Removal of Pathogens from Drinking Water with Biosand Filters

Nathan Fulton and Brian Wood Environmental Engineering

Background

Over 1 billion people live without a safe source of drinking water and 1.8 million deaths are caused by diarrhea each year. 35-39% of these deaths could be prevented by improving drinking water. 90% of these deaths are children under 5 years of age. The Biosand Filter, originally designed by Dr. David Manz at the University of Calgary, is a simple, inexpensive, and easy to operate drinking water treatment method which requires minimal maintenance and training.

Both physical & biological removal mechanisms are believed to contribute to the improvement of water quality in Biosand Filtration. However, quantification of mechanism contribution has not been thoroughly studied. Biosand Filters can be used on a small community or household scale, thus are labeled a Point-Of-Use (POU) water treatment technology. Biosand Filters were originally designed for use in low-income communities and households without access to safe drinking water, but have recently been used for larger scale treatment processes.

Filter Bed Construction

Biosand Filters typically consist of three main media layers, including an underdrain, a separation layer, and the filtration media layer. Each layer is added into water to reduce void space, thus preventing preferential flow within the filter bed during use. Figure 1 shows the basic structure of a Biosand Filter.

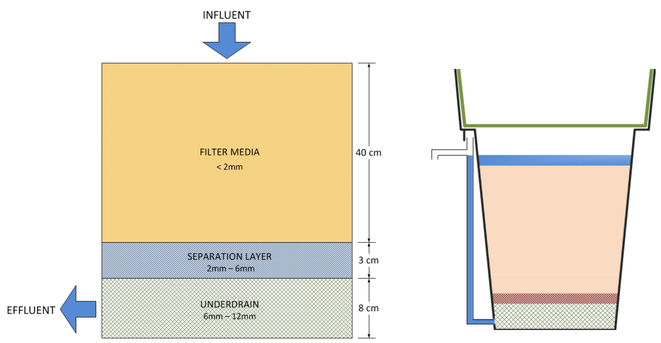

Figure 1: Biosand Filter Structure.

Biosand Filters differ from traditional slow sand filtration due to their intermittent feed, passive oxygen transfer region above the filter surface, periodic surface agitation, lack of harrowing/scraping, and are typically smaller in size. Media is sourced from uncontaminated quarry rock and sorted into the three size ranges established for each layer. The media is hand washed prior to filter bed construction and allowed to dry in a sanitary location. The oxygen transfer region is established by locating the effluent pipe approximately 5cm above the surface of the filter media.

Operation

Biosand Filters have been shown significant removal of parasites, bacteria, viruses, algae, suspended solids, and taste and odor compounds. Arsenic, mercury, lead, oxidized iron, manganese, and hydrogen sulfide has also been removed with Biosand Filters with the help of pre-treatment. Previous studies have repeatedly shown an increase of pathogen removal with maturation time for newly installed filters. Decreasing hydraulic conductivity due to biological growth has also been documented, as shown in Figure 2.

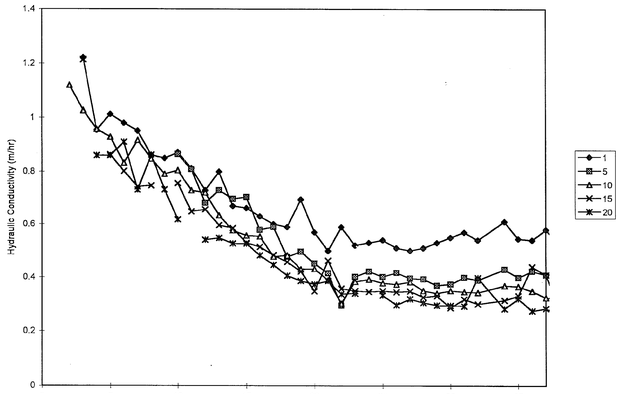

Figure 2: Decreasing hydraulic conductivity with operation time. (Buzunis, 1995)

After the hydraulic conductivity has decreased, the surface of the filter is gently disturbed by hand, being sure to only penetrate the filter bed surface at a maximum of 5mm. The suspension in the headspace is then decanted, and operation can be resumed as normal. Removal of filter media does not occur in this process, thus media replacement is not needed during the filter life (approx. 10+ years). Figure 3 illustrates the agitation process.

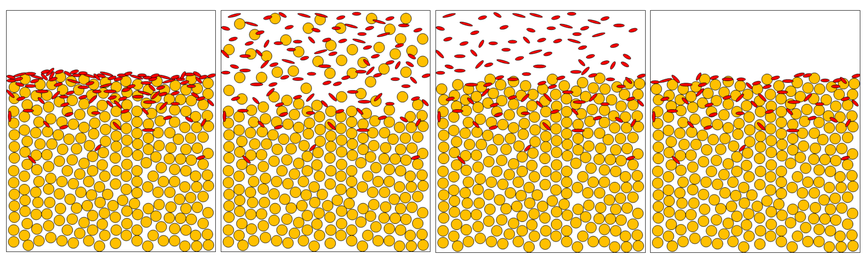

Figure 3: Biosand Filter agitation process.

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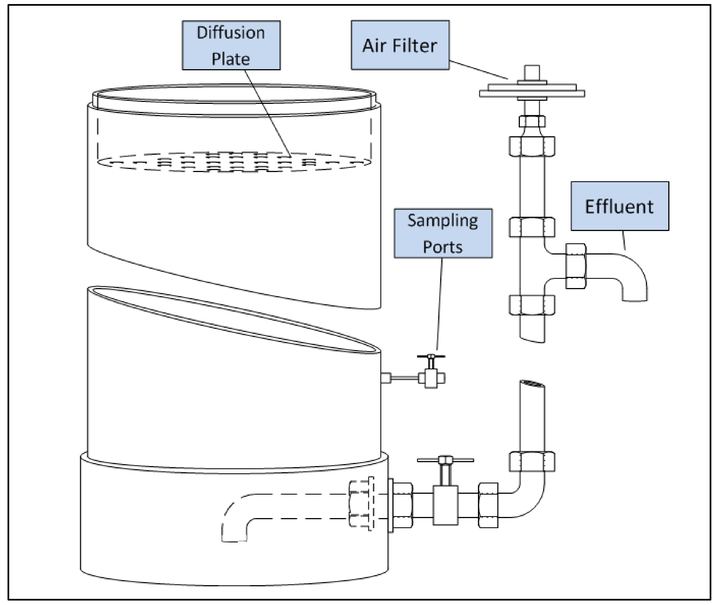
Appropriate Technology

Because of the dominant application of this technology, Biosand Filters are specifically designed such that they are an appropriate technology. This design allows for local BSF production, thus promoting local economy. Little training is needed for construction and operation of Biosand Filters, and minimal maintenance is needed to sustain a filter for a long operating life. Table 1 summarizes the findings of a previous study which compared the most successful means of point-of-use water treatment technologies, indicating that Biosand Filtration is the preferred treatment technology.

technology	quantity	quality	ease of use	cost	supply chain	overall score
free chlorine	3	1	3	3 (liquid) 2(tablets)	1	11 10
coagulation/chlorination	2	3	1	1	1	8
SODIS	1	1	1	3	3	9
ceramic filters	2	3	2	3	2	12
biosand filters	3	3	2	2	3	13

Table 1: Comparison of POU water treatment technologies. (Sobsey et al., 2008)

Column Design



Future Research

- DO & TOC monitoring.
- Vary loading and pause times.
- Pathogen removal monitoring with viruses and bacteria.
- Use of alternative media, including beach and river sand.
- Monitor recovery from catastrophic failure, such as filter dewatering or temperature extremes.