Intermittent Slow Sand Filters for Household Use - A Field Study in Haiti

D. L. Baker*, W. F. Duke**

*Centre for Affordable Water and Sanitation Technology, Canada, dbaker@cawst.org
**University of Victoria, Victoria, BC, Canada, bsduke@telus.net

Abstract An intermittent slow sand filter for household use, commonly referred to as the Biosand Filter (BSF), was developed by Dr. David Manz at the University of Calgary, Canada, in the 1990's. The version most widely in use is constructed of concrete, stands 95 cm in height and 36 cm in width. The flow rate is 20 – 40 litres per hour. The cost to produce a BSF is approximately 15 to 30 Euros (20 – 40 USD). Over 80,000 Biosand Filters are in use in 36 countries. Modifications to conventional slow sand filtration include; 1) reducing the height of the supernatant to 5 cm to provide the schmutzdecke or 'biofilm' with sufficient oxygen to allow intermittent use, and 2) eliminating the need for sand bed removal through a 'clean in place' technique which simplifies maintenance. These adaptations provide an affordable option for household application of slow sand filter technology to treat drinking water in rural and peri-urban communities of developing countries. In early 2005, a field study of the Biosand Filter was undertaken in Haiti by the Centre for Affordable Water and Sanitation Technology (CAWST), a Canadian NGO, and the University of Victoria, Canada. The effectiveness of the BSF in removing E. coli and decreasing turbidity was evaluated for 107 filters which had been in use for an average of 2.5 years (range 1 to 5 years). The sustained use and user satisfaction were assessed through interviews in each of the 107 households. Durability of the filter, maintenance requirements, and affordability were appraised by recording specific observations during the visits.

Keywords Intermittent slow sand filter, household water treatment, biosand filter effectiveness

1.1 Introduction

Over 1 billion people in the world lack access to safe water – a major feature of extreme poverty. Nearly all of these people live in developing countries, especially in rapidly expanding urban fringes, poor rural areas, and indigenous communities (Bartram, 2004). Community or municipal water treatment systems are frequently impractical and often unaffordable in these settings. At the present time, household water treatment provides the only reasonable alternative for many of these people.

In order for a household water treatment technology to achieve widespread sustainable use among the poor, it must meet the 'criteria of the poor':

- effective in cleaning the water and improving its taste, smell and appearance
- easy to operate and maintain
- affordable and durable, with little or no recurring costs
- manufactured using local skills and materials
- does not use chemicals or energy

The Biosand Filter, an intermittent slow sand filter developed by Dr. David Manz, has become one of the most widely-distributed devices for household water treatment in developing countries around the world. This filtration device provides a critical component of a household water treatment (HWT) system involving; sedimentation, filtration and disinfection. A recent survey found that, as of June 2005, over 80,000 Biosand Filters have been installed, impacting over 500,000 people in 36 countries (CAWST, 2005).

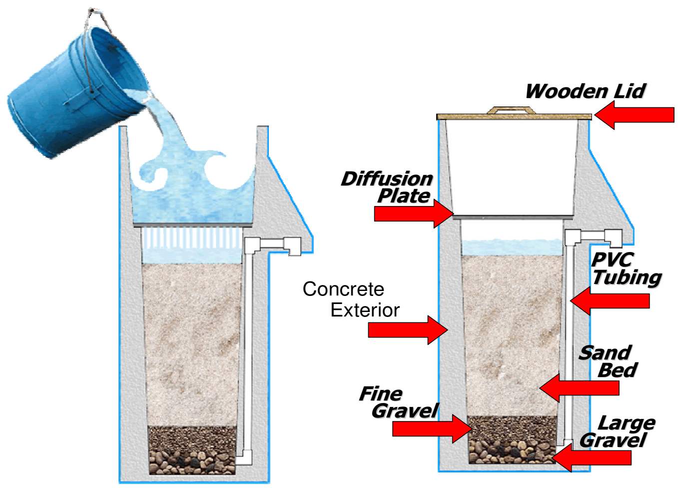

Figure 1.1 Biosand Filter

Unpublished laboratory studies have shown the biosand filter to be effective in significantly reducing the number of parasites and bacteria in the source water (Palmateer, 1999; Bruzunis, 1993). There is, however, very little data available, published or unpublished, regarding the filter's effectiveness and sustained use over time within households in developing countries. A field study was conducted in Haiti, West Indies, during the first half of 2005 to help fill this gap in knowledge. Included in the objectives of this study were to:

(1) collect data about the filter's effectiveness in removing bacteria and reducing turbidity under typical working conditions in a developing country,
(2) record the perceptions of household users with regard to water quality from the filter, ease of use, and level of satisfaction with the filter to assess sustainability,
(3) make observations about the durability of the filter after prolonged use, and
(4) measure the levels of *E. coli* in household water from source to point-of-use.

2.1 Methods

In the Artibonite Valley of Haiti, approximately 2000 Biosand Filters had been installed in households, between 1999 and 2004, by the Community Development Division of Hospital Albert Schweitzer. The research team visited 110 households to request consent of the householders to participate in the study. This resulted in finding 107 households with working filters.

Interviews, observations, measurements and water samples were carried out by two teams of Haitian enumerators, each consisting of a nurse and a filter technician. Water analyses were performed by Haitian lab technicians using the membrane filtration method to determine *E. coli* colony counts as the indicator bacteria for faecal contamination. Training of the research team and supervision of the visits and lab analyses were carried out by the research investigators and CAWST staff.

Water samples were taken at the water source for each household when possible. The other relevant sample points were;

(1) transfer bucket used to carry water from the source; the **Influent** to the filter,
(2) the spout of filter where the water flows out; the **Effluent** of the filter
(3) the storage container in the household; the **Point-of-Use**.

All samples were tested for *E. coli* running 10% duplicate and 10% blank tests. Turbidity was also measured using the Hach 2100P Turbidimeter. The water in the storage container was tested for pH and free chlorine, immediately after taking the sample at the time of the household visit, to determine if chemical disinfection was being used.

Interviews, using prepared questionnaires, were carried out after consent was received from each householder. Translation was available to the research investigator during the interviews. Measurements of the filter flow rate and height of supernatant (height of water above the sand during the pause period) were made for each filter. Observations of the filter's physical condition including filter body, diffuser plate, lid, and overall hygiene were recorded.

3.1 Results and discussion

Shallow, hand-dug wells, were the only source of water for 61% of the households. The water from these wells contained an average of 234 *E. coli* cfu/100mL (median 53 cfu/100mL). Water piped from springs or deep wells, provided water for 26% of the households (average 195, median 27, *E. coli* cfu/100mL). Thirteen percent had access to both types of water sources and just 3% had plumbing in their home.

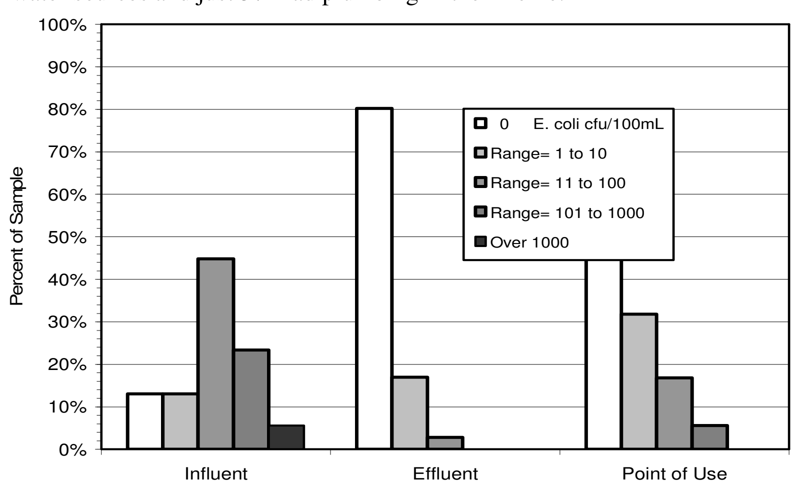

Figure 2.1: Effectiveness of Biosand Filter and Recontamination at Point of Use

The Biosand Filters effectiveness in removing microbial pathogens from the water was based on the *E. coli* colony counts from the effluent. Eighty percent of the water out of the BSF had zero colonies in the sample, 17% tested between 1 and 10 colonies, while 3% were over 10 (cfu/100mL). Bacterial removal in the filter averaged 98.5% overall (n=92).

Recontamination of the drinking water occurred post-treatment. While only 3% of samples from the filter effluent tested *E. coli* >10 cfu/100mL, the samples taken from the storage containers at point of use tested 23% > 10, including 6% > 100. Fourteen of the 107 households reported that they had had problems with slow flow rates from the filters, and 6% said that they had to obtain assistance from Community Development to correct the problem. In all of these cases, the problem was blocking of the filter due to impurities and suspended solids in the water. All were corrected by the 'swirl-and-dump' (clean in place) procedure. The average flow rate for the filters was 35.4 L per hour, ranging from 11 to 95 L per hour.

In 92% of the cases, the filters were found to be well-maintained. Only minor problems such as cracked lids or diffuser plates were observed. One of the filters was found to have a crack near the lip of the filter above the spout, but it was still being used. At the time of the unannounced first visit, 97% were found to be functioning after an average 2.5 years in use.

In 91% of the households, the filtered water was used only for drinking. None of the households treated the water with chlorine after filtering. Eighty-five percent poured the source water directly into the filter, not allowing time for sedimentation or settling. One hundred percent reported that the filter was easy to use, even for older children. Ninety-nine percent said that the filter produced enough water for the entire household.

One hundred percent of the households reported that they "liked" their filters, citing better quality water (49%), health protection (22%), and "because it works well" (7%) as reasons. In 99% of the interviews, the participants answered that the filtered water appeared cleaner, tasted better, and smelled better than the source water. Ninety-five percent felt that their families' health had improved since they began using the filter, while 5% had not noticed any change. Ninety-five percent responded that they would recommend the filter to others.

4.1 Conclusions

Perceptions of Householders:

High level of satisfaction was reported by the 107 families using the Biosand Filter in terms of: (a) the taste, smell and appearance of the filtered water, (b) ease of use of the filter, and (c) sufficient quantity of water for the entire family.

Observations:

(1) Overall; filters were durable, well-maintained, with 97% functioning after avg. 2.5 yr
(2) Major user problem: plugging of the filter due to suspended solids in the influent
(3) Lack of knowledge regarding:
- Maintaining the filter to remove plugging material and restore flow rate
- Disinfecting the water post-filtering, safe water storage practices and containers

Water Analyses:

(1) Good turbidity removal; average: influent 6.2 NTU ➔ effluent 0.9 NTU
(2) Significant bacterial removal; average 98.5% removal of *E. coli* overall
(3) Substantial recontamination of the stored water occurred post-treatment.

References

Bartram, J. Howard, G. (2004) Domestic water quality, service level and health. *Bulletin World Health Organization,* 82(3):

Centre for Affordable Water and Sanitation Technology (2005) Results: Key Performance Indicators. *CAWST 2005 Annual Report*, www.cawst.org , p. 10

Palmateer, G. Manz, D. (1999) Toxicant and parasite challenge of the Manz intermittent slow sand filter. *Environ.Tox*. 14:217-225.

Bruzunis, B.J. (1993) Laboratory report: conformational testing of an intermittently operated slow sand filter. *Department of Civil Engineering, University of Calgary, Calgary, Alberta, Canada*.