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**Evaluation of the long-term sustainability  
of biosand filters in rural Ethiopia**

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*Point-of-use water treatment is growing in popularity in the developing world, especially in rural areas where the costs of providing centralised treatment systems are higher than their low cost counterparts. One such technology, the biosand filter, has been shown to effectively remove turbidity and pathogens in laboratory and field research but the long-term performance of the filter and its sustainability are not well documented. An evaluation was therefore conducted to examine filters in rural Ethiopia installed more than 5 years previously. Filters were examined to assess filter performance, maintenance practices and the supporting environment. The working filters showed an average E.coli reduction rate of 87.9% with 75.7 % of filtrate samples achieving rates of <10cfu/100ml and 81.2% achieving turbidity values of <5NTU. The varied levels of usage in the three study villages, from 44% to 100%, also highlighted several risks and opportunities for continued active long term adoption.*

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### **Context**

Of the 1.1 billion people currently without access to safe water (UNDP, 2006) millions have abundant access to water but from rivers, streams and other unsafe sources (Sobsey 2004). In many such areas the implementation of centralised water treatment systems can be both impractical and costly thus making low cost household water treatment systems a reasonable alternative (Duke et al., 2006).

In recent years studies have concluded that these simple low-cost household interventions have the potential to be as effective at preventing diarrhoea as other environmental approaches such as improved sanitation, improved hygiene (hand washing with soap), or improved water supply (Clasen et al., 2006). However, there remain many questions relating to the long term sustainability of such interventions and the ability to scale up successful projects.

### **The study**

The study examined some of the 1300 filters installed in Ethiopia by the Ethiopian Kale Heywet Church (EKHC) between 1999 and 2001, supported by Samaritan's Purse Canada. Due to restrictions of time and transport the study concentrated on only three of the eight villages, those located in the same region as the EKHC field base. In each village 10% of the originally distributed filters were selected at random, totalling 57 filters. In each of the selected households, water testing, structured observations and semi-structured interviews were used to assess maintenance practices, user perceptions and the supporting environment. Semi-structured interviews were also carried out with the trained village caretakers, field workers and management staff. Water quality testing of the raw and filtered water for each filter included testing for E-coli using the DelAgua membrane filtration kit and turbidity using the DelAgua turbidity tube.

### **Usage**

The filter usage rates in two of the study villages, Koftu and Filtino were very high, 85% and 100% respectively. The overall average usage rate however was considerably lower at 70% due to the very low usage rates in Nenema of 44%. Likely explanations for this variation are explored later in this paper.

Of the filters not in use 36% were broken beyond repair, often as a result of people trying to move their filters unsuccessfully. Around 50% of the filters not being used, however, could easily have been brought back into use by active caretakers or project staff. Filters in this category include filters in need of replacement sand, filters with insufficient flow and filters with minor leaks.

All households interviewed had a positive view of the filter and were pleased they chose to receive one. Users identified a number of perceived benefits including improved health and the ability to use pure/clean water, which were reported by 91.2% and 75.4% of respondents respectively.

### Filter performance

The biological and turbidity removal rates of the 39 functioning filters are given below in Table 1.

<b>Table 1. Filter removal rates</b>		
<b>E-coli Removal</b>	<b>Acceptable</b> ( $<10$ cfu/100ml)*	<b>Average Removal</b>
	75.7%	87.9%**
<b>Turbidity Removal</b>	<b>Acceptable</b> ( $<5$ NTU)	<b>Average Removal</b>
	82.1%	69%***

\*' Reasonable' according to WHO definitions for water safety (WHO, 2004)

\*\* Ignores 2 filters where quality deteriorated,

\*\*\* Ignores 3 filters where turbidity increased

The mean (arithmetic) reduction in E.coli was 87.9%. This is greater than the expected rate of an unripened filter of 70% but lower than the expected rate for a matured filter of  $>97\%$  (Duke et al., 2006, Stauber et al., 2006). It should be noted, however, that 71.8% of samples achieved  $>99\%$  reduction in E.coli and that all filters removing less than 97% were found to be outside the recommended parameters for pause water depth and/or flow rate.

The mean (arithmetic) reduction in turbidity measured was 69.0%. The actual reduction rate is likely to be higher since the minimum measurable value of turbidity with the equipment used (5NTU) was obtained by 82.1% of samples and many achieved visibly higher standards.

### Maintenance and cleaning

Only 26.3% of households indicated filter flow rate was a significant factor for initiating sand cleaning suggesting that the majority of the households do so out of routine rather than necessity. In addition 77% removed large volumes of sand for cleaning rather than using the now recommended 'swirl and dump' practice, agitating the surface of the sand and then removing the water with the suspended particles. This means that the biological layer, of vital importance to the treatment process, is being disturbed far more than is necessary. Furthermore, incorrect maintenance procedures result in lower depths of sand and incorrect pause water depth, as observed in 90% of filters. This further compromises the health of the biological layer and reduces the effectiveness of the BSF. Poor sand cleaning also contributes to the very low flow rates observed which, in extreme cases, have led to people ceasing to use the BSF.

Another area where the cleaning procedure could be significantly improved is the cleaning of the spout. With 50% of spouts observed as being visibly dirty or broken, cleaning is clearly not adequate. Acceptable cleaning methods such as the use of a clean cloth/sponge or soap and detergent are practiced by only 36.8% of households and 21% of households do not attempt to clean the spout at all. The remaining 40.4% of households use unsanitary cleaning methods such as utilising fingers, grass and sticks which pose a risk of recontamination of the water as it leaves the filter.

### Household problems

Although the majority of households reported they had experienced no problems with their filter since receiving them 5-6 years previously, the remaining 45.6% reported a variety of problems rectifiable by a competent local caretaker, including cracks and leaks, loss of sand and low flow rates. Even where

householders identified problems there was a very low rate of reporting these problems to caretakers or project staff (42%) and a worrying number of those reported remained unsolved (73%).

One plausible reason for the lack of reporting was a lack of knowledge as to who they should relate problems, with only 36.8% of households identifying the caretaker and 43.9% of households stating there was no one to turn to if they experienced problems. In addition, according to EKHC staff, there is often a lack of recognition within communities that the caretakers are adequately qualified to aid them, resulting in users preferring to wait till project staff visit instead of reporting their problems to the caretaker.

### **Support**

The caretakers in Koftu and Filtino, where 85% and 100% of sampled filters were being used respectively, were proactively visiting households in their community to ensure everything was running smoothly. Conversely in Nenema, where only 44% of sampled filters were functioning, the caretakers were found to be generally unavailable to solve filter users' problems suggesting that caretaker support had a direct influence on filter usage.

Interestingly whilst the caretakers from Nenema wished to provide more support, they simply could not afford to leave their fields or paid work for substantial periods of time. The Filtino caretaker, however, charges for the time he spends on a filter thus providing compensation for money he might have otherwise earned elsewhere and allowing greater availability of his services.

A lack of tools and materials was clearly a factor preventing all caretakers from adequately carrying out their role. Only in the case of Filtino, where material supplies are not always expected to come from the EKHC, were replacement sand occasionally acquired by the caretaker and householders instructed to buy cement for the repairs. In none of the villages did the caretakers have access to any tools.

Unfortunately the subsequent phase, running at the time of the evaluation, included no funding to support the initial 1300 beneficiaries, leaving the EKHC team without resources to help these users. Whilst the project aimed to provide autonomous village caretakers, the reality is that problems arise beyond the capacity of the caretakers to resolve. Although project staff make considerable efforts to aid caretakers when time and other commitments permit, any assistance is given on an ad hoc basis. This assistance depends on when and to whom the request was made and is often limited to informal advice or provision of replacement sand. In addition the restrictions result in no formal system for receiving and documenting requests for help, hence reported problems are occasionally forgotten, filters fall into disrepair and users are forced to return to unsafe drinking water sources.

### **Discussion**

The distribution of biosand filters in the DebreZeit region has undoubtedly been a success. Many hundreds of people previously reliant on the use of contaminated surface water are benefiting from improved water quality more than 5 years after receiving their filters. Householders are very happy with their filters and the study also found the number of people benefiting from the filter project was not limited to households who had received a filter; friends, neighbours and workers also used the water produced.

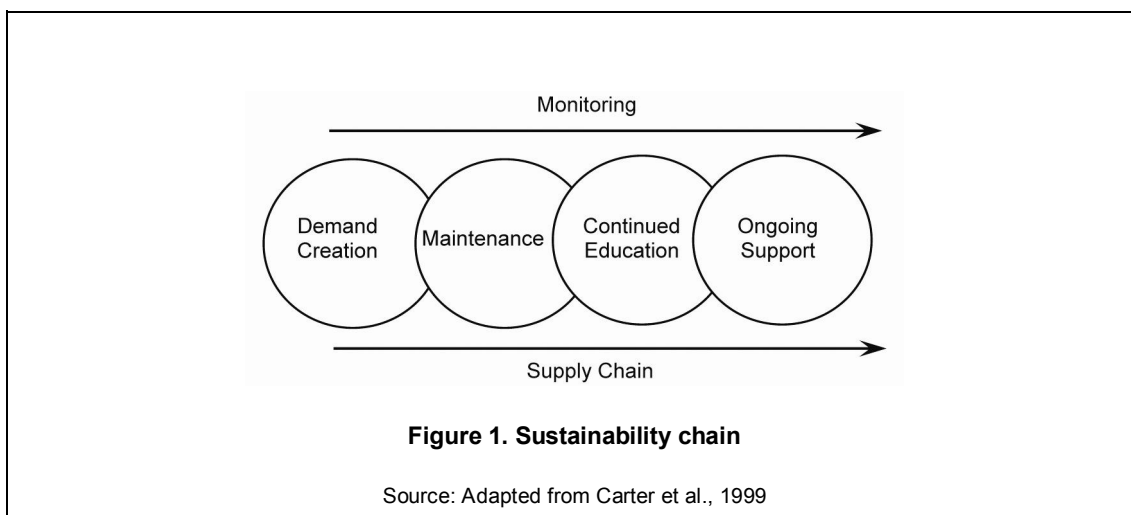
In terms of the filter technology there seems to be little to fault. Even after many years of use and, in some cases, highly dubious maintenance procedures, 71.8% of filters still remove >99% of faecal contamination demonstrating that the technology can be effective in the long-term if well-maintained. Even the remaining filters, functioning below this level due to operation outside recommended parameters, are still benefiting householders, improving their water quality, reducing possible exposure to a 'significant infectious dose' (Fewster et al., 2004) and thereby reducing their overall risk of waterborne disease.

Whilst overall usage rates are impressive, especially considering these were the first pilot villages in Ethiopia and that lessons learnt led to improvements in both the following phase and other BSF programmes worldwide, the varied filter usage rates across the villages indicated several factors preventing optimal filter operation. This disparity in usage rates and other data collected during the study however allows the identification of a number of significant threats to the sustainability of biosand filter programmes and provides insight into possible opportunities for increasing sustainability, as highlighted below in Table 2.

**Table 1. Sustainability opportunities and threats**

Opportunities	Threats
<ul style="list-style-type: none"> <li>• Reinforcement of messaging through printed reference material such as posters and stickers</li> <li>• Reinforcement of caretaker’s status by community leaders and project staff</li> <li>• Caretaker payments to increase availability and proactiveness</li> <li>• Significant demonstrated demand for caretaker services</li> <li>• Peer to peer interaction of caretakers to allow mutual support in neighbouring villages</li> <li>• Clear perceived benefits to filter users creating significant demand</li> <li>• Well trained local staff and available filter moulds</li> </ul>	<ul style="list-style-type: none"> <li>• Poor maintenance and cleaning practices</li> <li>• Poor educational follow up</li> <li>• Limited availability of caretakers</li> <li>• Poor availability of tools for caretaker use</li> <li>• Poor supply chain for replacement materials</li> <li>• Poor acceptance of caretaker by end users</li> <li>• Confused problem reporting structure</li> <li>• Poor definition of support available to caretakers</li> <li>• Lack of regular monitoring and record keeping</li> <li>• Lack of funding for monitoring and support</li> <li>• Lack of exploration of continued adoption and support strategies</li> </ul>

These identified opportunities and threats make it clear that technical efficacy of the biosand filter alone is not enough to ensure sustainability. Instead it is suggested that achieving continued and active long term adoption relies on four interlinking elements; demand creation, maintenance, continued education and long term ongoing support beyond project implementation as indicated in Figure 1. To ensure these elements are in place there is also a need for support in the form of monitoring and the provision of a suitable supply chain. Failure of any of anyone of the four elements or the supporting processes will prevent programmes from reaching their full potential and providing sustainable benefits to the widest possible population.



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