Comparing Water Filter Effectiveness

How effective are different types of water filters at removing bacteria?

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Abstract

Clean water is vital to human health. This experiment compared the effectiveness of three types of water filters: Sawyer brand, ceramic, and biosand. A bacteria-rich mixture was poured through the filters and the bacteria concentration was measured before and after filtration to calculate the percent removal of bacteria. Flow rates were also measured. The Sawyer brand and ceramic filters reliably removed 100% of bacteria while the biosand filters' effectiveness varied based on the type of input water and time allowed for filtering. These filters can be ranked by flow rate from fastest to slowest: Sawyer brand, ceramic, and biosand. Each filter was then given a recommendation for conditions of use.

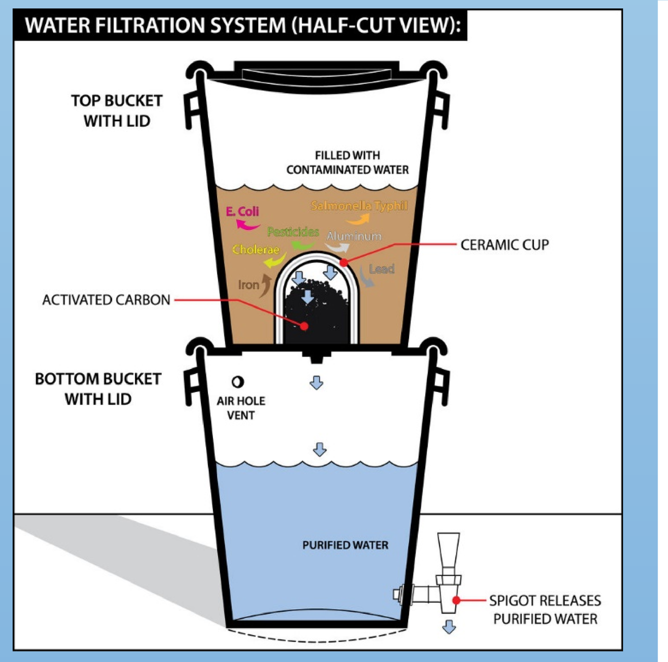
Introduction

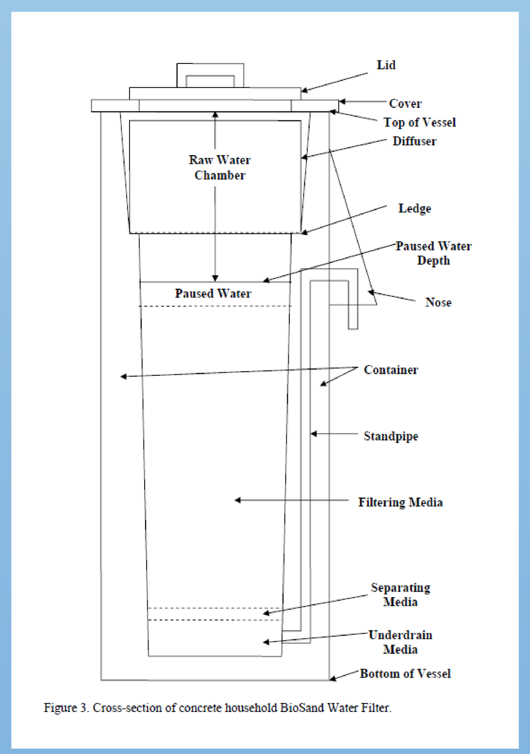
Access to clean drinking water is a worldwide issue. According to the World Health Organization (WHO), 4,500 children die each day due to a water-borne illness. Proper water filtration could have prevented these deaths. Water sources may contain dirt, minerals, poisons, or viruses that must be removed to make the water drinkable. Almost all water sources contain bacteria that must be removed before drinking. Thus, this project focused on the effectiveness of filters to remove bacteria from water. This project tested three common filter types that could easily be implemented worldwide to decontaminate water:

Sawyer brand filter: U-shaped microtubules; mechanical filtration, $55

Ceramic filter: microscopic pores in the ceramic and carbon filling; mechanical filtration, $35

Biosand filter: sand, biofilm; mechanical and biological filtration, ~$65





From left to right: Sawyer filters, ceramic filter, full-scale biosand filter

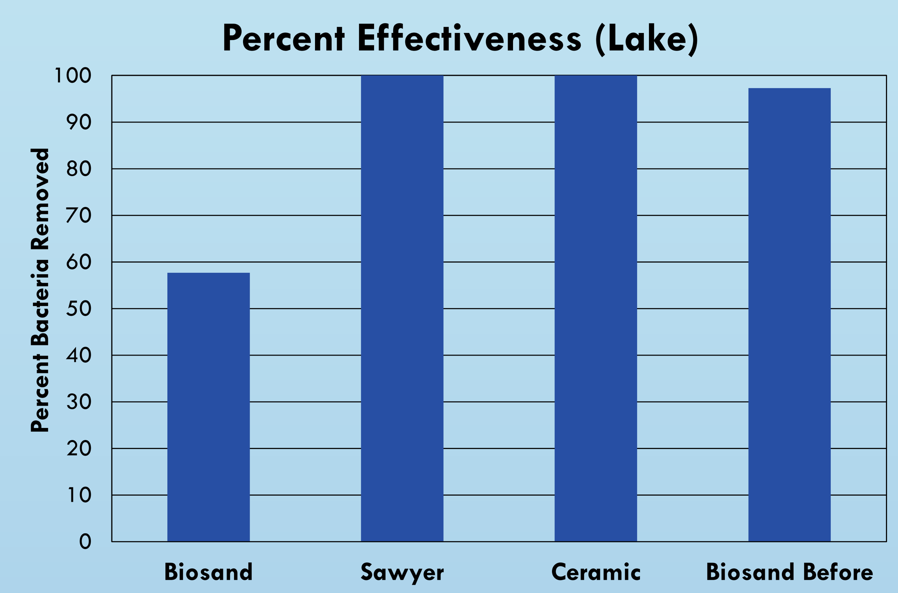
Methodology

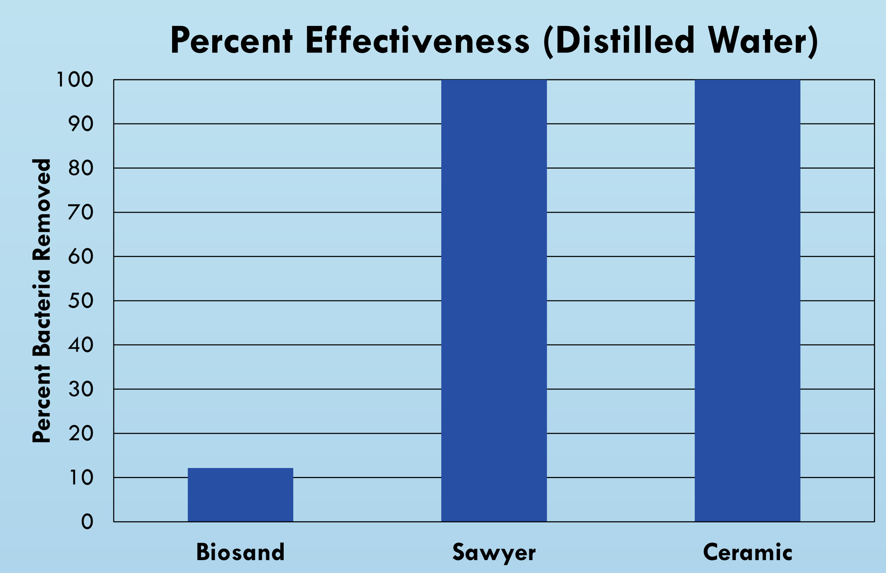
A general outline of the experimental steps:

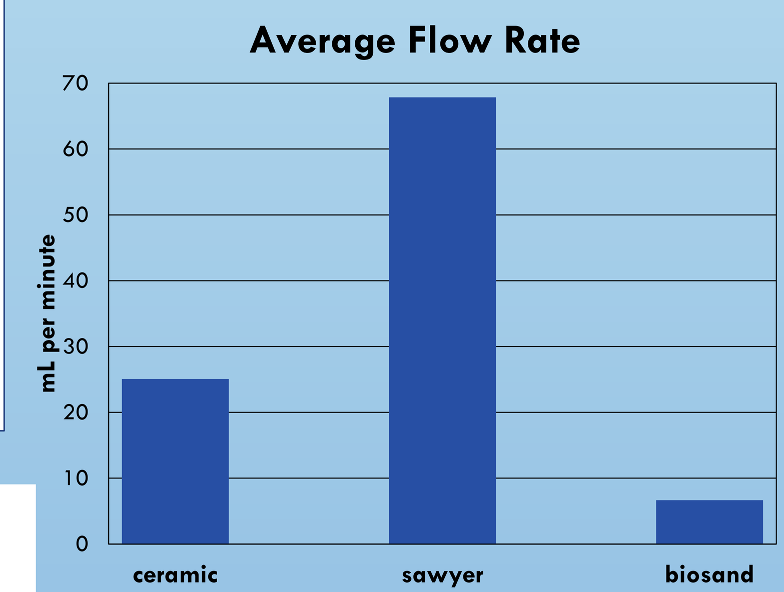
Build biosand filters; install ceramic and sawyer filters in buckets. Feed biosand filters with lake water to grow biofilm. Mix e. coli culture into distilled water (first two trials) or lake water (last three trials) to get an approximate concentration of 1000 bacteria/mL. Pour this mixture into all filters. Take samples of first of mixture, last of mixture, biosand discharge immediately and after 1 L filtered, and the ceramic and Sawyer filters after some liquid has been filtered. Use e. coli count plates to measure bacteria concentration, diluting samples as needed. Measure flow rate of filters.

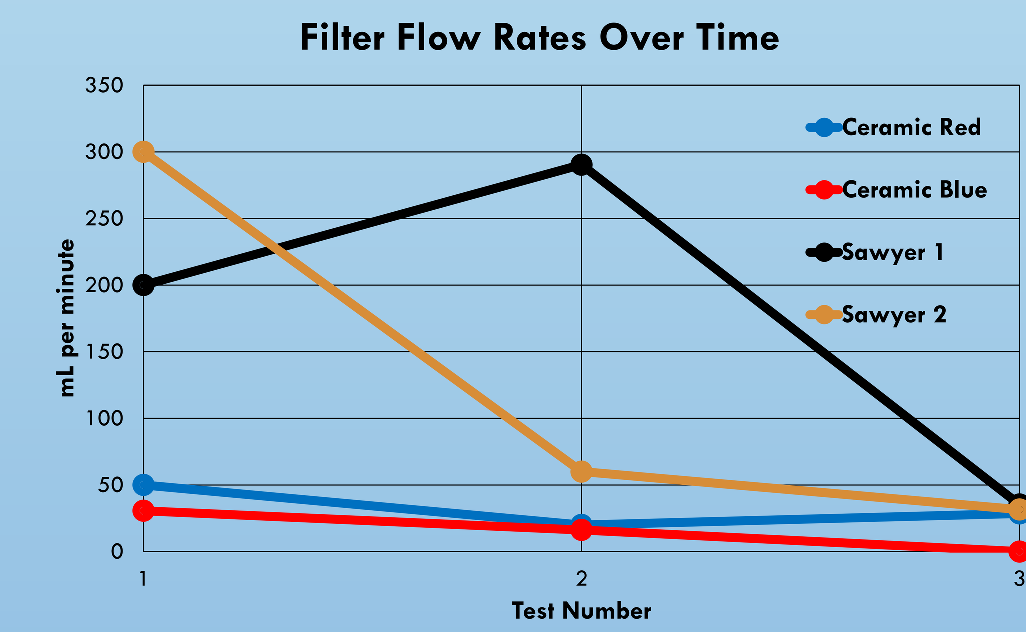
Analysis

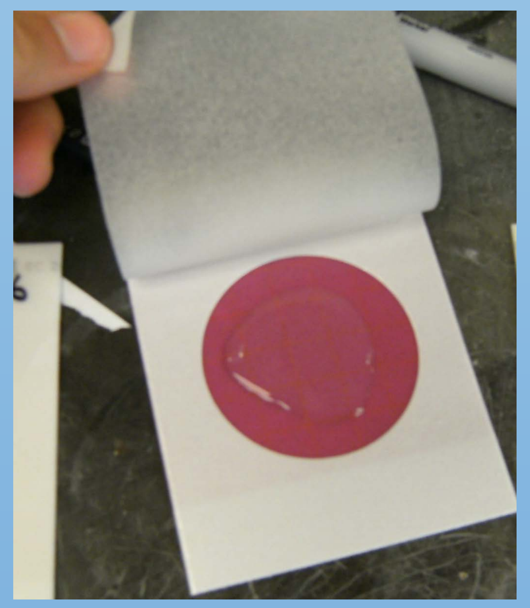
The biosand filters had the lowest effectiveness overall, but improved when tested with lake water (57% bacteria removal) instead of distilled water (21% bacteria removal). They performed even better when allowed to sit stagnant before testing (97% bacteria removal). The ceramic and Sawyer filters were equally effective, each consistently achieving 100% bacteria removal. The Sawyer filters attained the highest flow rates, averaging 69 mL/min while the ceramics were slower (25 mL/min) and the biosand filters were the slowest at 7 mL/min. All filters' flow rates decreased over time.











From left to right: ceramic filter, preparing the count plate, reading the count plate

Experiment Improvements/Next Steps

Improvements: feed biosand filters regularly with lake water before and during testing, build full-scale biosand filters, perform more trials (replication), carry out a wider range of dilutions for biosand filters, use multiple count plates per filter per trial

Next Steps

- Compare flow rates over a long period of time to determine how quickly and severely the filters become clogged. Determine best ways to unclog filters and document regular maintenance required fro each type of filter
- Compare filter effectiveness over a long period of time filtering several liters per day
- Run filters frequently and with large volumes to determine overall durability

Recommendations

Biosand Filters: Must be a long-term investment with a strict maintenance schedule. Good for very turbid water or if large volumes of water need to be filtered at a slow and steady pace. Not suitable if clean water is needed quickly or at irregular intervals. Not portable or ensured to produce extremely clean water.

Sawyer filters: A good option if extremely clean water is needed quickly or for a definite period of time. Very portable and reliable. Easy to use, little maintenance required. Great option for fast, on-demand drinking water.

Ceramic filters: A balance between the biosand filters and the Sawyer filters. Less portable than the Sawyer filters, but also reliably provide extremely clean drinking water. Not a good option if water is needed immediately due to a ten to twenty minute delay between pouring in dirty water and clean water discharging.

From left to right: preparing the bacteria mixture, measuring flow rate, biosand filter setup

Sources of Error

The main errors occurred in the biosand filters. First, it can be concluded from the data that they did not have adequate time to fully develop biofilms. This could be due to not feeding them regularly enough or that the distilled water did not have a high enough carbon content to sustain the biofilm. Also, too much water may have been run through the biosand filters too quickly, thus killing the biofilm. The water levels in filters 2 and 3 accidentally dropped to the sand once each during testing. Number 4 was started late. All biosand filters were downscaled for ease of testing.

Other errors include a slight variation of the bacteria mixture concentration from start to end of each experiment. Additionally, the tubing sat in the filtered water, then touched the sampling test tube. Pipettes were not exactly 1 mL as required for the count plates. Counting was accurate except for the plates designated "too many to count" and mostly accurate when one square was counted and multiplied by twenty to obtain the total count.

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