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 rerecommendation 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.

Methods

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

Revisit 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)

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)

Flush twice with unsolicited water

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

Spike BSFs with target of 10^3 CFU/100 mL E. coli and process influent (membrane filtration)

Procurement and setup

E. coli Concentration Analysis

Study Design

Figures

Figure 1. Percent removal of turbidity by each BSF

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

Results

Turbidity

E. coli

Cryptosporidium parvum

BSP Turbidity Percent Removal

Escherichia coli Percent Removal

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.

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.

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.

Acknowledgements

This project was funded by the Clare Boothe Luce Research Fellowship and the STEPS & Environmental Initiative Research Fellowship. Special thanks to Jellison lab and George Yasko for providing so much support and assistance throughout this project.