Evaluating the "Safir" Gravity-driven Membrane Filter in Bolivia

Bolivian families recently participated in field tests of the "Safir", a new generation household water filter, to help optimize its design and functionality. Tests were done at two locations and the results will be used to prepare the filter design for mass production. Selina Derksen[1], Valentin Graf[1], Maryna Peter-Varbanets[1]

Introduction

The "Safir" filter (See Photo 1) was designed by Eawag in collaboration with the Zürich University of the Arts, and was initially modified after field evaluation tests in Kenya. It is an ultrafiltration membrane module with a pore size of 20–40 nm that is placed into the raw water container. A mesh on top of the container reduces the spilling of water and protects the membrane from damage. The water passes through the membrane by gravity and is collected in the pure water tank. The filter does not require any cleaning, pressure or power; maintenance is limited to occasional flushing of the sediments that accumulate in the raw water container. The low-maintenance is possible due to the formation of the pervious biofilm on the membrane surface, which helps to sustain the stable flux of about 4–10 L/h per 1m^2 of membrane. Each filter lasts between 5–8 years.

Field evaluation in Bolivia

The goal was to involve users in the filter's design optimization process and test its functionality. Locally available ceramic candle filters were used for comparison. Handling and design were evaluated through structured interviews, workshops and video recorded observations, while functionality was evaluated through measuring water flow, frequency of use and water quality parameters. Two field sites were selected: Encanto Pampa, a peri-urban community, and San Benito, a rural community. 11 families at each site, that consumed untreated water from a river or from unprotected shallow wells, participated in the study. Each family started with either the Safir or the ceramic filter and then used the other one for at least one month.

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Photo 1: Safir filter in Bolivia.

Filter functionality

Microbial water quality. *Escherichia coli* counts were measured in the water storage tank, at different sampling points within the filter, and in the drinking cup. The log removal values (LRV) calculated between the storage tank and the tap showed ~ 2-log removal for both filters in San Benito. Although less than 10 % of all samples from both filters showed 1 or more *E.coli* in 100 ml sample of permeate, about 30 % of all samples taken from the tap and 30–50 % of all samples tested in the cup had *E.coli*. This showed that contamination occurred either at the tap or after it.

Water flow. The Safir's flow rate was generally higher than the ceramic filter. An approximate 1.2–1.5 L/h flow rate was observed at 12 cm at both field sites, while the ceramic filter's flow rate at this pressure was lower than 0.5 L/h. In San Benito, highly turbid water led to clogging of the ceramic filter.

Filter use. Both filters were used regularly at the two sites. The Safir was filled 6.1 times per week on average, while the ceramic filter was filled 5.2 times a week. However, the volume filled in the filter was relatively low: 3.6 L/fill in the Safir and 3.9 L/fill in the ceramic filter.

Filter handling and maintenance

Everyday handling and maintenance were evaluated. The criteria of the former were: handling ease of filling with water; use of lid; handling and location of tap; height and stability of the stand; risk of damage to the filter from improper use, such as opening the membrane tank; the handles and printed instructions. Major criticism of the filter concerned its lid and the stand's height. The tap was perceived as good due to regulation and high flow, but as not robust. None of the users opened the membrane tank during use, but they could do so if asked. An important recommendation was to create a better mechanism to protect the membrane from possible damage.

The maintenance criteria involved: the flushing of the accumulated sediments from the raw water tank, cleaning of the clean water tank, and tap replacement. In general, users managed to clean the filter and replace the tap by following the instructions. About half of the participants understood the concept of shaking the filter for cleaning purposes; however, some of them shook it the wrong direction which affected the cleaning efficiency. Improving the instructions and relocating the position of the handles were two recommendations. The majority perceived the filter as heavy during cleaning, but not unbearably so.

Conclusion

Functionality. The Safir is a fully functional filter. Re-contamination of the tap was observed in both the ceramic and the Safir filters and could be reduced by either introducing a post-treatment step, i.e., chlorination, or hygienic education of the users. The Safir is especially well suited to treat highly turbid water, while other technologies, including ceramic filters, fail at this.

Use. The Safir and ceramic filters were not used at full capacity. Factors, such as the actual need for water or the size of the vessel used to collect water, impacted the volume of filtered water. Therefore, the size of the clean water tank could be reduced to 10 litres or less.

Design. In general, the design was considered adequate and the families perceived the Safir as nice and easy to use. Design recommendations were collected to improve and prepare it for mass production.

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