

**34th WEDC International Conference, Addis Ababa, Ethiopia, 2009**

WATER, SANITATION AND HYGIENE:  
SUSTAINABLE DEVELOPMENT AND MULTISECTORAL APPROACHES

## **Evaluation techniques for household water treatment projects: Biosand filter pilot project in Lao PDR**

*B. Bhandari<sup>1</sup>, R. Lentz, & B. Suvanthong, Canada*

REVIEWED PAPER 86

---

Recently, many UN agencies have been promoting the household water treatment (HWT) as a viable way to begin meeting the needs of millions who lack access to safe water. This paper describes an approach that was used in a recent evaluation of a biosand filter (BSF) pilot project in a peri urban community located in Vientiane municipality, Lao PDR. Simple evaluation techniques such as household surveys, water quality testing, filter performance assessment and observations on safe water storage, source protection and sanitary conditions were used. These techniques captured user perceptions, water quality indicators, fulfilment of operating parameters, and filter effectiveness and acceptability. This approach can help project implementers and end users to understand project effectiveness and contribute to effective follow-up programs to overcome barriers to proper use of the filters and the handling of safe water.

---

### **Introduction**

Recently, many UN agencies have been promoting household water treatment (HWT) as a viable way to begin meeting the needs of millions who lack access to safe water (Baker, 2006). This paper describes an approach that was used in a recent evaluation of a biosand filter (BSF) pilot project in a peri urban community located in Vientiane Municipality Lao PDR. The evaluation was conducted by a team of 8 senior staff from the Ministry of Health, National Centre for Environmental Health and Water (Nam Saat). The team members were not directly involved in the project implementation. A field survey was carried out in Na Ngom Mai village where 76 filters were installed in January 2008. The aim of the evaluation was to learn how to scale up BSF project implementations.

### **Methodology**

Nam Saat formed an evaluation team comprised of 8 staff under the leadership of the Chief of Environment Health Division. Prior to primary data collection, one evaluation team member interacted with the village head, community health volunteers and end users in order to get acquainted and to explain the goals of the evaluation. In addition to a review of UNICEF, WSP-EAP/World Bank and Nam Saat documents, a three pronged data collection method was employed: household surveys, informal meetings with village leaders and BSF technical committee members, and water quality tests. Questionnaire design, field surveys and evaluation reporting were completed within a three week period. Based on end user requests, water quality tests and household surveys were conducted in 76 households. Qualitative data were also obtained through informal, unstructured and open-ended interviews with key participants including local leaders, elderly community members and health post staff. Qualitative data helped to verify and enrich the quantitative data obtained from the survey.

To further assess the precision of the effectiveness of the biosand filter, five filters from households were selected through random selection for more detailed study. Samples from source water and filtered water were tested over five consecutive days. Wagtech International and Oxfam DelAgua membrane filtration

---

<sup>1</sup> [bbhandari@cawst.org](mailto:bbhandari@cawst.org), 12, 2916-5 Avenue NE, Calgary AB, Canada, T2A 6K4

water testing kits were used with Lauryle Sulphate broth. All water quality testing kits were calibrated prior to testing. Five percent (5%) blank samples were used for quality control. Turbidity tubes and a turbidity meter were used to measure the turbidity of water samples.

### **Indicators for the evaluation of household water treatment**

There are several existing studies on the effectiveness of the biosand filter water treatment technology. The original work started in the laboratories in the Department of Civil Engineering at the University of Calgary. (Buzunis, 1995) Many technology evaluation studies have been done by the Massachusetts Institute of Technology (MIT) students for partial fulfilment of their graduate studies. University studies focused on the effectiveness of technology, e.g. removal rate of *E.coli* and turbidity. The project BRAVO in Haiti looked at 106 filters over a six month period to determine the field effectiveness of the technology. The evaluation showed that the filter effectiveness was very high 98.5%, and that the end user acceptance was also very high (Duke et al., 2006).

Other evaluation studies, carried out by UNICEF, Samaritan's Purse (Canada) and the University of North Carolina, focused on effectiveness, sustained use and adaptation of the technology, user perception and health impact (Brown and Sobsey, 2007). A literature review of epidemiological studies, conducted by a team of researchers at the University of North Carolina, affirmed that ceramic and biosand filters improved water quality and reduced diarrheal disease. The studies used the following indicators for the project evaluation: quantity of filtered water, user friendly, time to treat water, affordability and availability of technology and their parts. Longitudinal and cross-sectional studies have been carried out to assess health impact (Sobsey et al., 2008). Results of these studies in general to be used for analysis and planning of specific field projects; however such types of studies need more resources to carry out field surveys Health impact studies are not deemed an operational tool for specific field project evaluations (Cairncross, 1990) and therefore other project evaluation tools need to be used when looking at any particular project.

Based on a literature review and group discussion prior to carrying out the evaluation, the Nam Saat team decided to use the following indicators for this particular biosand filter project: user perception, operating parameters, level of turbidity within national standard, source protection, removal of biological contaminants, sanitary situation around the households with filters, and clean storage.

## **Results**

### **User perception**

A questionnaire was prepared and carried out by members of the team with the 76 householders that were selected for the evaluation. The survey results showed that 95.2% of end users were satisfied with the taste, smell and appearance of the filtered water. All end users(100%) stated that the quantity of filtered water was appropriate for their drinking and cooking purposes. All interviewed end users stated that filter operation was easy and most family members were using the filter properly. Although most villagers had only three months experience with the biosand filter, 27.6% of the family heads arranged to order the filter to their relatives and friends.

### **Operating parameters**

The filters in each householder were inspected to determine if they were operating correctly. The following eight conditions were used as indicators of proper operations of the filter.

1. Filter should be mature (must be more than a month old before water samples were taken).
2. Diffuser should be in good condition and properly positioned.
3. Filter water flow rate should not be more than 0.6 litres per minute.
4. Water level should be not more than 5 cm (2") above the sand level.
5. Top sand layer should be level.
6. Inlet water turbidity level should be reasonable (less than 50 NTU).
7. Filter should be in use and water must be added regularly (at least daily).
8. The concrete filter body should have no leaks.

Of all the filters that were surveyed, 63.2% of them met all of the conditions listed above. Several filters demonstrated a high flow rate problem and excessive water levels above the sand level. When conditions were not met, the filter was categorized as not meeting the operating conditions. Preliminary checking of the operating parameters was a screening process for water quality testing.

Although some filters were not meeting all of the operating conditions, results show that they were working effectively. A few households recently moved the filter to their new houses which may have affected the performance.

### Level of turbidity within national standard

Levels of turbidity in the filtered water complied with the Lao PDR national drinking water standard which is less than 5 NTU. The turbidity was measured only in the source water being used in the filters with only 17.1% of the samples meeting the standard of less than 5 NTU. The water turbidity was also measured after the biosand filter in which 84.2 % of the samples meeting the standard of less than 5 NTU.

### Source protection

The source of water for each household was recorded during the field survey. Dug wells on the premises were used as the source of water for 74% of the households in Na Ngom Mai village while the remaining 26 % household obtained their water from community hand dug wells. The wells were usually dried up in April and May (dry season). Electrical pumps were used to extract water from the wells. A wooden fence protected only 43% of the surveyed wells. 87% of the wells were not protected from run-off water and outside contamination. Sanitary conditions around the wells were generally poor. Ninety five percent of wells were covered but lids were not well designed and did not cover the well completely. Twenty percent of wells were more than 15 meters deep and covered properly.

### Removal of biological contaminants

The WHO Guidelines recommend protection of the water source and treatment techniques to ensure the absence of biological contaminants. The presence of fecal coliforms in drinking water indicates pollution of warm-blooded animal feces that have a large number of pathogens. The degree of treatment required is a function of the source water and level of fecal contamination of the source.

<i>E. coli</i> level (CFU per 100 mL sample)	Risk	Recommended action
0-10	Reasonable quality	Water may be consumed as it is
10-100	Polluted	Treat if possible, but may be consumed as it is
100-1000	Dangerous	Must be treated
>1000	Very dangerous	Rejected or must be treated thoroughly

(WHO, 1997, Harvey 2007)

Water quality testing results showed that no wells had very dangerous amounts of fecal pollution. Seventeen percent of the source water samples showed to be of reasonable quality of water (<10 fecal CFU per 100mL). After filtration, 71% of filter output water samples had less than 10 fecal CFU per 100mL and were deemed to be of reasonable quality. The Lao PDR Drinking and Domestic Water Supply National Standards indicate that the fecal coliform should be zero but in practice up to 10 CPU per 100 mL of sample water is acceptable.

The consistency of the effectiveness of the BSF filter was measured by testing five filters on five consecutive days. Figure 1 below shows that the filter performance was very good over the test period. Although the water source was the same, the quantity of fecal contaminants varied slightly day by day. The filtered water quality was generally very consistent with the fecal coliform levels being zero or very low with only a few exceptions.

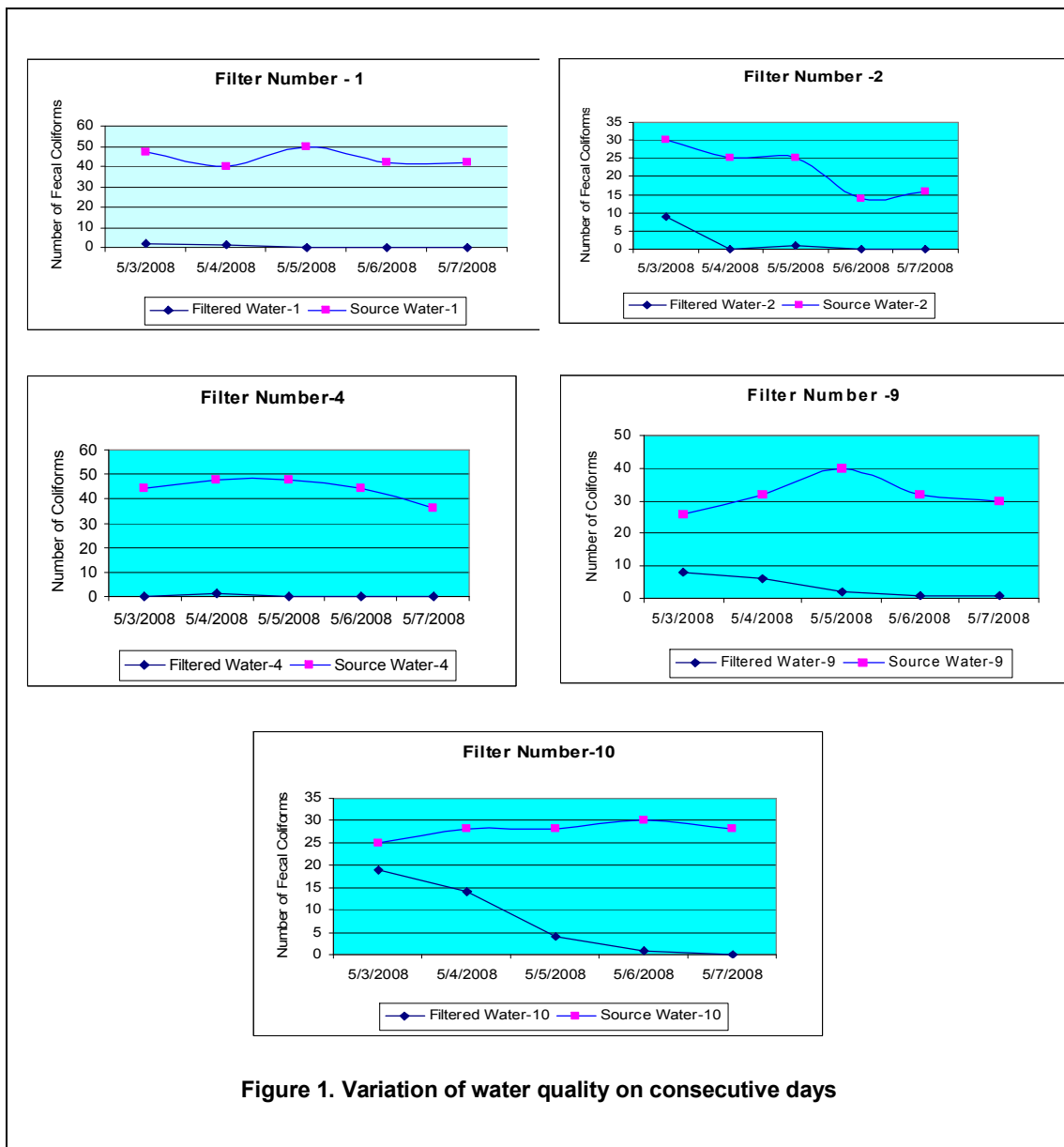


Figure 1. Variation of water quality on consecutive days

### Sanitary situation around the households with filters

During the surveys done by the team, observation were made and noted on the sanitation condition around the households where the filters were located. Many houses in the village were wooden framed structures on stilts above the ground level to keep them dry during the wet season. Due to the heavy weight of the concrete biosand filter, most users were unable to store it on the first floor. Approximately 53% of the filters were kept outside but under a roof.

Most houses (approximately 80%) were not tidy. There were no organized waste pits for solid waste and kitchen refuse, and no manure pits to collect cattle dung. Eighty percent of the upper and middle class families had chickens, ducks, cattle and a few other pets roaming around their houses. The area surrounding the houses was often unclean with haphazardly kept water storage containers without lids, fuel woods, and other farming goods. Some villagers (approximately 11 %) were keeping the filter inside and maintaining a good sanitary environment within the vicinity of the filter.

### Clean storage

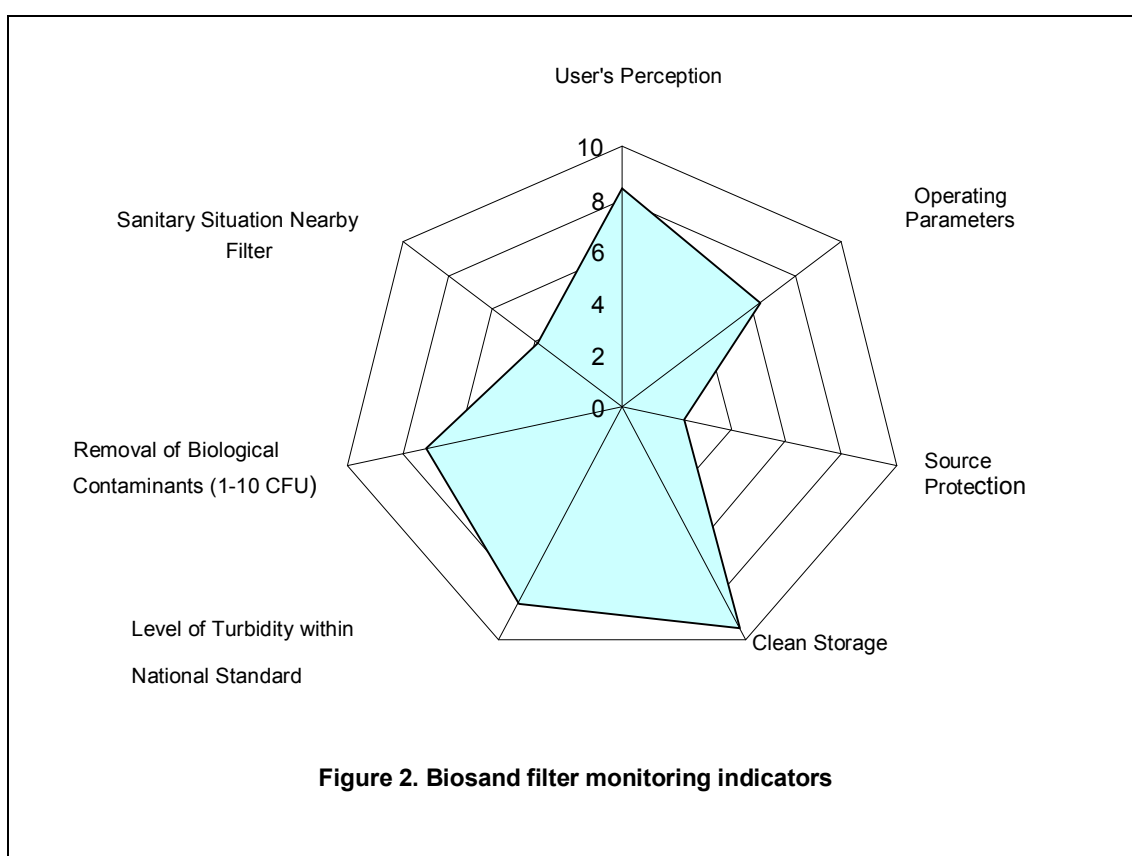
Village people had a practice of buying drinking water from a local vendor. Therefore, more than one third of households (68.4%) had narrow mouthed plastic containers. Some used both wide and narrow mouthed

containers to store filtered water. Eighty eight percent of containers had lids that covered them properly. Clean storage containers were used in 94.7% of the households. Most old, narrow mouthed containers were not clean. Villagers were not aware of the cleaning process of these containers.

Recontamination was a common problem. Although filters were removing contaminants from the source water, recontamination occurred in storage containers. Results of water quality testing showed that 30% of filtered water storage becomes recontaminated in the storage containers.

## Conclusions

Using the results of the household survey, observations and water quality testing, each indicator value of 76 households was converted to a scale of 10 units. The results were graphically displayed using a spider diagram in Figure 2: Biosand Filter Monitoring Indicators. This graphical display helps to visualize all of the indicators at one time. Where the indicators are low, further work is needed to improve the results and thus the success of the program.



**Figure 2. Biosand filter monitoring indicators**

End users are satisfied with the quality and quantity of filtered water. Most villagers are managing their own water source in their own homes. The low number of filters that met the operating parameters (63.2%) indicates that more work has to be done to ensure that the filters were built, installed and are operated properly. Training and follow up is also required with the filters users to ensure that they are following the operating parameters.

Community awareness and training in general hygiene and sanitation practices is also needed to improve the protection of the water sources and the sanitary conditions in the households.

The high number of filters that still had high turbidity (15.8%) showed that but there is a need to improve the filter operating conditions to reduce the turbidity further.

Biological testing of fecal coliform levels over a period of 5 days shows that the filters are working consistently. The levels of contamination (29% of filtered water over 10 CFU per 100mL) indicates that there might be problem in the filter media installation.. Once the operating conditions are improved, further water testing could be done to see if the levels of contamination would be reduced.

The evaluation process from planning to final implementation helped to improve the knowledge and skills of Nam Saat staff members in planning for project evaluation, water quality testing skills and preparation of final reports.

The methods used in the evaluation process and the final results were presented to end users, donors, implementers and more than 30 participants from government and non-government organizations. Participants took part in a field visit to learn more about the effectiveness of biosand filters and the process of evaluation. Application of the simple field analysis techniques outlined in this presentation is an effective means to conduct an evaluation of a household water treatment project in a short period of time.

---

## References

- Baker C. D (2006). *Household Water Treatment Technologies: Strategies for Scale Up and Success Indicators*. Proceedings of 32nd WEDC International Conference, Colombo, Sri Lanka, Sustainable Development of Water Resources, Water supply and Environmental Sanitation.
- Brown, J. and Sobsey, M.(2007). *Improving Household Drinking Water Quality Use of Ceramic Water Filters in Cambodia*. University of North Carolina School of Public Health, Department of Environmental Sciences and Engineering; Sorya Proum, Department of Chemistry, Royal University of Phnom Penh. Available at: [http://www.unicef.org/eapro/WSP\\_UNICEF\\_FN\\_CWP\\_Final.pdf](http://www.unicef.org/eapro/WSP_UNICEF_FN_CWP_Final.pdf).
- Buzunis, B.J. (1995) Intermittently Operated Slow Sand Filtration: A New Water Treatment Process. MSc Thesis, University of Calgary, Canada.
- Cairncross, A.M. (1990). *Health Impacts in Developing Countries: New Evidence and New Prospects*, Journal of the Institution of Water and Environmental Management. Vol 4, No.6.
- Duke, W.F., Nordin, R.N., Baker, D. and Majumder, A. (2006). *The Use and Performance of Biosand Filters in the Artibonite Valley of Haiti: a Field Study of 107 Households*, Rural and Remote Health, 6:570
- Harvey, P. (2007). *Well Fact Sheet: Field Water Quality Testing in Emergencies*. Water, Engineering and Development Centre, Loughborough University, United Kingdom.
- Sobsey, M., Stauber, C., Casanova, L., Brown, J., and M. Elliott (2008). *Point of Use Household Drinking Water Filtration: A Practical, Effective Solution for Providing Sustained Access to Safe Drinking Water in the Developing World*. Environment Science and Technology 42 (12), pp.4261-4267.
- World Health Organization (1997). *Guideline for Drinking Water Quality, Volume 3, Surveillance and Control of Community Supplies*, Geneva. Available at: [www.who.int/water\\_sanitation\\_health/dwg/gdwqv3ed.pdf](http://www.who.int/water_sanitation_health/dwg/gdwqv3ed.pdf)

---

## Keywords

Household water treatment, biosand filter, field evaluations, water quality, household survey.

---

## Contact details

Betman S. Bhandari  
12, 2916-5 Avenue NE, Calgary AB, Canada,  
T2A 6K4  
Telephone: 403.243.3285 ext. 230  
Fax: 403.243.6199  
Email: [bbhandari@cawst.org](mailto:bbhandari@cawst.org)  
Website: [www.cawst.org](http://www.cawst.org)

Ron Lentz  
12, 2916-5 Avenue NE, Calgary AB, Canada,  
T2A 6K4  
Telephone: 403.243.3285 ext. 228  
Fax: 403.243.6199  
Email: [rlentz@cawst.org](mailto:rlentz@cawst.org)  
Website: [www.cawst.org](http://www.cawst.org)