Revitalization of Abandoned Biosand Filters

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Abstract

Although biosand filters (BSFs) have been implemented in over 55 countries to provide safe drinking water, the necessity of operating filters on a daily basis has raised questions about filter efficacy after a period of abandonment (e.g., due to travels away from home, or school vacations when students/faculty are not present to use institutional filters every day). An assessment of the effectiveness of revitalized BSFs is being conducted on two full-scale concrete BSFs, two 5-gallon bucket BSFs, and two 2-gallon bucket BSFs that were abandoned for two years. The filters were revitalized by rehydration (as needed), swirl-and-dump sand cleaning, tubing disinfection, and flushing. The performance of the revitalized filters is compared to that of two newly built concrete filters by measuring influent and effluent levels of *Escherichia coli (E.coli)*, *Cryptosporidium parvum (C.parvum)* oocysts, and turbidity. Influent water is collected from a local creek to provide adequate nutrients to support biolayer development and to emulate field use. The influent is spiked biweekly, once with *E. coli* and once with *C. parvum*. The percent reduction of *E. coli* and *C. parvum* by each filter is calculated by testing the two subsequent effluents following each spike. In addition, flow rates of the filters as well as water quality measurements of influent and effluent water (i.e., conductivity, phosphates, ammonia, total nitrogen, total organic carbon) are evaluated weekly. Results of these analyses will also be compared with field studies of filters abandoned in Honduras and Haiti for two month and six month periods, respectively. Presently, the safe recommendation for abandoned filters is to deconstruct and rebuild, which is a cumbersome and time-consuming process that cannot easily be carried out in developing countries. Should rehydration be found an effective method of filter revitalization, it would ensure the continued growth of efficient drinking water treatment systems in developing nations.

Introduction

Biosand Filters (BSFs) are used in many developing countries as a means of drinking water treatment. Although BSFs have successfully been installed and operated in 55+ countries, there is a high rate of abandonment due to the inconvenient stipulation that they be used daily. Currently, the Centre for Affordale Water and Sanitation Technology (CAWST) cites rebuilding as the safe approach to revitalizing a BSF that has been abandoned. However, this process can be costly and time consuming, and there is no gaurantee that the BSF will remain in use. An assessment of the effectiveness of revitalized BSFs is being conducted on two full-scale concrete BSFs, two 5-gallon bucket BSFs, and two 2-gallon bucket BSFs that were abandoned for two years. The objective of this project is to determine whether or not abandoned BSFs, once revitalized, are as effective as newly built filters.

Methods

Rebuild two full size control BSFs (C1, C4) according to CAWST guidelines

Revitalize test BSFs
- Rehydrate (C1, C4, A1, A4)
- Disinfect tubing (all)
- Swirl and dump (all)

Spike BSFs with *C. parvum* and process influent (IMS-IFA)
Test flow rates
Test water quality parameters of influent and effluent

Process effluent 2 for *C. parvum* oocysts (IFA)

Spike BSFs with target of 10^6 CFU/100 mL *E. coli* and process influent (membrane filtration)
Process effluent 3 for *C. parvum* oocysts (IFA)

Process effluent 4 for *E. coli* concentrations (membrane filtration)

Process effluent 5 for *E. coli* concentrations (membrane filtration)

Adjust creek water influent turbidity to ~20 NTU and measure effluent turbidity

Flush twice with unspiked creek water

Results

Turbidity

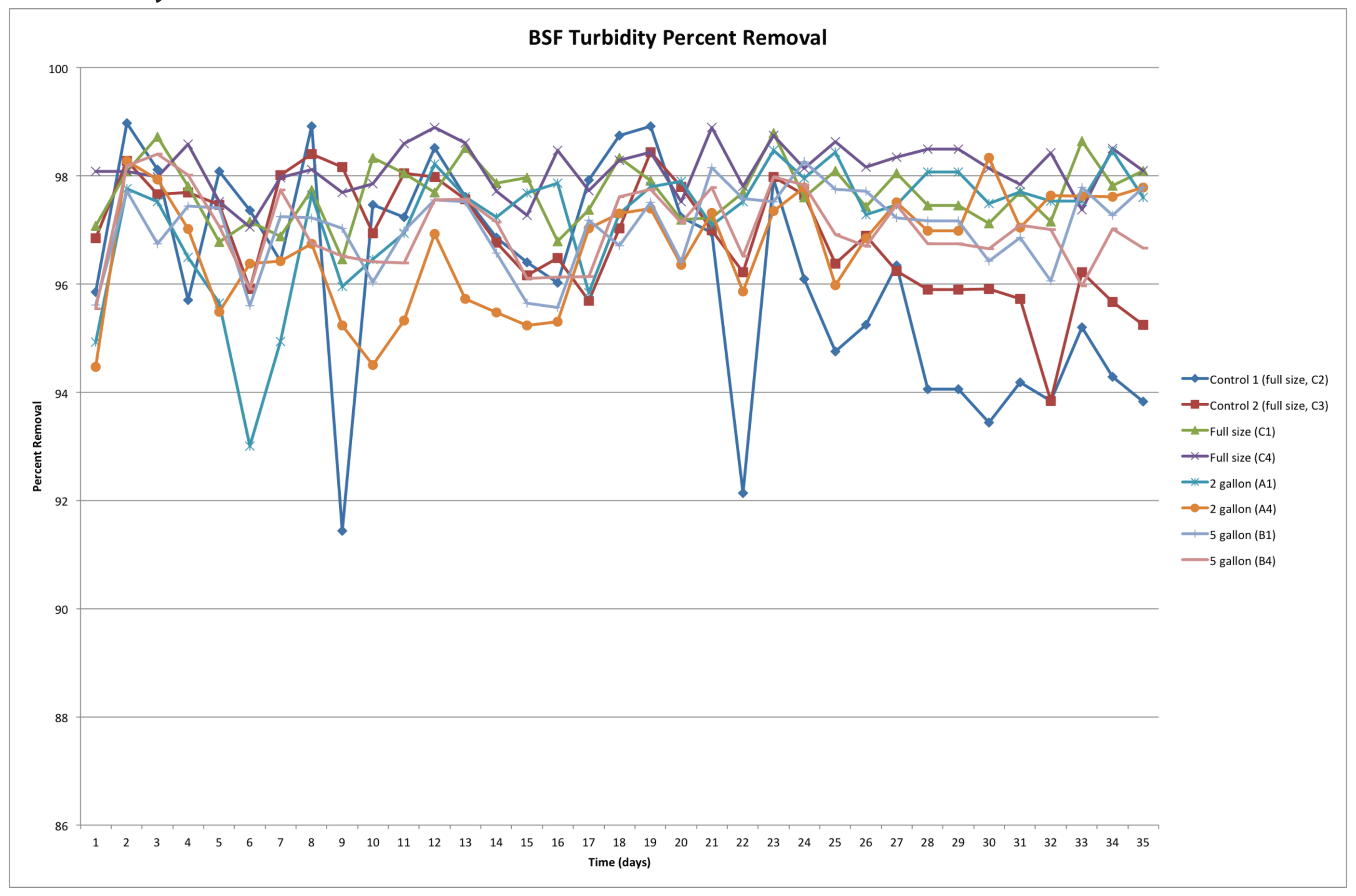

Figure 1. Percent removal of turbdity by each BSF

Escherichia coli

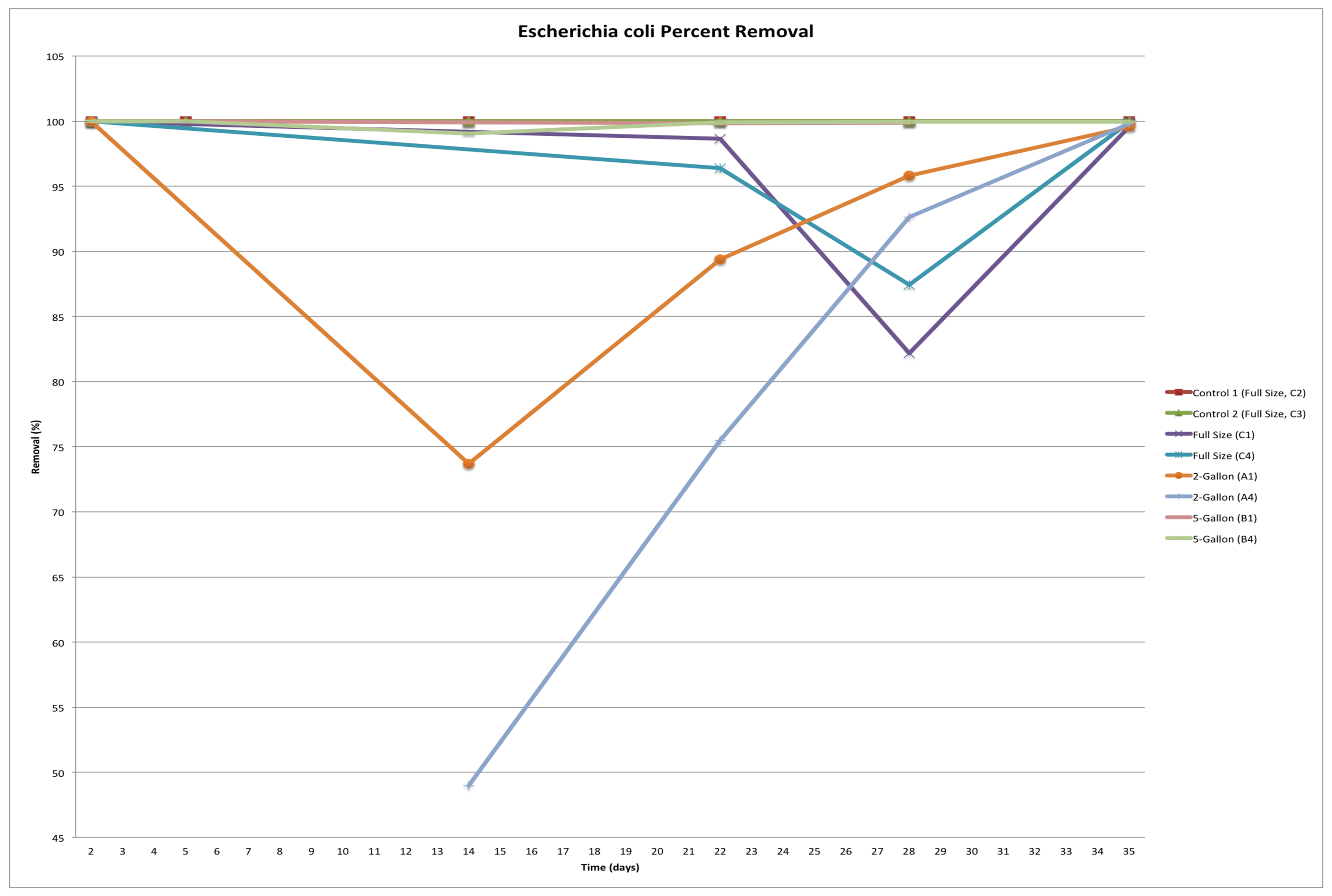

Figure 2. Percent removal of E. coli (CFU) by each BSF

Cryptosporidium parvum
Influent concentrations *C. parvum* were originally set at 10^3 oocysts/100 mL. However, it was found that the IMS beads were unable to pick up more than 250 oocysts in a sample, so the influent concentration was later changed to 500 oocysts/100 mL. For all effluent *C. parvum* analyses, no oocysts were detected.

Data Interpretation

Turbidity
All of the biosand filters were reasonably effective at lowering turbidity. The decreasing turbidity removal of the control BSFs may be attributed to the higher flow rate relative to the size of the filter. Additional data would be required to monitor whether or not the trend persists.

E. coli
Percent removal of *E. coli* was stable for both control and the 5-gallon biosand filters, which exhibited very high reductions. The experimental full size and 2-gallon BSFs were more variable in extracting *E. coli*, particularly in the fourth and fifth spiking weeks. This may be the result of a backlog of resident *E. coli* flushing out of the filters as they reached capacity for retaining *E. coli*. It can be observed that the BSFs that had to be rehydrated exhibit more variable removals than the control filter and the 5-gallon filters, which did not have to be rehydrated; the 5-gallon filters had retained the water left in them two years ago. The *E. coli* removals converged for all eight filters in the last spike shown, which would be after the maturation phase of the BSFs.

Impacts

This research could greatly affect the way people deal with abandoned filters today. Since the current recommendation is to completely rebuild abandoned filters, if this research, compiled with the field studies from Honduras and Haiti, prove to be successful in removing pathogens from the drinking water, it would allow drinking water to be more readily available to communities with biosand filters.

Future Work

-Continue to spike with *E. coli* weekly to determine the removals of each filter over a longer period of time.
-Continue to spike the filters with *C. parvum* to determine threshold removal of *Cryptosporidium* oocysts.

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