

Knowledge, attitudes and practices on use of Fossa Alternas and double vault urine diverting dry (DVUDD) latrines in Malawi

Save Kumwenda, Chisomo Msefula, Wilfred Kadewa, Bagrey Ngwira, Tracy Morse and Jeroen H. J. Ensink

ABSTRACT

Fossa Alternas and double vault urine diverting dry (DVUDD) latrines have been extensively promoted as ecological sanitation (EcoSan) latrine options in Malawi, but little is known about whether they are used properly. A qualitative study of EcoSan users was conducted in Blantyre and Chikwawa districts, Malawi. Data were collected using in-depth interviews (IDIs). Twenty-eight (28) and seventeen (17) IDIs were conducted with household heads that had Fossa Alternas and DVUDD latrines, respectively. Recorded data were transcribed verbatim and analysed thematically. Of the total 45 EcoSan users, 40 had moderate to high knowledge on EcoSan latrine use, four had low knowledge and only one had no knowledge of how EcoSan latrines operate. Blockages of urine diversion systems, intensive management and maintenance needed for the latrines were reported as some problems related to the negative attitudes about EcoSan use. Use of soil and ash, urine diverting, use of hot water and chemicals to kill maggots, urinating in the drop-hole of the DVUDDs and poor maintenance of the roof were some of the practices reported on use of these latrines. It is therefore recommended that government, through community workers, should be monitoring practices on EcoSan latrine use and provide necessary support to users.

Key words | double vault urine diverting dry latrine and Fossa Alternas, ecological sanitation, Malawi, practices

Save Kumwenda
Chisomo Msefula
University of Malawi, College of Medicine,
P/Bag 360, Blantyre 3,
Chichiri,
Malawi

Save Kumwenda (corresponding author)
Bagrey Ngwira
Tracy Morse
University of Malawi, The Polytechnic,
P/Bag 303, Blantyre 3,
Chichiri,
Malawi
E-mail: skumwenda@poly.ac.mw

Wilfred Kadewa
Lilongwe University of Agriculture and Natural
Resources,
PO Box 219, Lilongwe,
Malawi

Tracy Morse
Scotland Chikwawa Health Initiative,
Department of Civil Engineering,
University of Strathclyde,
Glasgow,
Scotland

Jeroen H. J. Ensink[†] (Deceased)
Environmental Health Group, Department of
Disease Control, Faculty of Infectious Diseases,
London School of Hygiene and Tropical Medicine,
Keppel Street,
London WC1E 7HT,
UK

INTRODUCTION

It has been estimated that about 1.5 million deaths globally have been caused by diarrhoea, and this has accounted for 2.7% of all deaths (WHO 2014). In addition, 24% of the world's population was infected by soil-transmitted helminths (WHO 2015). These diseases may be reduced through use of improved sanitation, provision of safe water supply and hygienic practices (Moore *et al.* 2001; Bartram *et al.* 2005). There are a wide variety of sanitation options available, and suitability varies by location and depends on affordability. Environmentalists promote the use of

ecological sanitation (EcoSan) because of its advantages, such as nutrient recovery and reuse, conserving the environment and minimization of hygienic risks. Furthermore, these latrine technologies range from those aimed at natural wastewater treatment to technologies that aim at reusing urine and faecal sludge (Langergraber & Muellegger 2005). Fossa Alternas and double vault urine diverting dry (DVUDD) latrines are among the types of EcoSan latrines that aim to recycle excreted nutrients into agriculture (Esrey 2001). The DVUDD, unlike the Fossa Alternas, is

raised off the ground and has a urine diverting toilet pan that leads to a soak-away just outside the latrine (Morgan 2007). In other areas of the country and elsewhere, urine is diverted to a tank where it is later diluted and used in the fields (Morgan & Mekonnen 2013). Fossa Alternas pits are dug up to 1.5 metres deep and are lined with bricks. Once a pit is full, it is sealed and the second is used. When both are full, the first one is emptied so that the contents can be used, while the other one is sealed and allowed to decompose. It takes a minimum of six months for the contents to be harvested after sealing a pit. The harvested sludge is used in agriculture. Both DVUDD and Fossa Alternas are also advantageous as they prevent groundwater pollution because the facilities are either built above the ground or dug to a maximum of 1.5 metres deep respectively as compared to traditional pit latrines, which may reach up to 5 metres deep. In addition to this, they also save land because they are permanent and reduce the need for building another latrine when full, as is the case with traditional pit latrines (Breslin 2002). The latrines are built with two vaults, which are used interchangeably, unlike most unlined traditional pit latrines in Malawi, for which, when full, the owner has to look for another space to dig and build a new latrine (Morgan 2010).

Fossa Alternas and DVUDDs have been promoted since 2005 in the areas of Chemusa, Angelo Govea and Lirangwe (SDI 2015). In Angelo Govea, all 64 houses, which people bought on loan at a subsidized price, had DVUDDs. These homes are called 'federation houses' and are named after the organization that provides houses to those who cannot afford a house at the market price. As of 2015, there were 40 DVUDD latrines still functional in the area, and 24 households had gone back to using pit latrines and flush toilets (HSA 2015), while in Ng'ombe and Zimola villages about 30 latrines were built in the year 2008 and 23 latrines were still functional. Before EcoSan latrine construction, household members were trained in how to use them. In addition to this, sanitation promoters were chosen in each area and trained to continuously offer technical assistance to users. They were also responsible for assisting those who wanted to have an EcoSan latrine to access loans. Those interested were asked to assemble the required number of bricks and bags of cement for latrine construction. The total cost was approximately K150,000 (USD

272). The loans were provided at an interest rate of about 4% per month, with a maximum payment period of two years (SDI 2015). Despite the promotion of such latrines, few studies have been done to assess whether these latrines are used properly. Proper EcoSan latrine use is important, as it may affect the safety of the sludge produced (Kumwenda *et al.* 2014). It has also been reported that uptake of such latrines is low in Malawi (Chunga 2015). It was therefore important to explore the knowledge, attitudes and practices of EcoSan latrine use, as this may be a starting point for effective promotion of such technologies.

METHODS

Study type and area

We conducted a qualitative descriptive study using a case study design. This was done in the peri-urban (Angelo Govea, Chemusa) and rural (Lirangwe) areas of Blantyre and in the rural villages of Ng'ombe and Zimola in Chikwawa District, Malawi. Blantyre had both DVUDD latrines and Fossa Alternas, while Chikwawa had only Fossa Alternas.

Sample size and sampling

The total sample size for the study was 45 household heads; 28 with Fossa Alternas and 17 with DVUDDs (Table 1).

In Lirangwe, Zimola and Ngombe, all the household heads with working latrines were selected for interviews, while in Chemusa and Angelo Govea, household heads were conveniently selected. Volunteers from the area who were actively involved in the EcoSan project were asked to assist in identifying the households with the latrines (these volunteers were known locally as sanitation promoters). Latrines were also observed to confirm the reported practices during IDIs. In cases where the head of the house was not available, the second most influential person was interviewed. The household heads were selected because it was assumed that they had an influence in adopting the latrine technology and were better placed to know the challenges of the latrines. In Chemusa and Angelo Govea, the sample size was determined through thematic

Table 1 | Location, type and number of EcoSan latrines sampled

District	Location	Location classification	Sample size	Type of EcoSan	Year constructed
Blantyre	Angelo Govea	Peri-urban	8	DVUDD	2005
	Chemusa	Peri-urban	9	DVUDD	2008
	Lirangwe	Rural	5	Fossa Alterna	2010
Chikwawa	Ng'ombe	Rural	17	Fossa Alterna	2008
	Zimola	Rural	6	Fossa Alterna	2008

saturation. Since there were more than 30 households with DVUDD latrines in each of the two locations, it was not possible to interview all the households, hence the method. The interviewer stopped looking for new households after three consecutive respondents gave no new information after probing.

Data collection

In-depth interviews (IDIs) were conducted with the household heads using these latrines at the time of survey. An IDI guide was used to collect data. Permission was also sought to observe the latrine after the interview. Data were collected in November and December, 2014. The interview took place at the respondent's house and took about an hour. During the interview, a voice recorder was used after obtaining signed consent from the respondent and notes were written in a book as a backup.

Ethical considerations

Before the interview and latrine observation began, the interviewer explained the background and purpose of the investigation, and the respondent was given time to ask questions. The respondent was also assured of the confidentiality of the information provided. The ethical protocol approved by University of Malawi, College of Medicine Research Ethics Committee (COMREC) was followed. The COMREC approval (P.04/14/1565) for the study was obtained in October 2014.

Data analysis

Recorded data were transcribed by two independent people verbatim in the local language (*Chichewa*) and translated to

English before being entered in NVIVO 10 for analysis. Themes were created after going through the transcripts and field notes. These themes were coded as nodes, and new nodes discovered during repeated readings of transcripts were also added.

In order to measure knowledge, attitudes and practices related to the use of EcoSan, we defined the criteria for measurement. Knowledge was defined as information or a skill that one gains through awareness or experience. An incorrect or correct answer is often used as a measure that a person does not know something (Hunt 2003). In this study, knowledge was measured by asking respondents to describe the steps followed when using the EcoSan latrine. The explanation was assessed based on how correct the procedures were described, and also if all the steps were explained. If a respondent mentioned all six important steps, including knowledge of things that are not supposed to be disposed of in the EcoSan latrine, he/she was classified as having a high knowledge on use. Those who mentioned the steps correctly, but who did not have a knowledge of prohibited items were classified as having moderate knowledge, and those who also missed some of the steps were classified as having low knowledge, while those who knew nothing were classified as having no knowledge. The steps in EcoSan use that respondents were supposed to know were the ones taught by the sanitation promoters and officers from the implementing NGOs. These included the removal of the drop-hole cover and use of footrests, being able to divert urine for the DVUDD latrine, urinating in the drop hole for Fossa Alterna, using decomposable anal cleaning materials, using ash and soil after use, not disposing of water in the latrine, and safety during the harvesting of sludge. We referred to attitude as one's positive or negative judgement about a concrete subject. Attitudes were measured indirectly using an interpretive technique.

Respondents were asked how they felt about the latrine they were using and also about what other people said about it. The answers given were analysed and interpreted as having a positive, negative or neutral attitude. On the other hand, practices were identified by analysing how each household used an EcoSan latrine and also from their explanations on challenges and problems faced during EcoSan use and how they solved them.

RESULTS

Demographic characteristics of respondents

Of the total respondents (45), 42% were males and 58% were females. Most respondents were females because men were not available during the time of survey. In the peri-urban areas of Blantyre, they were either at work or doing business. About 47% had received primary education, 33% secondary education and none tertiary education. The age range was from 20 to 78 years.

Knowledge on EcoSan latrine use

Of the 28 respondents using Fossa Alterna and DVUDD latrines, 50% and 65%, respectively, had high knowledge of how the latrine operates. Only one out of all the respondents had no knowledge of how the latrine works, and this was because the respondent was not aware of the type of latrine being used (Table 2).

The sanitation promoters said that during the project phase in 2008 to 2012, they had constant awareness campaigns and visits by officials from implementing NGOs and Health Surveillance Assistants (HSAs), but these stopped. This might be one of the reasons why about half

of the respondents had moderate to low knowledge on use of EcoSan latrines. It was also reported that after the project was phased out, the HSAs' concentration on EcoSan latrines was reduced and not included in their daily work, as quoted by one of the respondents:

.....it's good that you have come to remind us about some of the things that we should follow. The officers who used to remind us about how to take care of our latrines stopped coming and the HSAs no longer talk about our latrines any more. Male respondent, Lirangwe

On how the latrines are used, there was no difference in numbers between those using Fossa Alternas and those using DVUDDs, except for the urine diversion. Respondents indicated that they squat over the drop hole while stepping on raised footrests, if available. After defecation, users drop ash and soil through the hole, although this is often forgotten, especially by visitors and children. All 44 respondents with at least some EcoSan knowledge agreed that they immediately apply ash and soil when they notice that someone has not done so after using. Below are the quotes from respondents on use of ash and soil:

....it happens, so when one forgets, we pour in the ash and soil. We also pour it in the evening, because nobody else goes in there so we do this so that it mixes up properly. Female respondent, Angelo Govea

If we suspect that someone has not followed direction, especially visitors and children, we follow up and pour in ash and soil. Female respondent, Ng'ombe Village

Attitudes about use of EcoSan latrines

While 91% (41) had both positive and negative stories about these latrines, 11% (3) of the household heads with Fossa Alterna and 6% (1) with a DVUDD latrine failed to find anything positive in their use of the latrine. The feeling of being disgusted during handling of human faecal sludge and eating of the crops fertilized by the sludge, the latrine being labour intensive to use and blockage of the urine diverting system for DVUDD latrines were the main concerns relating to the negative attitude towards these latrines. The blockage

Table 2 | Knowledge levels on use of Fossa Alterna and DVUDD latrines

Knowledge rating	Respondents with Fossa Alternas	Respondents with DVUDD latrines
High	14 (50%)	11 (65%)
Moderate	9 (32%)	5 (29%)
Low	4 (14%)	1 (6%)
None	1 (4%)	0 (0%)

in the urine diversion pipe for DVUDD latrines was due to the improper use of soil and ash, which ended up in the diversion pipe. The other problem concerned the maggots that crawled out of the latrines, especially during the rainy season. This problem was reported by 25% (7) respondents with Fossa Alternas and 12% (2) with DVUDD latrines. The reported advantages of EcoSan latrines included source of human faecal sludge, saving land and not producing bad smells. Respondents indicated that unlike traditional latrines, which collapse within a few years, the EcoSan latrines can be used for many years without the need to dig another latrine. Overall, 73% (33) of the respondents had a positive perception of use of the sludge in agricultural fields. The others were not sure whether it was right to use the sludge in agricultural fields, especially for growing vegetables, as evident in the following quotes:

Those without EcoSan say it's unhygienic and they would not eat our maize grown with the manure which I feel is safe, but I do not believe it's safe to use the manure in vegetables because it takes few days before you start harvesting unlike maize. I cannot eat such vegetables but maybe we eat unknowingly. Female respondent, Chemusa

We tell others who say that EcoSan latrine and their sludge is disgusting that they say this because they have not benefited from it. But look at us; we have tomatoes, vegetables, because of the sludge from this latrine (EcoSan). They say they were disgusted but then when you harvest manure, they ask, share me a little I should apply in my nursery too. Female respondent, Lirangwe

It was also evident that EcoSan users had an attitude towards the latrines concerning what other people say, as evident from 11% (3) of respondents with Fossa Alterna and 29% (5) using DVUDD latrines. Below is the quote from one respondent:

.....people talk, because they do not know, for example when we moved in this house, they would say we defecate in pails, they said there would be cholera in our household, but up to now (from 2010) no one has ever suffered from cholera or other diseases. Now people

from other places have started admiring this latrine.
Female respondent, Angelo Govea

In terms of respondents' attitudes towards owning an EcoSan, respondents using a Fossa Alterna saw themselves as better off because they were able to pay back the loan and used cement for building the latrine as compared to the majority of households who were using traditional pit latrines built using local materials and who could not afford a Fossa Alterna. This is why these latrines are called *zimbudzi za makono*, meaning 'modern latrines'. In the peri-urban areas of Blantyre, people use pit latrines with concrete floors and iron roofs, which are not different to the DVUDD latrine. Therefore, these respondents did not see themselves as better off.

Regarding the relationship between the use of EcoSan and the risk of diseases, 16% (7) of respondents thought there was a risk of contracting diseases through handling faecal sludge while 20% (9) were sure that the sludge was safe. The remaining 64% (29) were not sure whether the sludge was safe or not. Below are quotes from some of the respondents:

No, if there were some, we could be sick by now. It's not that bad as it seems. We just wear plastics for the sake of cleanliness. The white people were touching it with bare hands. It's not harmful. Male respondent, Zimola village

No. Look some of it (manure) is there...right there, if they had pathogens kids would not play on it, it's only urine that usually has pathogens and that's why we divert it to prevent pathogens so that the manure is safe. Female respondent, Angelo Govea

Below is one of the quotes from those who were aware of the risk that EcoSan sludge can have if harvested early and not well taken care of:

For the manure, if it is harvested earlier, that is before six months, it can have some germs.after harvesting, we keep the manure in direct sunlight for a day or two to reduce 'power' which may kill our plants. As for worms, people here receive drugs every year from officers who came from Ministry of Health (Chikwawa District

Health Office) to visit us. Female respondent, Zimola village

Respondents also indicated that after harvesting, you need to put the sludge in the open under direct sunlight before it can be applied on crops. The reason given was to reduce fertilizer value. They believed that the sludge had very high fertilizer value which could kill the plants if applied directly. Although there was no evidence for the reason given, keeping the manure in direct sunlight has been found to reduce helminths in the sludge. Solar or ultraviolet radiation reduces and affects the survival rates of pathogens in sludge that is applied on fields in direct sunlight (Redlinger *et al.* 2001; Schönning & Stenström 2004). The respondents quoted above were advised by the implementing NGO to leave the sludge in the direct sunlight for at least a week before packing it in bags or transporting it to the fields for use.

Perceived benefits for EcoSan

Users of both Fossa Alternas and DVUDD latrines indicated the following as benefits for using the latrines: a source of human faecal sludge for use in gardens and/or for sale, the latrines not producing bad smells due to use of ash and soil, the latrines not collapsing during the rainy season and, since they act as permanent latrines, they save land. It was, however, noted that the perceived benefits were not the same in both urban and rural areas; for example, the manure benefit was more common in Fossa Alterna users residing in rural areas. Also common in rural areas was the reduction of smell in the latrine and the latrines not collapsing during the rainy season. For those using DVUDD latrines in peri-urban areas, the main beneficial factors were saving space, reduction of bad smells and also the latrines not collapsing during the rainy season. These latrines were built either by using loans provided by implementing NGOs or by the NGOs as a demonstration. No new household built the latrine after the project phased out, despite the many benefits experienced by users of EcoSan. Despite these many reasons, all respondents agreed that they could build latrines with the help of loans, or the latrines would have to be free (i.e., built by NGOs). In Angelo Govea, the implementing NGO

had a policy that every house in their area should have an EcoSan latrine. In Chemusa, respondents said that the DVUDD latrines were also promoted by an NGO where households were given loans. In Lirangwe, the EcoSan toilets were built as demonstration units for selected strategic households. The quotes below are evidence of what respondents said on how EcoSan latrines were built in their area:

They [NGO] taught us to be building these latrines; they gave loans to people if they wanted to build an EcoSan latrine. I can say the advantages are that it does not smell and we harvest manure. Female respondent, Angelo Govea

After they left [NGO officials], some people showed interest in EcoSan latrines but no one built it because they do not have money to buy cement. Male respondent, Lirangwe

In Chikwawa, Zimola and Ng'ombe villages, the implementing NGO engaged chiefs and village management and encouraged every member of the village to have a latrine – preferably EcoSan. Those without any form of latrine were fined approximately 1 USD if found using someone else's latrine.

Reported practices on use of DVUDDs and Fossa Alternas

After defecation, a minimum of one cup of ash and two cups of soil were poured in the latrine drop-hole. Some households pre-mixed ash and soil, while others preferred putting them in separate containers. The respondents reported that soil and ash helped to desiccate faeces and reduce smells and moisture, make the pit/vault contents less compact, and leaving it less unsightly for the next user. In terms of how much ash and soil to use after defecation, about 9% (4) of respondents said they determined the number of cups of ash and soil mixture to pour in by estimating the amount and type of faecal matter dropped in the pit/vault. Some quotes below provide evidence of how ash and soil is used:

We take 3 cups full of ash and soil mixture but if it's normal faeces, we use one cup. We premix...they (women) are told

to mix...one pail of 5 litres ash and 2 of soil. Male respondent, Zimola

.....we take the buckets of ash and soil outside because there is no roof there. In case rains come it might get wet so we keep them inside the house. We ask men to fix the roof, but other men are lazy, they always say they are tired so right now I have fetched grass to fix the roof myself. Female respondent, Zimola village

In some situations, the use of ash and soil led to blockage of the urine diversion pipe. Some children defecated on the urine diversion pipe. Three households reported that their urine diversion pipe had a small diameter that easily became blocked and caused the urine to overflow and spill into the drop-hole. The drainage system is shown in [Figure 1](#) as well as the bags of ash and soil stored inside the latrines.

Materials thrown in EcoSan latrine

Almost all the respondents 98% (44) knew the materials that are supposed to be deposited in EcoSan latrines and also those that are restricted. The materials used for anal cleansing were toilet paper, leaves, maize cobs and loose soil lumps. Some cow dung, food leftovers and chicken droppings were also thrown in the pit/vault because they are decomposable. Two Muslim families using Fossa Alternas in Ng'ombe village said that although they are supposed to use water for anal cleansing, they cannot use it because water is not allowed in EcoSan latrines. Instead, they agreed to use the bathing room for anal cleansing after defecation in the latrine. On the other hand, all respondents indicated that during the time they were using ordinary pit latrines they threw in things like broken glasses, worn out clothes, plastic papers, used water, dead snakes and

everything that was not to be seen by people. About 98% of the respondents also agreed that most of the time people do not follow what is required; they throw in waste water, papers and other things that are not decomposable.

Reported practices during urination

Urine management is different between DVUDDs and Fossa Alternas. For the DVUDDs visited in Blantyre, urine is diverted to a soak-away pit together with water from the bathing room. The DVUDD relies on desiccation to sanitize the vault contents, which is only possible when the urine is diverted. Unlike the DVUDD, the Fossa Alterna does not have urine diversion: all faeces and urine go into the same pit. Sanitization relies on the ammonia produced from urine, an increased pH due to the addition of ash, and heat. However, these processes do not happen properly because people do not follow proper practices. For example, 24% (4) of respondents using a DVUDD in Angelo Govea and Chemusa areas reported that some members of their household occasionally urinate in the vault where faeces go because of laziness and also because they do not want to see their urine, especially when the diversion system is not working well. Those using Fossa Alternas have a habit of urinating in the bathing room and not in the latrine. All the respondents using a Fossa Alterna reported that most members of their households, including themselves, urinate in the bathing room or the bush. The reason was that it was common knowledge that if one wants to urinate, i.e., a visitor, he or she has to be directed to the bathing room unless he or she specifies that he or she wants to defecate. As for those using DVUDDs, only one user in Chemusa and one from Angelo Govea reported using the bathing room for urination. They reported that they avoided urinating in the latrine because urine smells bad, especially when the urine

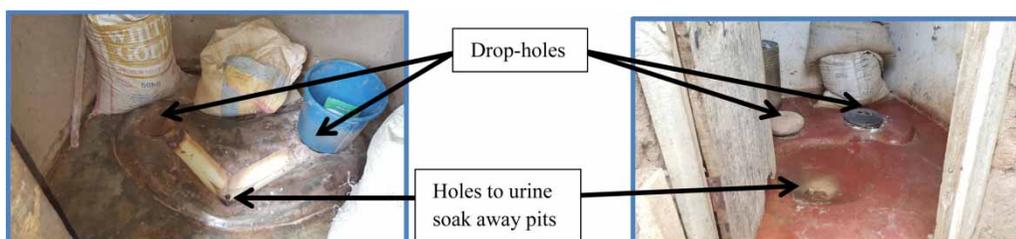


Figure 1 | DVUDD latrine floors showing urine diversion system.

diversion system blocks. Below are some quotes that resulted:

The rightful place is the bathing room or the bush because urine wets the latrine and makes it collapse faster, also because urine is the one that creates the smell. Urine also destroys the bricks in the pit. Female respondent, Zimola village

When a visitor comes we show them a bathing room. We don't urinate here in the latrine. But if you want to urinate here, urine goes outside through the drainage pipe to soak-away pit and faeces in the hole. Male respondent, Chemusa

Teaching visitors and children about the use of EcoSan

Visitors and first time users were supposed to be given some instructions on how to use EcoSan latrines. The instruction could have helped them to be able to separate urine from faecal matter if using a DVUDD latrine and on how to use ash and soil for both types of EcoSan latrines. During this survey, it was observed that explaining the instructions to visitors depended on the situation and the visitor. The respondents said that they could opt to leave the person to use the latrine and let one member of the house apply ash and soil later if it was a respectable visitor like a father-in-law or mother-in-law or someone respectable in society who did not know about EcoSan. Household members usually rely on smell and the presence of house flies to know that ash and soil has not been used. Regarding trespassers, respondents either checked the latrine at intervals or used a lock to prevent entry. Others were unable to explain how to use an EcoSan latrine to visitors because they were afraid of being labelled as 'rude'. Some of the issues concerning visitors are evident in the following quotes:

Maybe the visitor is rushing. Explaining to them would be like torturing them but sometimes we don't because of shyness especially with older people. Others would prefer to assume that the visitor will know by looking at the design. But sometimes visitors have problems channeling their urine to the drainage pipe or sometimes

they urinate in the vault (for DVUDD latrine) so they need instructions. Female respondent, Angelo Govea

We do not allow people who pass to use the latrine. We lock it because others may be drunk and misuse it. Urine from the drunken person smells bad. Male respondent, Chemusa

Here we have two types of latrines, an EcoSan and a traditional pit latrine. All visitors who do not know how to use EcoSan, we show them traditional pit latrine. Male respondent, Chemusa

Respondents with children between the age of six and ten years indicated that they teach them how to use the Fossa Alterna or DVUDD latrine. Those with children between four and five years allow them to use the latrine and whenever they finish the older family members go in to pour soil and ash, while those below four years old defecate outside the latrine and their guardians are responsible for disposing of the faecal matter in the latrine. In Ng'ombe, a mother said she advises those below the age of five years to defecate in the bush while others said they go with the child and assist the child to use the latrine while others follow no specific order. Problems with children included not being able to separate urine and faeces, defecating and urinating in the sides of the drop-hole, not putting back the drop-hole cover, not using ash and soil after defecating, and defecating in the urine drainage pipe (for the DVUDD latrine). For those using the Fossa Alterna, the main problems included not using soil and ash, not putting back the drop-hole cover and missing the drop-hole when defecating. One of the households in Lirangwe had a separate latrine for children. The quotes below show some of these sentiments:

The kids, we would help. We go in and help the youngest kids but if they go in alone, they urinate everywhere. Female respondent, Angelo Govea

Children do not manage to separate urine and faeces to the designated places and may not use ash and soil. So we make sure we go and pour in soil and ash and cover the lid. Female respondent, Angelo Govea

When a child goes in and is not followed up by an elderly person, the child may pour in the vault all the soil and ash and also may cause blockage because they even throw in some ash and soil in the drainage pipe. Male respondent, Chemusa

Reported practices when harvesting human faecal sludge

About 62% (28) of the respondents were aware of requirements like wearing gloves, using a shovel and wearing boots. Regardless of this knowledge, most of them, especially those with Fossa Alterna where the person harvesting enters the pit/vault, did not have the required materials to use when harvesting. The other 13% (6) of respondents thought that since the sludge was from their faeces and that it had been sanitized, there was no problem touching it with bare hands and thought that there was no risk of disease because the sludge looked just like soil. One respondent in Ng'ombe village had all the required materials such as gloves, a shovel and boots, which were provided by the implementing NGO. However, since time had passed from the period the materials were given, other respondents did not know whether these materials still existed in their area. Only three neighbouring respondents said they were still borrowing these materials. The other two respondents from the same village said they relied on hand washing with soap and bathing after harvesting the sludge. They believed that the germs in human faecal sludge have been washed away during the waiting period. Below are quotes showing knowledge of best practices during harvesting:

We are supposed to have gloves, but because of our financial position we just remove the manure without any protection. But during sensitization, they [NGO officials] told us to be using gloves when removing manure. The manure is dry and since it's ours, we just touch it without gloves, it doesn't disgust us,it's pure soil and not faeces. Male respondent, Chemusa

We open the vault and remove manure with a shovel... you stand from outside and remove it using the shovel. You also use gloves, mask and gumboots, if you don't

have these you use alternatives like plastic papers as gloves and a cloth as a mask. Female respondent, Angelo Govea

We bathe after removing the manure. We do not wear any protective wear. We bath because we have touched bad things. Male respondent, Zimola village

...people were afraid that this would give them an infection so they thought of mouth covering. We also use a shovel and gloves...we borrow them from the health worker; when he has, he shares. Male respondent, Ng'ombe village

Problems and challenges faced when using EcoSan

The main problems in rural areas for EcoSan users were the leaking of roofs, the lack of materials to maintain or re-roof the latrines, and the rapid filling rates. The fast filling rates of the pit/vault led to the removal of sludge in less than six months. Large families of more than ten people indicated that it took them three to four months to fill the pit/vault. The other challenges were a lack of bags for storing the faecal sludge and a lack of buyers for the sludge. The implementing NGOs promised people that they would find customers for the faecal sludge, but supplies were small in the initial phase and this scared away potential buyers. For those in Chemusa and Angelo Govea, finding a tenant who is well conversant with use of the latrine was a challenge. In addition, lack of land where they can grow crops and use the sludge from latrines was another challenge. Those without gardens were disposing of the sludge just as they would do with any general solid waste.

DISCUSSION

Knowledge on EcoSan use

The respondents had moderate to high knowledge except for four who had low knowledge, and one respondent who had no knowledge at all. The low knowledge was because the respondents were not there during the awareness campaigns, either because they had a temporary job elsewhere

or had just arrived to rent a house with an EcoSan latrine. For the one without any knowledge, it was because the land lord (the owner of the house) did not inform the new tenant about the type of latrine and the tenant assumed it was the usual traditional pit latrine. In general, respondents thought that their knowledge had declined because they were struggling to remember some things that they were taught by officials during the project time. The perceived drop in knowledge levels of respondents could be attributed to the phasing out of the projects and lack of support from government field officers.

Attitudes of people on EcoSan use

Although most respondents (41) had positive sentiments on the use of EcoSan latrines, some (4) with EcoSan had only negative attitudes towards latrine use and its faecal sludge. Some respondents indicated that they cannot eat food fertilized by EcoSan sludge because they think it is contaminated with faecal matter. Those with positive attitudes in Blantyre liked the EcoSan because it saves space, while those in Chikwawa said the latrines do not collapse during the rainy season and are a source of faecal sludge for crops. In Indonesia, the main driver for EcoSan use was as a source of sludge (Albrecht *et al.* 2010). In Tanzania, people accepted EcoSan latrines because of the permanency, durability, environmental friendliness and fertilizer value (Shayo 2003), while in other areas, fertilizer value was not a major driver because the faecal sludge was in small quantities and some latrine owners did not have gardens (Drangert & Stockholm Environment Institute 2004; Okem *et al.* 2013). This meant that people preferred EcoSan latrines not mainly as a means of sanitation but because of other associated benefits. The negative issues about EcoSan use were mainly influenced by what other people who did not have the latrines said. The main issue was the feeling of disgust, because they imagined that the faecal sludge was in the crops they produced. Furthermore, lack of technical skills to address a problem with the latrine, i.e., blockage of the pipe, and drainage problems, led to the development of negative attitudes about the latrines. Negative attitudes were also found in other studies, which showed that some people think crops fertilized with faecal matter grow and faeces are in the food (Nawab *et al.*

2006). In another study done in South Africa, it was found that attitudes towards handling of faecal matter were strong; however, people showed an openness to changing their minds (Duncker *et al.* 2007). While other studies reported cultural issues (Nawab *et al.* 2006), this study found no cultural issues related to EcoSan. Most respondents were of low economic status, earning an average of USD 36 per month, and mostly used unimproved traditional pit latrines previously. This made them view a Fossa Alterna or a DVUDD latrine as an improvement from the ordinary latrine, which is built using local materials. For those in rural areas, the EcoSan latrine is an improvement in their lives because it is built using bricks and cement. This confirms that sanitation needs to follow Maslow's hierarchy of needs, where once a need is satisfied a higher need emerges (Dellström Rosenquist 2005). While this study reported that the main barriers for DVUDD latrines were financial resources, attitudes and lack of gardens to apply faecal sludge, others studies found similar barriers (Rajbhandari 2008; Keraita *et al.* 2013; Uddin *et al.* 2014). The cost of EcoSan is lowest in Southern Africa, estimated at USD 350 (Mara 2008). The sociocultural issues about reuse of sludge from human excreta and the practice of urine diversion also influenced the attitudes towards Fossa Alterna and DVUDD latrines by users as they referred to what other members of the society said about their latrines. According to a study on knowledge, attitudes and practices on oral health in children, the sociocultural environment was an important factor in development of an attitude (Smyth *et al.* 2007).

In Zimola and Ng'ombe, the EcoSan latrines were introduced in 2008; people still see latrine technology as new. For users to completely get used to the technology and change their attitudes, they need enough time to go through stages of behaviour change (Prochaska & Velicer 1997). EcoSan latrines are mostly introduced in communities through NGOs, who usually have a defined period to work in an area depending on funding. This short implementation period makes it difficult for communities, especially those slow in adopting technologies, to be taken through a stage where they start using their own initiatives to build EcoSan latrines. During the time of this survey, the implementing NGOs were no longer supporting communities in terms of awareness, loans and

technical advice. This could also partly explain why no household made their own efforts to have EcoSan after the implementing NGOs left.

Ecosan practices

Common unacceptable practices observed included throwing non-biodegradable materials like stones, metals, glasses and plastic papers into the latrine, not maintaining the roofs, using chemicals and hot water, urinating in the latrine drop-hole for those using a DVUDD latrine, and urinating in the bathing room or bush for those in rural areas and using DVUDD latrines. Practices such as using chemicals and hot water were undertaken to abate the effects of improper latrine use, such as smell and maggots. Through observations and discussions, maggots coming out of the pits/vaults occurred when ash and soil was not used and when water from rain entered the latrine as runoff or underground, or through a leaking roof. Those households with maggot problems reported using hot water, hot ash, battery acid, chlorine and other chemicals to kill the maggots. In order to make sure there are no maggots, users were supposed to prevent water entering the vault and use ash and soil as required. For DVUDD latrines, a lack of proper urine diverting systems contributed to the problem. Urinating in the bathing room for those using a Fossa Alternas reduces urine content, which has fertilizer value and is a source of ammonia, which acts as a sanitizer (Fidjeland et al. 2013, 2015). As for DVUDD latrines, urinating in the vault makes the contents moist, contrary to the aim of DVUDD, which is to make the sludge dry. Different practices may affect human faecal sludge quality and pathogen die-off rate. Practices especially disposing of waste water and failure to make the latrine pits/vaults water-tight, mean the pits/vaults are filled with water, promoting the multiplication of maggots. It was also noted that while respondents used to throw anything in ordinary pit latrines, they now know that not everything can be deposited in an EcoSan latrine. This was similar to other studies, which also found that people just throw anything into an ordinary pit latrine and this contributes to quick fill-up and problems in emptying (Bakare et al. 2012). Problems with latrine use have also been reported in other studies involving urine diversion latrines, which have suggested using a urine pipe

of about 75 mm in diameter and a gradient of at least 1% for effective urine separation (Jönsson & Vinnerås 2007). This study observed that most urine diversion pipes were small, with diameters of less than 50 mm. Other households used electrical tubing pipes for urine diversion because they are cheap. Although the knowledge levels do not always translate into good attitude and proper practice, it is important as it is the starting point towards achieving a proper practice (Smyth et al. 2007). The EcoSan users need periodic awareness because they meet different technical challenges as they are using the latrines.

During harvesting, households were unable to use proper protection mainly because they could not afford to buy protective wear like gumboots and gloves, although some utilized local resources like plastic bags. The perception that human faecal sludge is safe contributed to the lack of initiative to protect oneself during harvesting of the sludge. Dryness of sludge, lack of smell and seeing children playing on heaps of human faecal sludge made users think that it was safe. A similar perception was also found in a study done in Vietnam where the human excreta was not associated with any risk if it was dry and had no odour (Mackie Jensen et al. 2008). The various factors that affect attitudes and subsequently practices in this study are summarized in Figure 2, which also incorporates a supportive environment and environmental factors as important to sustain good practice on EcoSan use.

The practices displayed during EcoSan use in Chikwawa and Blantyre in Malawi may be best explained by the model in Figure 2. Sustainability of the practices on use depended upon constant monitoring of officials from implementing NGOs and also the trained sanitation promoters and health surveillance assistants. This was found to be temporal due to lack of government support because after the projects were phased out, this support system died.

CONCLUSIONS

Despite some unacceptable EcoSan practices, respondents knew what EcoSan latrines were and also knew the basic operational principles such as urine diversion, the need for soil and ash, and allowing a waiting period before harvesting the sludge from the pit/vault. This means periodic

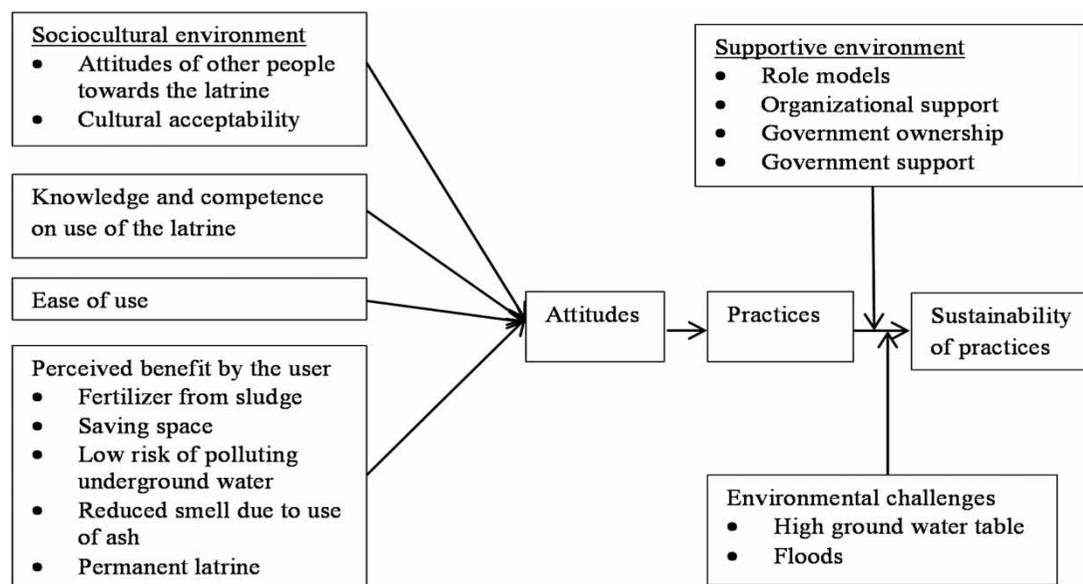


Figure 2 | Factors related to practice and sustainability of such practice.

awareness campaigns on use and maintenance of the latrines would be useful in maintaining good practices. Most of the poor practices observed were technical in nature and required a competent extension officer to advise households facing such problems. Regarding perceived safety of the sludge, there is need for awareness so that people know that their sludge may not be safe. This will assist people to use protective wear when harvesting, transporting and applying the sludge in their fields. The awareness will also help the users of EcoSan sludge to store it in a hygienic manner. The government, through water monitoring assistants and health surveillance assistants, should periodically monitor how EcoSan latrines are used and provide appropriate support to users, especially after the implementing NGOs phase out their projects.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution of Mr. Kondwani Chidziwisano and Mr. Limbani Kalumbi during data collection and also Mr. Sothin Ziba and Miss Rossaine Daudi for transcribing data. We are also grateful to Dr. Elizabeth Tilley for assisting in proofreading this manuscript. This paper has been produced from part of

the PhD research work on pathogen survival in EcoSan latrines and the associated health risks. The PhD fellowship is supported by the Consortium for Advanced Research Training in Africa (CARTA), Southern African Consortium for Research Excellence (SACORE), Scotland Chikwawa Health Initiative (SCHI) and University of Malawi, The Polytechnic.

REFERENCES

- Albrecht, M., Blackett, I. & Arianto, I. 2010 Ecological sanitation: social factors impacting use of EcoSan in rural Indonesia. Water and Sanitation Program Learning Note. <https://openknowledge.worldbank.org/handle/10986/11697>.
- Bakare, B. F., Foxon, K. M., Brouckaert, C. J. & Buckley, C. A. 2012 Variation in VIP latrine sludge contents. *Water SA* 38 (4), 479–486. http://www.scielo.org.za/scielo.php?script=sci_abstract&pid=S1816-79502012000400002&lng=en&nrm=iso&tlang=en.
- Bartram, J., Lewis, K., Lenton, R. & Wright, A. 2005 Focusing on improved water and sanitation for health. *The Lancet* 365 (9461), 810–812.
- Breslin, E. D. 2002 Introducing ecological sanitation: some lessons from a small town pilot project in Mozambique. *Water Science and Technology* 45 (8), 217–224.
- Chunga, R. 2015 Sanitation technology preferences and drivers of demand for ecological sanitation. Thesis, London School of Hygiene and Tropical Medicine London, UK.

- Dellström Rosenquist, L. E. 2005 A psychosocial analysis of the human-sanitation nexus. *Journal of Environmental Psychology* **25** (3), 335–346.
- Drangert, J.-O. 2004 *Norms and Attitudes towards Ecosan and Other Sanitation Systems: Desk Study by a Group of Experts on Ecological Sanitation*. Stockholm Environment Institute, Stockholm, Sweden.
- Duncker, L., Matsebe, G. N. & Moilwa, N. 2007 *The Social/Cultural Acceptability of Using Human Excreta (Faeces and Urine) for Food Production in Rural Settlements in South Africa*. Water Research Commission, Gezina, South Africa.
- Esrey, S. A. 2001 Towards a recycling society: ecological sanitation—closing the loop to food security. *Water Science and Technology* **43** (4), 177–187.
- Fidjeland, J., Magri, M. E., Jönsson, H., Albihn, A. & Vinnerås, B. 2013 The potential for self-sanitisation of faecal sludge by intrinsic ammonia. *Water Research* **47** (16), 6014–6023.
- Fidjeland, J., Nordin, A., Pecson, B. M., Nelson, K. L. & Vinnerås, B. 2015 Modeling the inactivation of ascaris eggs as a function of ammonia concentration and temperature. *Water Research* **83**, 153–160.
- HSA 2015 *Health Surveillance Assistants' (HSAs) Reports on Sanitation. Routine data. Blantyre and Chikwawa in Malawi*, Ministry of Health, Malawi.
- Hunt, D. P. 2003 The concept of knowledge and how to measure it. *Journal of Intellectual Capital* **4** (1), 100–113.
- Jönsson, H. & Vinnerås, B. 2007 Experiences and suggestions for collection systems for source-separated urine and faeces. *Water Science and Technology* **56** (5), 71–76.
- Keraita, B., Mackie Jensen, P. K., Konradsen, F., Akple, M. & Rheinländer, T. 2013 Accelerating uptake of household latrines in rural communities in the Volta region of Ghana. *Journal of Water, Sanitation and Hygiene for Development* **3** (1), 26.
- Kumwenda, S., Msefula, C., Kadewa, W., Ngwira, B. & Morse, T. 2014 Is manure from ecological sanitation latrines safe for use to fertilize crops? A review of evidence from literature. In: *Sustainable Water and Sanitation Services for All in A Fast Changing World*, WEDC, Hanoi, Vietnam. <http://wedc.lboro.ac.uk/resources/conference/37/Kumwenda-1853.pdf>.
- Langergraber, G. & Muellegger, E. 2005 Ecological sanitation – a way to solve global sanitation problems? *Environment International* **31** (3), 433–444.
- Mackie Jensen, P. K., Phuc, P. D., Knudsen, L. G., Dalsgaard, A. & Konradsen, F. 2008 Hygiene versus fertiliser: the use of human excreta in agriculture – a Vietnamese example. *International Journal of Hygiene and Environmental Health* **211** (3–4), 432–439.
- Mara, D. D. 2008 Sanitation now: what is good practice and what is poor practice? In: *Proceedings of the IWA International Conference Sanitation Challenge: New Sanitation and Models of Governance. Sub-department of Environmental Technology*, Wageningen University, Wageningen, the Netherlands. <http://eprints.whiterose.ac.uk/9218/>.
- Moore, S. R., Lima, A. a. M., Conaway, M. R., Schorling, J. B., Soares, A. M. & Guerrant, R. L. 2001 Early childhood diarrhoea and helminthiasis associate with long-term linear growth faltering. *International Journal of Epidemiology* **30** (6), 1457–1464.
- Morgan, M. 2010 Ecological sanitation in Malawi – putting recycling into practice. Ecological Sanitation Research (EcoSanRes). Stockholm Environment Institute (SEI). <http://www.susana.org/lang-en/library?view=ccbkyteitem&type=2&id=993>.
- Morgan, P. 2007 Toilets that make compost: low-cost, sanitary toilets that produce valuable compost for crops in an African context. Stockholm Environment Institute. <http://www.sswm.info/library/27>.
- Morgan, P. & Mekonnen Tesfaye, A. 2013 Paving the way to scaling up Ecosan in Malawi. Share Research. http://www.sharesearch.org/LocalResources/Morgan_and_Mekonnen_2013_Paving_the_Way_to_Scaling_Up_Ecosan.pdf.
- Nawab, B., Nyborg, I. L. P., Esser, K. B. & Jenssen, P. D. 2006 Cultural preferences in designing ecological sanitation systems in North West Frontier Province, Pakistan. *Journal of Environmental Psychology* **26** (3), 236–246.
- Okem, A. E., Xulu, S., Tilley, E., Buckley, C. & Roma, E. 2013 Assessing perceptions and willingness to use urine in agriculture: a case study from rural areas of Thekwini Municipality, South Africa. *Journal of Water, Sanitation and Hygiene for Development* **3** (4), 582.
- Prochaska, J. O. & Velicer, W. F. 1997 The transtheoretical model of health behavior change. *American Journal of Health Promotion* **12** (1), 38–48.
- Rajbhandari, K. 2008 Ecological sanitation latrines: the experience of Nepal. *Beyond Construction Use by All: A Collection of Case Studies from Sanitation and Hygiene Promotion Practitioners in South Asia*. https://www.wataraid.org/documents/ch5_ecological_sanitation_latrines_the_experience_of_nepal.pdf.
- Redlinger, T., Graham, J., Corella-Barud, V. & Avitia, A. 2001 Survival of fecal coliforms in dry-composting toilets. *Applied and Environmental Microbiology* **67** (9), 4036–4040. doi:10.1128/AEM.67.9.4036-4040.2001.
- Schönning, C. & Stenström, T. A. 2004 *Guidelines on the Safe Use of Urine and Faeces in Ecological Sanitation Systems*. EcoSanRes Programme.
- SDI 2015 Building EcoSan toilets in Blantyre, Malawi. Shack/Slum Dwellers International. *SDI Focus Stories*. www.sdinet.org.
- Shayo, A. J. 2003 Acceptance of Ecosan concepts in Tanzania—a case study of piloting ecological sanitation, Majumbasita, Dar Es Salaam. In: *Ecosan-Closing the Loop. Proceedings of the 2nd International Symposium on Ecological Sanitation*. Tanzania, pp. 7–11. <http://www.waterfund.go.ke/watersource/Downloads/003.%20Tanzania%20Ecosan%20Pilot%20Project,%20Dar%20es%20Salaam%20.pdf>.
- Smyth, E., Caamaño, F. & Fernández-Riveiro, P. 2007 Oral health knowledge, attitudes and practice in 12-year-old schoolchildren. *Medicina Oral, Patología Oral Y Cirugía Bucal (Internet)* **12** (8), 614–620. http://scielo.isciii.es/scielo.php?script=sci_abstract&pid=S1698-69462007000800016&lng=es&nrm=iso&tlng=en.

Uddin, S. M. N., Muhandiki, V. S., Sakai, A., Al Mamun, A. & Hridi, S. M. 2014 [Socio-cultural acceptance of appropriate technology: identifying and prioritizing barriers for widespread use of the urine diversion toilets in rural Muslim communities of Bangladesh](#). *Technology in Society* **38**, 32–39.

WHO 2014 *WHO The Top 10 Causes of Death*. World Health Organization, Geneva, Switzerland. <http://www.who.int/mediacentre/factsheets/fs310/en/>.

WHO 2015 *Soil-transmitted helminth infections*. World Health Organization, Geneva, Switzerland. <http://www.who.int/mediacentre/factsheets/fs366/en/>.

First received 4 November 2015; accepted in revised form 19 September 2016. Available online 20 October 2016