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Biosand filters in schools: can they be restarted after abandonment over the long holidays?

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Biosand filters are an established point-of-use water treatment technology for household use. However, their need for daily operation makes them challenging to implement in school settings where long holidays may mean the filter remains dormant for several months. This study investigated whether school filters could be restarted without reinstallation after having remained dormant during the Honduran winter break. Two months before the start of the winter break, eight filters were operated and tested in schools near Trojes, Honduras. They were left dormant for at least two months over the school holidays, then restarted and operated for two weeks before the onset of testing. All eight test filters performed acceptably (median E.coli concentrations in filtered water of <1 cfu/100mL) after having been restarted.

Introduction

Much of the focus of point-of-use (POU) water treatment research has been at the household level, such as the World Health Organization's (WHO) Household Water Treatment (HWT) Network (WHO, 2015). However, in order for access to safe water to be of the greatest benefit to health, people must be able to drink safe water at all times, not only in the early mornings or late evenings when they are at home. During the academic year, children spend much of their time outside of the home and during the day will consume the water available from their school. Thus to ensure the maximum health benefits to children, it is necessary to ensure that schools have access to safe water.

The technical options for POU water treatment in small, rural, and remote schools are often similar as for households. However, there are significant differences in the usage and maintenance patterns for the technologies that pose unique challenges.

Biosand filters are a widely used POU technology, with over 650 000 in operation as of 2014, impacting approximately 4 million people (Ngai et al. 2014). The main advantage of a biosand filter is that it has no replaceable parts or consumable requirements. One of the challenges of placing a biosand filter (BSF) in a school is ensuring that the filter continues to be dosed during the period when school is not in session, such as during school holidays.

Pure Water for the World (PWW) is a global non-profit organization. The organization helps families and communities in Haiti and Honduras by providing sustainable safe drinking water filtration systems, latrines, and hygiene education. In addition to implementing water, sanitation, and hygiene projects, PWW Haiti and PWW Honduras are designated Water Education Training (WET) Centres in partnership with the Centre for Affordable Water and Sanitation Technology (CAWST) in Calgary, Canada. PWW has installed over 23 500 biosand filters (BSFs) in Central America since 2001.

Pure Water for the World has been working in the rural areas around Trojes, Honduras for 6 years, and began working on the issue of drinking water in schools in 2012. One of the technologies considered for implementation in schools is the biosand filter. However, in the communities PWW is working with around Trojes most teachers do not live in the community full-time, but rather commute to the schools on a weekly basis, going home for weekends and vacation. The schools themselves are not always close to the students' homes, in many cases the houses in these communities are very spread out. The most significant break for Honduran schools is the three month winter vacation. During the winter break, the school is locked up.

Because of the distance between the schools and homes, it is difficult to find someone who lives close enough for the visits to the school to be convenient and who is willing to operate the filter reliably. In addition, the winter break falls during coffee harvest season, which is the busiest time of the year for the members of these communities. However, if the filter is not dosed consistently, the biolayer of the BSF will not be receiving the oxygen and nutrients required to survive, and so can suffer significant damage or die off (CAWST, 2012). CAWST frequently receives inquiries from clients world-wide who face similar challenges with biosand filters in schools.

There is no clear recommendation for this situation, as no formal studies have investigated how to reactivate a BSF after a period of dormancy. The conservative recommendation is to completely reinstall a filter which has been left unused for several weeks. This would require visiting every school each year after the winter vacation, and replacing all the gravel and sand, then reactivating the filter through daily use for one month before the students returned. This is a costly and time consuming process and would not be a sustainable model.

No published papers were found which looked at BSFs which had been left unused or gave recommendations on how to properly reactivate an abandoned filter. The topic of reactivating BSFs that have been unused for a significant period of time is one that has not received much attention.

PWW Honduras would only consider the BSF for their school implementation programs if it can be shown that filters could provide safe water for the children after being re-started after the school holidays, without a full re-installation after each holiday. PWW partnered with the Research Learning department at CAWST to study the feasibility of BSF in schools near Trojes.

The specific objective of this research was to indicate whether or not BSFs could be revived, without reinstallation, after an extended period of dormancy.

Methodology

Two months before the school holidays, eight Hydraid biosand filters were installed in rural schools near Trojes, Honduras (Photograph 1). The installation visit included training for the teachers and community members who would be involved in the study (Photograph 2). The filters were ripened and operated until the holidays began. The filters were left dormant for at least two months over the holidays, and then were restarted one month before the students returned to class. The one month period was selected for the purposes of the study to allow enough time for PWW to sample the filters and confirm whether they were functioning adequately before exposing the school children to the water. The filters were operated by a teacher when possible, as teachers return to class several weeks before students do, or by a community member that was recruited for this purpose. The filters were restarted by simply beginning to pour water into the filter's diffuser basin again.

Two samples were taken from the filters before the holidays to ensure that the filters were functioning normally, and then three samples were taken after the period of dormancy, once the filters had been given two weeks to re-acclimatize.

Photograph 1. School in Cayantu

Photograph 2. Training and installation of Hydraid Filter in school

During each sampling visit, water samples were taken from the school's water source and water coming from the biosand filter. Water samples from the filter were taken as grab samples from the outlet tube 10 minutes after water had been poured into the filter, to ensure consistency from sample to sample. Water samples were tested for turbidity and *E.coli*. After the first sampling visit, it was found that *E.coli* levels in the filter effluent were too low (typically <1 cfu/100mL) to allow for the calculation of a removal rate, and so total coliforms were also analysed in subsequent visits. At each visit additional data was collected about how the filter had been operated since the previous visit, such as frequency of dosing. The filter's maximum flow rate and sand level were also checked. This was in order to ensure that the filter was running within the acceptable operating parameters. The pH of the source and filtered water was tested during one visit.

Total coliform and *E. coli* concentrations in samples were analyzed using the membrane filtration method with m-coliBlue 24 as the growth medium (Hach, 2012). Samples were diluted as necessary to target plate counts of between 20 and 80 colonies. Commercially available bottled water was used for dilutions. After the petri dishes were prepared, the samples were incubated at 35^0 C for 24 hours. After 24 hours the samples were removed from the incubator and the colonies immediately counted. Blue colonies indicated *E.coli*, while the sum of red and blue colonies indicated total coliforms. Two blank samples were processed with each sampling group for quality control. All ten blank samples that were analysed had 0 cfu/100mL.

Turbidity was measured using a Hach 2100P portable turbidimeter. The flow rate was measured at the very beginning of the filter run by timing how many seconds were required to fill a 500mL container.

The scope of this study was only the impact of a period of dormancy in the filters, and did not include the issue of having the biolayer dry out. Honduras has a very humid climate, and all of the filters in this study retained a water layer above the sand surface during the entire period of dormancy.

Results

The pH of the source water in this study sample water was similar for all of the schools, being close to neutral but slightly acidic, with an average of 6.6 and a range of 6.2 to 6.8. The filtered water all showed an increase in pH, as has been noted elsewhere to occur (Young-Rojanschi and Madramootoo, 2014), ranging from 0.4 to 1.6, with an average pH increase of 1.1.

The results for *E.coli* removal (Table 1) were limited in that most of the filtered samples did not have any *E.coli* colonies (recorded below as < 1 cfu/100mL). This is encouraging from a project implementation point-of-view, but adds a level of statistical difficulty in that it prevents the calculation of average *E.coli* concentrations and removal rates. Instead, Table 1 presents median and interquartile (25th and 75th percentile) values. The 25th and 75th percentile values are those shown in parenthesis. The removal rates reported are the maximum removal rate that could be calculated given the source concentration. The actual removal rate would be somewhere between that value and 100%. The results must be interpreted with caution because of this, as low removal rates may be indicative of low source *E.coli*, not low treatment efficacy. For example, it occurred several times that the source and filtered water each had no detectable *E. coli*, resulting in an apparent removal rate of 0%.

Table 1. E.coli

Sample visit	**Median *E.coli* cfu/100 mL (25th and 75th percentile)**		**Median percent removal (25th and 75th percentile)**
	From source	**From filter**	
Sample 1	41 (20, 65)	< 1 (<1, <1)	> 97% (> 93%, > 98%)
Sample 2	9 (3, 18)	< 1 (<1, 2)	> 80% (> 25%, > 98%)
2 month period of dormancy			
Sample 3	13 (8, 15)	< 1 (<1, <1)	> 92% (> 68%, > 93%)
Sample 4	40 (3, 205)	< 1 (<1, <1)	> 98% (> 68%, > 99.5%)
Sample 5	30 (9, 42)	<1 (<1, 1)	> 93% (> 69%, > 97%)

After the first sampling round showed the limitation of too little *E.coli* for calculating removal rates, total coliforms were added to the analysis (Table 2). As with *E.coli*, many of the samples from the filters had no observable colonies, and so it was not appropriate to calculate averages. In addition, the data was not normally distributed, making averages deceiving even when they could be calculated. Medians and interquartile ranges are reported instead.

Table 2. Total coliforms

Sample Visit	Median *total coliforms* cfu/100 mL (25th and 75th percentile)		Median percent removal (25th and 75th percentile)
	From source	From filter	
Sample 1	n/a	n/a	n/a
Sample 2	63 (55, 210)	2 (<1, 11)	97% (> 90%, 98%)
2 month period of dormancy			
Sample 3	76 (29, 116)	< 1 (< 1, < 1)	> 98% (> 96%, 99%)
Sample 4	240 (130, 1160)	4 (2, 9)	95% (91%, 99%)
Sample 5	65 (51, 90)	7 (4, 10)	81%, (89%, 92%)

The bacterial removal rates before and after the school holidays were comparable. As very few filtered samples detected any *E.coli* at all, the two-week long re-ripening period appears to have been sufficient and the filters appeared to be functioning adequately with no need for a reinstallation. This is encouraging, as teachers typically return to the schools several weeks before the students do and would be able to manage this period.

The turbidity of the filtered water was higher after the dormant period as compared to before (Table 3). This could be an indicator of short-circuit flow paths having developed within the filter media, however, the results of bacteria tests (Table 1, Table 2), show that this does not appear to have occurred. Thus the increase in filtered water turbidity may be due to sloughing off of biofilms within the filter which had died during the dormant period. The majority of filtered water samples in this study had quite low turbidity, and all samples remained below the WHO guideline of 5 NTU, so the difference noted here did not raise concern.

Table 3. Turbidity

Sample Visit	Median turbidity (NTU) (25th and 75th percentile)		Median percent removal (25th and 75th percentile)
	From source	From filter	
Sample 1	2.1 (0.4, 2.7)	0.2 (0.2, 0.2)	89% (71%, 92%)
Sample 2	3.5 (1.5, 6.7)	0.5 (0.3, 0.6)	81% (65%, 91%)
2 month period of dormancy			
Sample 3	2.1 (1.2, 3.5)	0.7 (0.6, 1.1)	69% (34%, 77%)
Sample 4	2.1 (1.6, 2.7)	1.0 (0.6, 1.1)	48% (-5%, 84%)
Sample 5	1.5 (0.5, 2.1)	0.6 (0.4, 1.0)	57% (-2%, 78%)

Conclusions

The eight BSFs in this study performed well in the schools after being directly re-ripened for two weeks, without a reinstallation, indicating that the BSF is a feasible technology for schools in rural Honduras.

To complement this work, PWW Haiti is presently undertaking a study to examine some additional questions:

- How long before the end of school holidays do we need to start the filter to ensure that students receive safe water? In other words, how long does re-ripening take after restarting a filter which has been dormant?
- Is it still possible to restart a filter without reinstallation if the biolayer has dried out?
- What if the dormancy period is longer (e.g. six months instead of two or three months)?
- Do restarted filters ripen faster than new filters? Once they have been restarted are they able to reach the same performance levels as new filters?

Further research relating to BSFs in schools would be beneficial, including:

- Is a re-ripening period necessary after shorter school holidays (i.e. one or two weeks)? How long a period of dormancy can the biosand filter withstand before re-ripening is necessary?
- What is the impact on filter performance of the filters not being operated over weekends?
- Do filters which have undergone a period of dormancy have special concerns regarding nitrates and nitrites, due to the higher level of decaying organic matter inside the filter (namely the microbes which died during the dormant period) and extended anaerobic conditions in the filter?

PWW and CAWST hope that this research will assist other water project implementers in making decisions about BSFs in schools, as well as BSFs in households which have undergone a period of dormancy.

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References

CAWST (2012) *Biosand Filter Manual*. Centre for Affordable Water and Sanitation Technology. Calgary, AB

Hach (2012) *Method 10029 Coliforms – Total and E.coli.* Hach Company. U.S.A.

Ngai, T., Baker, D. and Coff, B. (2014) *Recent advances in household biosand filter design*. Presented at the 37th WEDC International Conference, Hanoi, Vietnam: WEDC.

Young-Rojanschi, C. and Madramootoo, C. (2014) *Comparing the performance of biosand filters operated with multiday residence periods.* Journal of Water Supply: Research and Technology. Available online 16 August 2014. DOI:10.2166/aqua.2014.027

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