Assessment on the Performance of Biosand Filters Built with River Sand and Quarry Sand

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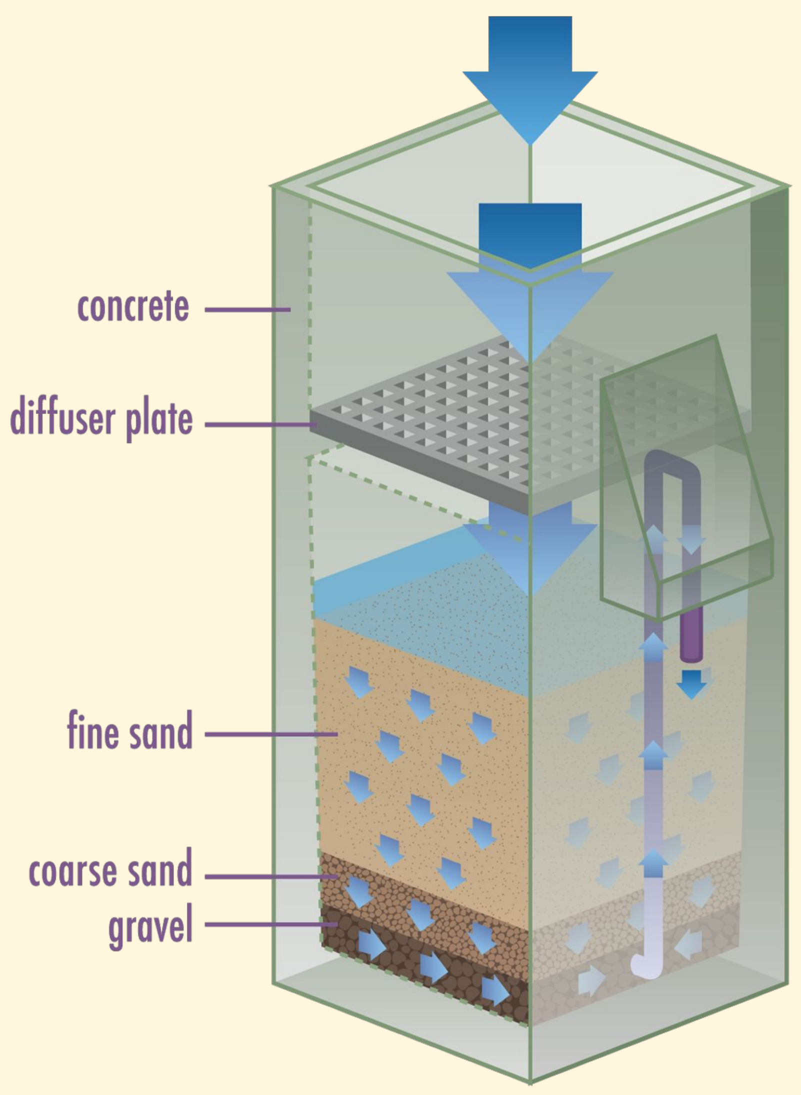
INTRODUCTION

In developing countries, where water treatment infrastructure is often nonexistent and access to safe drinking water is limited, the use of **biosand filters (BSFs)** as a point-of-use water treatment system is a potential solution.[1] BSF treatment technology has been implemented in over 55 countries worldwide, providing access to clean drinking water in rural communities. The **Center for Affordable Water Sanitation and Technology (CAWST)** has recommended standards for the proper construction of BSFs. Crushed rock or quarry sand is recommended for use as a filtration medium in the construction of BSFs; however, BSFs are often made using river sand, which is readily accessible in rural communities. Currently, the use of on-site material for building BSFs is discouraged because of potential risk of contamination from pathogens and organic matter. Nonetheless, many BSFs are still filled with river sand because it is what is most available.

How does a BSF work?



Using concrete and sand, these biosand water filters remove impurities and provide water for drinking and cooking.

Figure 1. Schematic of a typical BSF.

RESEARCH GOALS

The aims of this research project are as follows:

(1) to determine whether river sand is a comparable and adequate substitute for quarry sand in BSFs.

(2) to quantify the effectiveness of each filter through removal efficiency of turbidity and *Escherichia coli* (*E. coli*).

EXPERIMENTAL SETUP

The initial stage of the project consisted of constructing four scaled-down versions (5-gallon buckets) of the standard v10 BSFs constructed according to CAWST guidelines. Two BSF controls were constructed with quarry sand, a recommended filtration sand by CAWST standards. The remaining two BSFs were constructed using river sand to test for turbidity and *E. coli* removal efficiency.

The following was assessed :

- proper sand and gravel grain size distributions
- adequate filter flow rates (hydraulic loading rates) were measured according to the protocol outlined in CAWST's Biosand Filter Manual from September 2009
- turbidity and *E.coli* removal

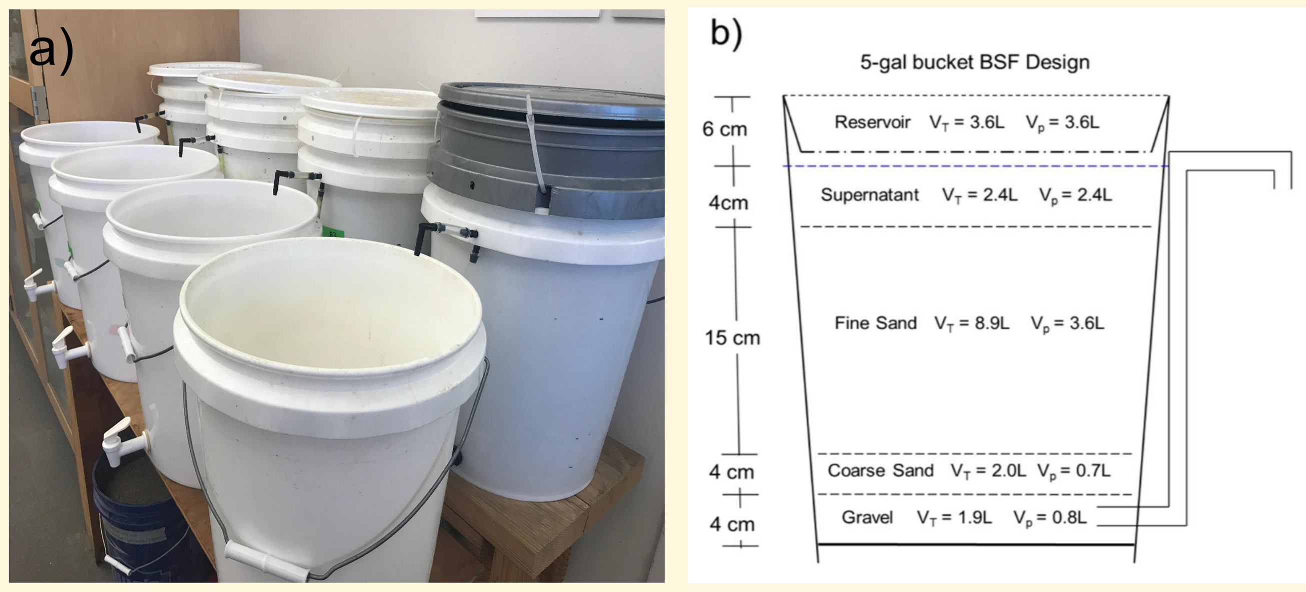


Figure 2. (a) photograph of the BSF setup.
(b) 5 gallon bucket design created in collaboration with CAWST.

RESULTS & DISCUSSION

Turbidity Removal Capacity

One of the key components of BSF effectiveness is the reduction in turbidity. For the purpose of our study, we compared percent removal between the two quarry sand filters and the two river sand filters. The results of the ~6 weeks are shown in the top right.

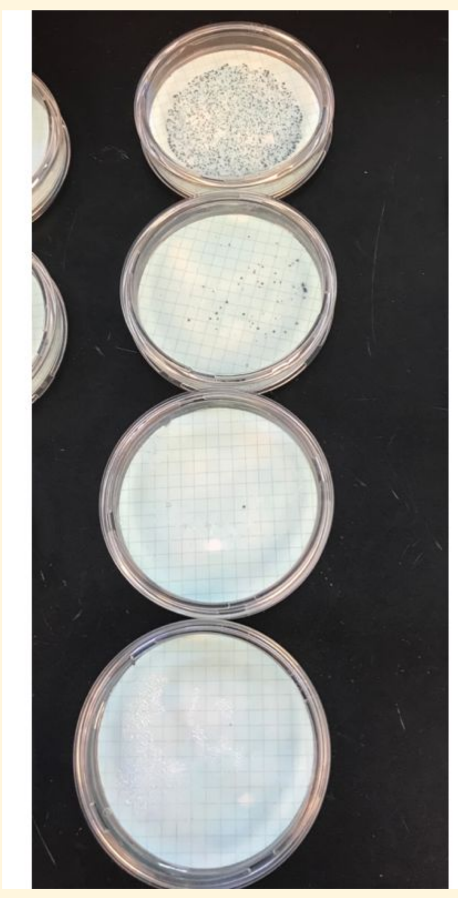


Table 1. example of *E. coli* culture count inconsistency

	Dilutions			
	10^-1	10^-2	10^-3	10^-4
B1	2	0	0	0
B2	0	15	0	0
B3	5	1	0	1
B4	TNTC	66	1	1

Figure 3: *E. Coli* plate count at four different dilution levels. Top is least diluted.

RESULTS & DISCUSSION

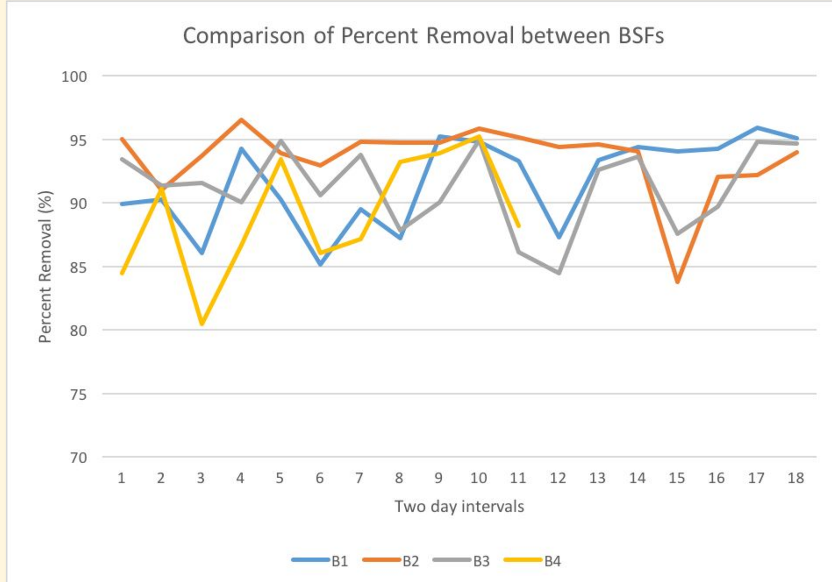


Figure 4. Percent Turbidity Removal

Figure 4 represents the comparison of turbidity reduction expressed as percent removal. No value is below 80%. The trend shows little difference between quarry and river sand in the given time period.

CHALLENGES

The research conducted this summer contained many setbacks with design issues and equipment malfunctions. A list of challenges is provided:

- Difficulty obtaining the correct grain size distribution with the volume required of a 10-gallon filter
- Broth used to grow *E. coli* was determined to be contaminated
- PVC tubing for Filter B4 (river sand) failed, which required a redesign and complete restart in developing the biolayer
- Petri dishes grew *E. coli* cultures inconsistently.

CONCLUSIONS AND FUTURE OUTLOOK

Due to issues concerning the *E. coli* culture counts, assumed to be due in part to faulty petri dishes, the research will be continued during the fall semester. However, valuable data was collected on optimal grain size distributions, filter flow rates, and the turbidity removal capacity.

In addition, we will incorporate the usage of chlorine following the BSF process for multi-barrier water treatment. We are interested to see if sand type impacts the dose of chlorine required for effective disinfection or the formation of disinfection byproducts.

REFERENCES

1. Sisson, J., Wampler, P., Rediske, R., Molla, A. (2013). "An assessment of long-term biosand filter use and sustainability in the Artibonite Valley near Deschapelles, Haiti." Journal of Water, Sanitation, and Hygiene for Development, 3(1), 51-60.

2. Center for Affordable Water Sanitation and Technology (CAWST). 2012. "Biosand Filter Construction Manual."

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