew from investing in one, as the length of tenancy is often

uncertain and out of their hands. At times a landlord could own several households in a block and oblige its tenants to share a single facility amongst them. Some tenants in Lilongwe (urban) may have chosen to adopt an eco-san toilet but refrained from building one because they were not granted permission from their landlords.

3.1.3. PREFERRED TYPE OF ECOSAN TOILET



The *Fossa alterna* is by far the most preferred type of eco-san toilet adopted by over 80% of the rural and 70% of the urban respondents. The *Arborloo* was the second most commonly constructed eco-san toilet in the rural areas but not used in the urban areas due to lack of space. In the rural areas, families often start with the use of an *Arborloo*, then move on to the *Fossa alterna*. Depicted in its appellation “the moving toilet”, the *Arborloo* requires more space since it involves moving the toilet pit from place to place and planting

trees. And the displacement of the *Arborloo* is often met with the scarcity of space in urban settings, encouraging the search for a replacement technology among the urban households constrained of back yards. This movement from one technology to another complicates the assessment of the number of units of each type in use. The *Skyloo* (urine diversion) was not common in the rural areas and was mainly constructed for schools, although this technology is not ideally suited to schools. The *Skyloo* is technically more complex to build and use, compared to other eco-san toilets.

The first villages to be introduced to eco-san toilets around the year 2001 adopted the *Arborloo* type because it was simple and very low cost. However once the value of the human compost had been revealed (by accelerated growth of trees grown on *Arborloo* pits) the preferred option moved to the adoption of the *Fossa alterna* which provided a more permanent facility and also a regular supply of pit compost, which was found to be valuable (Morgan 2003).

According to the Bunda report, culture and/or religion did not count against adoption even in districts like Salima, Nkhotakota and Machinga, where anal cleansing with water is a common practice amongst Muslims. This result is surprising because regular addition of water to *Fossa alterna* pits would not favour efficient compost formation in the pit. Clearly further studies are required in this area. The addition of water to *Arborloo* pits however, whilst it would slow down the composting process within the pit, would be less critical, because the pit compost is not normally removed from *Arborloo* pits. Early interviews reveal however that where trees were not planted on *Arborloo* pits, or where a planted tree had died, the compost was often removed for use on farm lands. (Morgan 2003).

3.1.4. MANAGEMENT PRACTICES AT HOUSEHOLD AND COMMUNITY LEVEL AND THEIR IMPLICATIONS

The National Sanitation Policy states that for an eco-san toilet to be considered as an adequate sanitation facility, it must be accompanied by the practice of adding ash/soil following each toilet use. Generally households who adopt eco-san toilets are provided with information regarding the management routines linked to the particular type of eco-san toilet they set to adopt including the

addition of cover material, ideally a mix of soil and/or ash, and green foliage. Morgan (2009) recommends up to a maximum of 50:50 of total added material to excreta ratio to achieve good results: control odor and flies, increase the potassium and carbon contents and help maintain elevated alkaline environment unfavorable to pathogens but to a level supported by waste degrading biomass. Beyond the composting toilet pits and vaults in case of UD toilets, caution has to be made regarding the added amount of ash, as this will also affect the pH of the matured compost. High pH compost could be detrimental to plant and soil biota later during application.

A mix of soil and ash is the common addition used. Nonetheless, the advocacy on the importance of adding the cover materials didn't translate into the availability of containers in toilets, disposing these. Ash/soil was missing from a substantial proportion of sampled households using eco-san toilets. Wood is the primary fuel used for cooking. Particularly in rural communities both wood ash and soil are perceived to be abundant. It is commonly thought that ash should be generally available and that the absence of cover material and persisting fly and bad smell could simply be linked to the low level of awareness regarding the role of additions in the operation and maintenance of eco-san toilets. This aspect requires further study. A closer follow-up of management practices during the use of eco-san toilets and their products, and initiation of refresher awareness messages to households might be beneficial in this regard.

3.1.5. DURATION OF STORAGE OF HUMAN COMPOST WITHIN PITS

The storage period of the human compost in the pit after closing the eco-san toilet pit varied from district to district: 5.5 months in Lilongwe to 8.4 months in Mzimba district. The recommended period of storage is 12 months. (Morgan, 2004). However the common and commendable practice of combining the use of two pits within a single superstructure in Malawi, does influence the size of the pits used. They are smaller than ideal. Where a portable structure is used, and moved from one pit to the other pit size can be increased substantially. The storage periods noted in Malawi are therefore linked to the design of the toilet itself.



With respect to how the compost is stored after removal from the pits, the survey found that households store it in plastic bags or simply pile it up in the open (51.1% of households). In some instances, it was found that they do not remove it from the pit until they are ready to take it straight to the field or give it away. Secondary composting, in bags or in protected heaps, may be a good practice in terms of compost safety, although levels of nitrogen may fall. Where the culture of composting is extended beyond in toilets mixing pit compost with garden compost is also a recommended practice.

3.1.6. USES OF HUMAN COMPOST

Investigation of the use of human compost indicated that 90% of households use the compost in their gardens, whereas the remainder do not use the compost themselves, preferring to dump it in a rubbish pit or away from their households (Figure 4.5). In all cases where the human compost was used, maize was the main target crop followed by the combination of maize and vegetables (in a mixed cropping set-up). This is a surprising finding considering the relatively low levels of nitrogen in the compost, and this area of study warrants further investigation. As can be noted from Figure 4.5b, very few people used the human compost on leafy vegetables for fear of the vegetable being contaminated with “faeces” and pathogens - people are more concerned in this regard with leafy vegetables than maize because the edible part of the plant is more likely to come into contact with the human compost. Most users did not indicate a problem applying the human compost to fruit trees and other non-food crops, like cotton. The main factor affecting the use of compost in agriculture was transportation from the villages to distant fields. Where this was the case, most people preferred to just throw the compost away. People with rented agricultural plots, and those who had another source of income, like fish vending in Salima, also preferred to throw away the compost or place it in pits rather than use it.

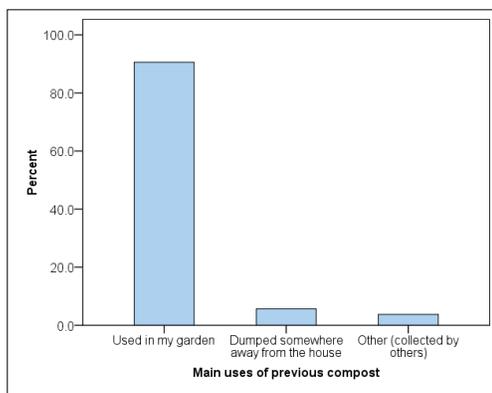


Figure 3 4: Proportionate use and handling of the human compost by households in Lilongwe, Salima, Nkhotakota, Mzimba, Machinga and Blantyre district, Malawi

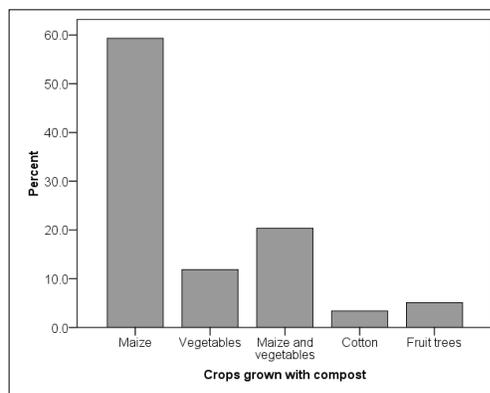


Figure 3 5: The main crops grown using human compost in Lilongwe, Salima, Nkhotakota, Mzimba, Machinga and Blantyre district, Malawi

3.2. CHALLENGES ASSOCIATED WITH ECO-SAN TOILETS IN DIFFERENT DISTRICTS

The available data on the number of households who adopted eco-san toilets are estimated to amount 14,000. This figure is outdated and does not reflect the reality on the ground. Not all the households who have been exposed to eco-san toilets adopted them and did not continued their use. Also an unknown number of families changed the use of their eco-san toilet from *Arborloo* to *Fossa alterna*, which complicates accurate data collection.

In the WAMA experience of the eco-san technologies, in Malawi, it is common that users overlook the addition of the cover material after using the toilets (30%). The irregularity of soil/ash availability in toilets put to the test the appropriate operation and maintenance of these types of toilets (25%) by family members/ users. This is epitomized in the bad smells, flies (in 31 %) observed of the toilets visited. The hazard caused by incomplete inactivation of pathogens in composts from toilets is transformed into real risk as compost “harvesting” is practiced with bare hands due to shortage of appropriate tools for its manipulation.

The level of compost stability/ maturity has also a critical significance for land application because immature compost can be detrimental to plant growth and the soil environment. Immature compost may continue biodegradation after field application and the process may lead to reduced oxygen concentration in the soil, reduced available nitrogen (Brinton and Evans, 2001; Keeling et al., 1994; Hue and Liu 1995), or even the production of phytotoxic compounds.

Eco-san toilets as a locomotive for livelihoods improvement is also challenged in peri-urban areas particularly due to weak or absent market for the compost (case of Blantyre, Angelo Govea). This is explained by the fact that 90% of those who adopted eco-san toilets continued to adhere to it because they applied it on their own farms or gardens. In the rest of the cases households dumped their composts (lack of market in the vicinity, transport constraints hindering access to far away markets, or simply due to taboo against the use of faecal nutrients for food production). This meant that eco-san toilets were burdens to their owners rather than advantages. They demanded extra maintenance obligations to produce compost which they did not use (Nalivata and Matiya, 2012).

In cases where a high number of people used the same eco-san toilet, the frequency of pit emptying had put off their use and households reverted back to the use of deep traditional latrines. Consequently some chiefs prohibited the use of eco-san toilets for public venues, although they adopted and adhered to them for their own familial uses. This is in part due to the obvious accelerated frequency or pit emptying burdens and in other part for the inconveniences of instructing a large number of users on how to use the toilets and cultural inopportuneness of discussing defecation as a subject.

Usage of inappropriate construction material, also led to eco-san toilets posing physical and health risks. Some toilets lacked roofs and others threaten to pollute, or polluted ground water despite their shallow pit depths. Elevated levels of saturation in composting faecal heaps prohibited access to and use of the end products. In some parts of Salima and Nkhotakota the walls and slabs of eco-san toilets collapsed due to saturation from high groundwater table. Although lack of resources has been identified as the main bottleneck, previous study by Nalivata and Matiya (2008) for WaterAid found a significant level of weakness in the way eco-san toilets are promoted and diffused. According to the same authors, poor dissemination of information had been one origin for the lack of adequate knowledge about eco-san toilets, and the eventual non-adoption in areas like Embangweni and Mzimba. The timing of awareness raising did not precede or coincide with the construction of the toilets and households were given or sold slabs before they understood the management and operational basics. For years later, such gaps in basic knowledge resurfaced as one of the barriers which stood between households and eco-san toilet technologies adoption, and accurate use (Nalivata and Matiya, 2012).

Even where the health related benefits are obscure to households due to lack of awareness or other reason, the impetus for privacy and dignity while defecating is a powerful driving factor for sanitation behavior. This is more visible in destitute urban and peri-urban areas where defecation in private by hiding in bushes and woods is meager. Despite this being evident, reduced access to finance and tightly competing household expenses do not favor the household's investment priority on latrines. Consequently lack of "initial money" for hardware simply leads to a lost opportunity of a household's vested interest to own one.

Some attempts are being undertaken to assist access to finance through loan and subsidy to entrepreneur -masons who build eco-san toilets on credit for households who opted to adopt eco-san technologies. In WAMA experience some mechanisms are put in place to challenge the problem with access to initial capital for hardware. These mainly involved training and subsidizing trained masons as entrepreneurs who in turn fabricate slabs and construct toilets on credit to households who would pay the equivalent price in multiple installments. However even in such types of arrangements, previous

studies in poor rural and low income urban areas show that these credits could prove unsustainable to some households and that some people drop-out on paying their installments towards the cost of toilet construction owed to entrepreneur masons. In some cases these masons dug out the slabs from the struggling households and sold them to others who were better able to pay the prices (Nalivata and Matiya, 2008).

All these challenges contributed to eventual non-adoption and un-adoption of eco-san toilets in some households and issues regarding affordability, approaches (technical, social, institutional), used for the promotion and diffusion of these technologies, call for further analysis and understanding if they are to be sufficiently addressed.

3.2.1. BIOLOGICAL SAFETY OF HUMAN COMPOST

The most relevant data for the safety of the compost comes from analyzing the material for faecal coliforms and helminth eggs. The major condition for pathogen kill off is the development and colonization of heat loving (thermophilic) microbial flora responsible for the continued decomposition of waste as temperatures rise beyond 45°C up to 70°C (158°F) without affecting their function and survival. The addition of ash in pit also casts major effects on pH which plays a vital role in eliminating disease causing pathogenic organisms. Where large numbers of people use the toilets with no urine diversion (e.g. in the *Fossa alterna*), the prevailing wet conditions (due to high levels of the urine 500l/p/yr) may hamper dehydration and decomposition processes. Under these conditions, the amount of cover material added has to be increased, in order to facilitate the dehydration process by rendering the moisture content to a favorable level to allow an aerobic digestion (between 40-60 %). Above 60% moisture content encourages the development of anaerobic activity while below 12% it stops microbial processes (Schonning and Stenström 2004). The addition of foliage also facilitates oxygen feed to the pile by prohibiting compaction of faecal additions to the pit and creating voids in the waste pile that promotes aeration. The oxygen level in a composting pit of an eco-san toilet should be greater than 10%.

Faecal coliforms were only observed in a small number of samples from Lilongwe (Mgona), Machinga and Salima), although conclusive laboratory data is missing. For helminth eggs, the WHO guidelines for excreta use in agriculture is <1 viable egg/g dry compost. Viable helminth eggs were detected by Bunda College laboratory from all the districts and fail by far to meet the WHO guidelines. Presence of faecal coliform and especially helminth ova in the human compost shows that the decomposition period or conditions were not optimal for their complete removal. This may render the compost unsafe for handling and use. However the lack of data on health profiles for families using toilet compost leaves a significant gap in our knowledge about the safety or otherwise of the compost in real terms. The high levels of helminth eggs found in Mzimba (Bunda report), where *Ascaris* infections have been found to be very low (clinic records from CCAP), leaves some doubt about the authenticity of the records.

In Salima, it is suggested that the negligent attitude of most households towards the management of their compost toilet - is because most people do not attach agricultural importance (which was initially found to be the biggest driver for adoption) to the human compost, most households just using eco-san as an alternative form of sanitation and do not take advantage of the compost for agricultural use. In a related study, it was found that people with occupations that require a lot of time spent away from home, are not interested in having a toilet (Nalivata and Matiya, 2008).

	Blantyre	Lilongwe	Machinga	Mzimba	Nkhotakota	Salima
Viable eggs	53	20	40	44	69	131
Non viable eggs	47	313	0	111	138	138

Table 1: Levels of viable and non-viable eggs in the 1g of human compost

Earlier researchers in Malawi have studied levels of *Ascaris* and pathogenic bacteria in human compost derived from eco-toilets. Studies by Mathews Tsirizeni (2004) reveal low levels of *Ascaris* but higher and variable levels of faecal coliforms in the compost. In analyses taken from *Fossa alterna*, counts were regarded as low after 9 months storage, with higher counts in the upper layers compared to lower layers in the pit. This indicates a natural die off of bacteria with time, as would be expected.

Further studies revealed in the work of Gremu (2004) found that the addition of ash and soil produces an alkaline mix which increases the pH value that enhances bacterial pathogen die-off (Strauss & Blumenthal, 1990). In the same study, the same duet also found that sun-drying the compost prior to storage and eventually use, reduced viability rapidly. In essence, storage or resting time of the compost and the pH of the excreta during the composting process were identified as influential factors in pathogen elimination/reduction of pathogenic viability. This secondary treatment has thus been proposed as a means of getting rid of pathogens in high risk locales.

This raises the question of climate and specifically altitude and location, such as density of occupation, on the rate of die off of potential pathogens in the toilet compost and also the prevalence of various diseases related to the potential uptake of enteric bacteria and worm eggs. One would expect, for instance, a greater potential for disease transmission in lower more humid areas, compared to cooler more elevated areas. Also the density of occupation, such as "plot size" for the homestead or household, would also influence the potential for transmission. WaterAid for instance operates in a variety of locations, from low lying areas (Salima) to elevated areas (Mzimba). Also density of settlement varies from high density (Lilongwe) to low density (Mzimba). Considering this variation in climate and location, the method of processing and use of toilet compost may vary considerably within the project areas served by a specific NGO. As far as is known this has not been taken into consideration in Malawi. The people using the human compost were handling and using compost from their own eco-san toilets, hence the presence of helminth ova indicates the health status of the household as well as the efficiency of the eco-san management system.

3.2.2. CHEMICAL QUALITY OF THE HUMAN COMPOST

On average, an adult produces around 500 liters of urine and 50 liters of faeces in a year. The contents of NPK in human faeces and urine vary from country to country and is heavily affected by the type of food consumed. This in turn influences the chemical characteristics of the compost derived from human excreta. The physical conditions and the environment within the composting pits are also very closely linked to the chemical characteristics of the final compost product ("humanure"). Incomplete biodegradation of organic matter or partial stabilization may have detrimental effects when composts of such nature are applied on farms (Brodie et al., 1994; He et al., 1995; Keeling et al., 1994).

The addition of cover material, if rich in carbon, as is the case of plant material, leads to an increase in the Carbon:Nitrogen (C:N) ratio. Micro-organisms which promote decomposition work best under high C:N ratio (15:1 to 30:1) (Mnkeni and Austin, 2009). When C is disproportionately high, microorganisms in the composting pit metabolize N and C to produce biomass, reducing available N later to plants. On the other hand elevated level of N can lead to loss of nitrogen through volatilization. Hence increasing cover material that is rich in carbon (leaves and other organic plant material) helps to achieve a

healthy balance during the composting process. However, in the final stages of the compost C/N ratio has to be below 20 for an acceptable maturity - a C/N ratio of less than 15 being even better (Inbar et al., 1990a).

In Malawi soils are generally close to neutral 5.5 – 6.6. . Addition of ash raises compost pH which if beyond 9 could harm soil, plants, and composting microorganisms. However the amount of ash added to toilet compost, when applied to gardens is unlikely to adversely affect plant growth. Bary et al. 2002, recommend compost pH of 5–8.5 However, the addition of ash and other cover materials may also contribute to the speedy filling up of the eco-san toilet pits. A balance is required between the amount and frequency of additions, the number of users and consequently the rate of filling and duration of composting period. When the *Fossa alterna* was first introduced to Malawi, it was in an early stage of development. It is thus important that the findings of this and earlier reports adds to our understanding and guides the further development of this technology.

The pH measured in all samples fall within suggested acceptable ranges rather to the extreme high, except in the case of Machinga where the measured pH amounted to 9.

C/N ratio for all samples consistently shows 20. This shows that the significant fluctuation in faeces detention time in composting pits did not have any effect in compost maturity. Incomplete biodegradation of organic matter or partial stabilization may have detrimental effects when composts of such nature are applied on farms (Brodie et al., 1994; He et al., 1995; Keeling et al., 1994).

The average levels of total nitrogen found in human compost, as reported by Bunda College, were 0.62 ± 0.36 g N/kg, and 0.47 ± 0.24 g N/kg in the soil ($\times 1.31$). Levels of phosphorus were 0.34 ± 0.09 g P/kg in the human compost while phosphorus levels in the soil were 0.048 ± 0.014 g P/kg ($\times 7.08$). Potassium levels were the highest in the human compost with 15.9 ± 0.70 g K/kg, but no data is recorded for P levels in representative soil levels. Studies by Morgan (2004) comparing natural soils and *Fossa alterna* soils reveal an increase in N levels of 700%, P levels of 600% and K levels of 800%. However there may be much variation depending on the natural soil type which varies greatly from one area to another. Clearly more studies are required in this area.

Parameter	District						Mean value
	Blantyre	Lilongwe	Machinga	Mzimba	Nkhotakota	Salima	
pH	9	8	9	9	8	8	8.5
P (g/kg)	0.385	0.306	0.355	0.260	0.355	0.366	0.34
N (g/kg)	0.868	0.385	0.915	0.343	0.602	0.582	0.62
K (g/kg)	16.9	16.0	15.5	16.4	15.5	15.1	15.9
OC (g/kg)	17.4	7.69	18.3	6.87	12.0	11.6	12.3
C:P	45	25	52	26	34	32	35.7
C:N	20	20	20	20	20	20	20

Table 2: The chemical parameters of the human compost from different districts in Malawi

The nutrients requirements to produce around 250 kg of cereal is estimated to be around 5.6 kg of Nitrogen, 0.7 kg of Phosphorus and 1.2 kg of Potassium. In terms of effect on maize growth, detailed studies by Snapp (1998), indicated that Malawi soils appear to be broadly K sufficient for the growth of maize. This would indicate, although not conclusively prove, that K is not a limiting factor for the growth of maize in Malawi. The elevated levels of P in human compost, compared to natural soils, would help promote root growth. The limiting factor is nitrogen, and the amounts available in human compost, although elevated above natural soil levels, would not be sufficient to induce healthy crops of maize. Therein lies the mystery that whilst the value of human compost is seen as a major factor in the

promotion of eco-san and its value in promoting maize growth, chemical analysis reveals that the compost alone could not possibly provide enough nitrogen to induce a healthy crop of maize.

The low nutrient quality of the human compost did not show direct correlation with soil chemical quality but this may be related to the dietary factors in the community compared to the diets of the people in South Africa, USA and the EU as has been suggested in previous sewage sludge studies in Malawi. Human faeces contain mainly undigested organic matter and nutrient constituent (e.g. nitrogen) is expected to be lower than in sewage sludge which has nutrient inputs from other sources of wastewater (e.g. food industries). Nevertheless, after pathogen destruction (through dehydration and/or decomposition), the resulting composted product still has enough nutrients and organic carbon to significantly improve the water holding capacity and nutrients levels in the soil.

All these factors in combination reveal a complex story of design, use, safety and biology, which certainly warrants further investigation. Malawi is a pioneer in the relatively wide uptake of low cost, shallow pit ecological sanitation, an area new to the discipline as a whole. A great deal of testing, monitoring and research is required to take this challenging aspect of ecological sanitation further along the road of development. The same holds true for the use of urine diverting technologies in higher density settlements. This report reveals important aspects which can act as guides to the future of this important aspect of sustainable sanitation in Africa.

4. CONCLUSIONS

This study reveals that many factors are at play favoring or de-favoring the promotion and implementation of eco-san in Malawi. These are both positive and negative, closely linked to how eco-san toilets are perceived by households, and influencing households' decisions on whether or not they adopt or do not adopt them. However not all of these factors have been exhaustively explored here in this report. The increased level of operation and maintenance, lack of space, and restricted property rights and land tenure are the obvious obstacles to wider use of eco-san toilets and critical factors influencing the adoption or non-adoption and un-adoption of eco-san toilets.

Investigations reveal that the concept of eco-san can be popular with demonstrable positive economic, social and environmental results that the eco-san toilet promises. Such results are central to widening and deepening sanitation coverage through progressive scaling-up of the eco-san concept by the "seeing is believing" principle. Several NGOs are at work promoting eco-san in different parts of the country, WaterAid being only one of them. Each NGO uses a different approach in its method of promotion and the precise technical details of construction. All technological and biological discussions revolve around the three popular types of eco-san toilets. These are the *Arborloo*, the most commonly used in Africa, with Malawi accounting for a certain percentage; the *Fossa alterna*, which Malawi boasts to own the highest number in Africa, and the less commonly used Urine diverting system (known as the *Skyloo* in Malawi).

Although the country can be regarded as the continental pioneer of low cost ecological sanitation, eco-san toilet designs used in Malawi have been borrowed from elsewhere, and apart from the restyling of the *Fossa alterna* superstructure (single rather than portable), have not been updated to suit population density and settlement patterns, social-cultural differences, economic circumstances and agricultural requirements.

This report concludes that eco-san toilets are particularly sensitive to bad design or careless operation. Eco-san does not suit everybody; therefore it is important to offer a range of technology options and to ensure a stricter application of the essential technical parameters. Households also must be allowed to make an informed choice based on their specific needs matched with realistic expectations from

proposed technologies. People can weigh up the merits of different systems and if eco-san offers the benefits they are seeking, under the prevailing contexts, they will select that option.

The *Fossa alterna* is under indiscriminate widespread use construed as a family toilet system which can be built in one location and used for many years, and particularly providing a valuable soil conditioner (perhaps a better word than compost). However this concept does not suit all the conditions found in Malawi. Whilst the toilet compost since long has been thought to considerably enhance the production of maize, this in fact is not the case, and that fact has been known for at least a decade. However the current view of eco-san toilet derived compost as an organic fertilizer can only be true if accompanied by the application of urine alongside it as the nitrogen levels, for instance, are far too low in the human fecal compost itself to support healthy maize production. Nevertheless, this compost is still valuable as a soil conditioner, and is clearly valued by its users.

The possibility of upgrading from one eco-toilet to another (*Arborloo* to *Fossa alterna* to urine diversion) should take a central interest in the quest for more adoption of the concept. Adapting the eco-san toilet from single household to collective, multiple household use and management technology needs to be studied given the high urbanization rate, densely populated urban settlements and high poverty levels characterizing Malawi.

The evidence from the different studies referred to for the preparation of this report show that there are mixed perceptions on the use of human compost for agricultural production. Whilst a good number of people use the compost for agricultural use, a substantial amount of compost is dumped due to negative attitudes towards its use outside the lack of farm lands, gardens, or marketing options. Over ten years have elapsed since the first introduction of eco-san toilets in Malawi, but knowledge on the continued use of units first built is lacking. The lack of follow up and monitoring of projects is a weakness common to most if not all NGOs working in this sector, not only in Malawi but also throughout the African continent

Further extension work is required to train the beneficiaries on the best management practices for eco-san toilets. Households are to be encouraged not to empty the composting pits whenever they need fertilizer, which has led to shortened periods of composting within the pit, but to stick to the stipulated minimum storage periods which should ideally be 12 months. While evidence shows that less than 12 months composting periods are being advised by eco-san implementing organizations and extension workers, the reasons behind that are not clear. In crowded urban areas, toilet sharing practice has been widespread among traditional pit latrine users and could still prevail after the adoption of eco-san toilets by the same households. Large family sizes in urban and rural areas could also entail shorter life of eco-san pits due to elevated frequency of use and service load hence imposing untimely emptying of immature compost.

In the same line, effective pit volume calculation is necessary and must take in to consideration decisive technical parameters including the total waste estimated to be produced by users, volume of cover material, as well as anal cleansing material and other charges, optimized for a 12 months pit design life, both for service and composting before emptying. The Malawian practice of placing both pits of the *Fossa alterna* within a single superstructure places constraints on the size of the pits, which are smaller than ideal and fill up faster. This in turn leads to reduced periods of processing of pit material before excavation.

The balance between achieving biological safety and preserving the nutrients is of paramount importance. The biological test results indicate a potential for the contamination of the compost by human pathogens, although at a low level. It is wise therefore to encourage the beneficiaries to handle the material with care and using gloves. The importance of safe secondary composting processes after

early pit content excavation should also be strongly stressed where 12 months composting period could not be maintained. It is clear that tests on the safety of the product require further investigation, both for faecal coliforms and *Ascaris* eggs.

On the management of the composting process, whilst the majority of the beneficiaries applied a drying material (combined ash and soil) for their compost, the amount used was generally insufficient – resulting in less odour and fly control and less moisture absorption. An approximate recommended mixture of the compost is 50% excreta and 50% additions (soil, ash and leaves) for an improved composting process. In properly maintained toilets and composting vaults, the compost product resembles soil, if soil has been added to the mix. Where ash is added the material will not resemble soil. However such a mix promotes a faster filling rate for pits and a compromise must be met.

As far as this study has shown, there is no established human compost market in rural Malawi and no pricing mechanism for this product. However this situation may be very different in the urban areas and further studies of NGOs like CCODE are required. Funding mechanisms, marketing and promotion methods used by other NGOs operating in this field have so far not been studied by SHARE. Until a broad study of the various methods of funding, promotion, marketing and establishment of entrepreneurship, has been collated, not complete understanding of the various aspects of eco-san development in Malawi can be established.

Nevertheless, there is a shift in strategy and for the promotion of eco-san toilets and sanitation service as a whole in Malawi. The creation of market and the development of the private sector in service delivery including operation and maintenance are high in the national growth and development policy agenda as well as sanitation sector strategies of major actors towards meeting the sanitation MDGs. The creation of a full capacity in the private sector and the establishment of functioning demand driven compost markets has a long way to go. The financial return from compost sale for very low income households is urgent. Yet, the absence of the conducive environments for immediate household economic benefits is witnessed to be the major catalyst for eco-san toilet user dropouts.

In short the eco-san sector, as it has developed in Malawi, has several strengths and weaknesses which need close attention if the sector is to be made more attractive and vibrant through a wider adoption of eco-san toilets. It is critical to encourage dialogue and collaboration amongst all the actors involved including the Malawian Government, and to encourage a better understanding of the processes and the impacts made so far so as to inform future strategies and decisions. Also critical for the diffusion of eco-san is respond to the needs of the community and target group, for instance by tailoring the technologies to the needs of the target beneficiary.

5. GENERAL RECOMMENDATIONS

The following general recommendations can be made as a result of this work, but not necessarily in order of priority.

1. A considerable need to co-ordinate the various activities of the NGOs promoting eco-san in Malawi by national forum. Currently there does not seem to be much dialogue between agencies.
2. Need to re-assess current status of existing eco-san facilities and their proper use. This would assist in revealing drop-out rates, lack of knowledge of proper use of the toilets and actual numbers in use as a percentage of the total.

3. Establish a health profile for those families using eco-san toilets to establish the positive or negative impact of the use of this type of sanitation.
4. Assess the actual reason for the apparent popularity of eco-san toilets, bearing in mind that the human compost, valuable as it may be, is not sufficiently fertile to promote the healthy promotion of maize crops on poor soil.
5. An assessment of the perceived real value of human compost and how to improve the quality of the product by secondary composting or processing.
6. A more accurate assessment of faecal organisms and helminth eggs, related to climate and other conditions.
7. An assessment of actual health risks associated with eco-san use
8. A re-assessment of the chemical quality of human compost related to surrounding soil
9. Usefulness of marketing, financing and other methods for promoting the wider use of eco-san in Malawi.
10. An in depth assessment of the use of eco-san in higher density suburbs. eg (CCODE)
11. An in depth assessment of the use of eco-san in schools. Best options may not be eco-san but modifications of the VIP.
12. Piloting the use of a restyled Fossa alterna, known as a "long cycle Fossa alterna" where larger pits and portable structures are used.
13. Possible revival and upgrading of the best practices used in eco-san toilet use and re-use
14. Further promotion of urine collection and use to promote healthy crops of maize.
15. Identification of National Champions in the promotion of eco-san
16. Attend more to the requirements of children e.g "children's toilet", a simple *Arborloo*.
17. Study or assessment of various actors working on eco-san promotion in Malawi. Merits of various methods of promotion by marketing, entrepreneurship with recorded achievements, as recorded by various NGOs.

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