Biosand Filter Performance After Periodic Abandonment in Honduran Schools

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PURPOSE

The purpose of this field study was to determine the VIABILITY and PERFORMANCE of the biosand filter on a school schedule with intermittent use.

INTRODUCTION

BIOSAND FILTERS

- One of the most effective water filtration systems for rural areas in developing countries is the biosand filter (BSF)[1]. The filters have been widely tested and accepted for daily household use by removing pathogens through mechanical trapping and activity of the biolayer, a diverse microbial community on the upper layer of sand that takes up to 30 days to establish[2]. The biolayer can be disrupted by cleaning or by inactivity.

http://www.clean-water-for-laymen.com/household-water-filter.html

BIOSAND FILTERS IN SCHOOLS

- BSFs have not been widely implemented in rural schools, where school breaks and weekends are longer than the BSF recommended pause periods of 1-72 hours[3].

IMPLEMENTATION

- Pure Water for the World (PWW) partners with communities to develop safe water solutions for communities in Haiti and Honduras.

- In 2014, PWW began pilot testing the use of BSFs in schools in the Trojes, Honduras region to develop best practices for WASH education and hygiene[4].

WASH Education and Hygiene in Schools in Honduras

Piped water systems with source water cisterns

Latrines and hand-washing stations

BSFs

Safe water storage containers

RESEARCH METHODS

Overall Study Design

- 45 schools with BSFs installed between 2014-2017
- 35 schools sampled in July 2016 and July 2017; 10 schools installed in 2017 and tested in July 2017. Filters were not used during the coffee harvest break from December to February; samples collected during the rainy season.

Water Quality Testing of Source and Filtrate to Evaluate Effectiveness

- Microbial samples were collected from the source and BSF effluent at all schools.
- Microbial samples also collected from the safe water storage containers at 12 schools installed in 2014.
- All samples were analyzed within six hours for total coliforms and *E. coli* using IDEXX Colilert Quanti-Tray/2000 and quantification methods based on the Standard Methods' Most Probable Number (MPN).
- Chemical measurements for turbidity, pH, temperature and conductivity were taken with a Hach portable 2000P turbidity meter and a LabQuest portable meter and probes.

Teacher Surveys to Identify Filter Use and Problems

- Acceptability questions (problems with filter, filter use, number of times used per day, sand removal/agitation and water access challenges)

RESULTS – WATER QUALTIY TESTING AND SURVEYS

Water Quality Summary in 45 Schools

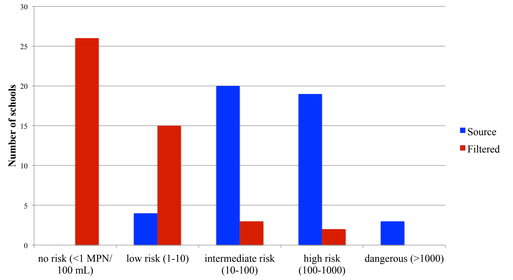
	2016 (35 schools)			2017 (45 schools)		
	Source	Filtered	Percent reduction	Source	Filtered	Percent reduction
E. coli **(MPN/100 mL)**	326.4	6.5	98	280	7.9	97
Total coliforms (MPN/100 mL)	7159.6	326.5	97	10807	477.0	96
Turbidity (NTU)	3.9	1.4	64	3.74	1.33	64
Conductivity (µS/cm)	67.0	161.0		89.0	143.8	
pH	8.0	7.4		7.24	7.13	
Flow rate (s/500 mL)		122.5			221	
Sand depth (cm)		5.0			6.0	

- BSFs demonstrated a mean reduction of 98% for *E. coli,* 97% for total coliforms and 64 % for turbidity.
- Mean flow rate was significantly lower ($p < 0.01$) in 2017 (221 s/ 500 mL) compared to 2016 (123 s/500 mL).

BSF Filter Use - Teacher Survey

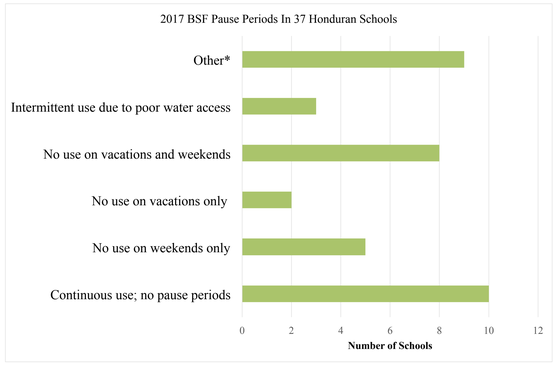
		2016		2017	
Questions		n*	%	n*	%
Problems with filter	yes	7	23	6	17
	no	24	77	29	83
Filter use	daily	29	94	28	85
	every other	1	3	1	3
	2 or more days	1	3	4	12
Number of times used/day	once	21	70	19	58
	twice	9	30	14	42
Sand removal/ Agitation	yes (slow flow)	4	13	9	26
	no	27	87	26	74
Short-term water access challenges	yes	--	--	12	32
	no	--	--	23	68

WHO Disease Risk Categories of Source and BSF Effluent for *E. coli* (n=43)



- Geometric mean *E. coli* in the source water was 326.4 MPN/100 mL, considered a "high" risk category by WHO guidelines, while the filtered water fell within the "low" risk category (6.5 MPN/100 mL).

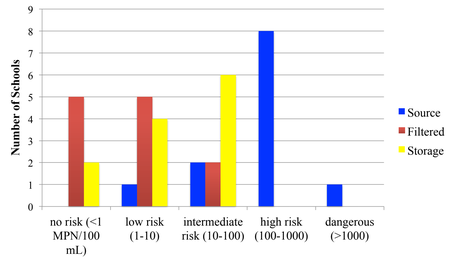
Treatment of Filters During School Breaks and Vacations



*Other treatments of the filter include: pause period on Saturdays not Sundays, water poured through filter 2 times each month during break; every other day over breaks and weekends; water poured through on Saturday but not Sunday, every other day over breaks; and 2 of the filters have been left for 2 or more months due to lack of water access.

RESULTS – SAFE WATER STORAGE

WHO disease risk categories for safe water storage containers (n = 12)



- Mean BSF effluent in 12 schools was 413.8 total coliforms MPN/100 mL and 6.0 *E.coli* MPN/100 mL after filtration.
- Contamination levels increased to 1151.9 total coliforms / 100 mL and 15.6 E. col MPN/100 mL in the safe water storage buckets.

CONCLUSIONS

- *Source water* in 42 out of the 45 schools contained contamination in the "*intermediate*", "*high*", or "*dangerous*" risk categories.
- *Filtered water* in *all but five* of the schools fell within the "*no*" or "*low*" risk categories.
- Teacher education and a high turnover with teachers in the regional schools is a key factor in sustainable clean drinking water in the schools. 94% of teachers interviewed use their filters daily.
- Short-Term water access challenges reported in 12 of 37 schools in 2017 (32%). Similarly, 73% of schools report pause periods in the filter use of a few days to a few months.
- Filters consistently demonstrated a high level of performance with a 98% reduction of *E. coli* and a 97% reduction of total coliforms and continued to perform after 1 - 3 years of use on a school schedule, suggesting that filters are being successfully reactivated after pause periods.
- *Safe water storage solutions* are needed due to recontamination of the storage bucket and residual contamination from intermittent use of the filters.
- BSFs are a viable solution for providing clean water to schools in the Trojes region of Honduras.

FUTURE WORK

- PWW is currently piloting the use of silver nanoparticle technology (AgNP) to eliminate residual contamination in the safe water storage containers. A follow-up study in 2018 is planned.

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