



Biosand Filter - Version 10

Research Leading to New Design

June, 2008

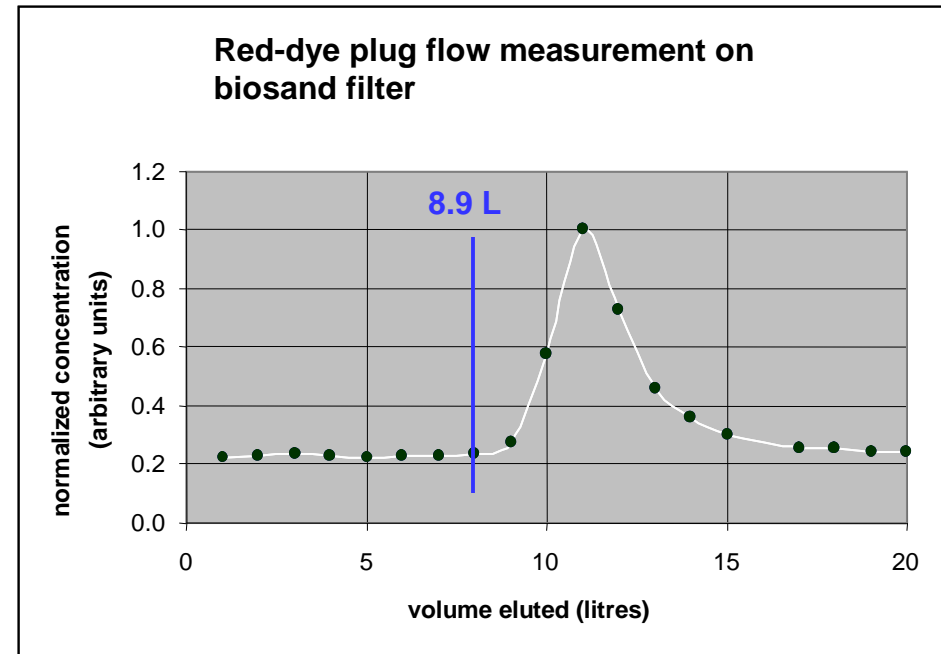
In the current design of the BSF, the reservoir volume is not proportional to pore volume

Current design:

Reservoir volume (V_{RES})
= 18.5 L

Pore volume (V_{POR})
= 8.9 L

In the current design, with each full 'dose' (or 'charge') of water, more than half of the water will pass through the filter without any retention time during the 'pause period'.



Plug-flow and Pore Volume Investigation on Household Biosand Filter

By: Laith Semonian, CAWST, February, 2007

Jill Baumgartner et al

Published in Environmental Research Letters (2007):

Research Question:

Does the biosand filter's bacterial removal effectiveness vary at different "sample collection points" during a single filter run?

Sample Collection Point	Pause Period	Total Coliform Removal
5 litres	12 hours	95.9%
	36 hours	95.7%
10 litres	12 hours	81.0%
	36 hours	78.3%
20 litres	12 hours	79.1%
	36 hours	73.7%

Conclusion: *"We observed a decreasing trend in total coliform removal by sample collection volume with the highest removal efficacy at the 5 litre sample collection point (versus at the 10 and 20 litre collection points)...In the short term, filter implementers might consider advising households to either filter just the water volume held in the influent reservoir (approximately 5 litre) or separately collect the initial 5 litre of filtrate for consumption and use the remaining filtered water for other household needs."*

Mark Elliot et al

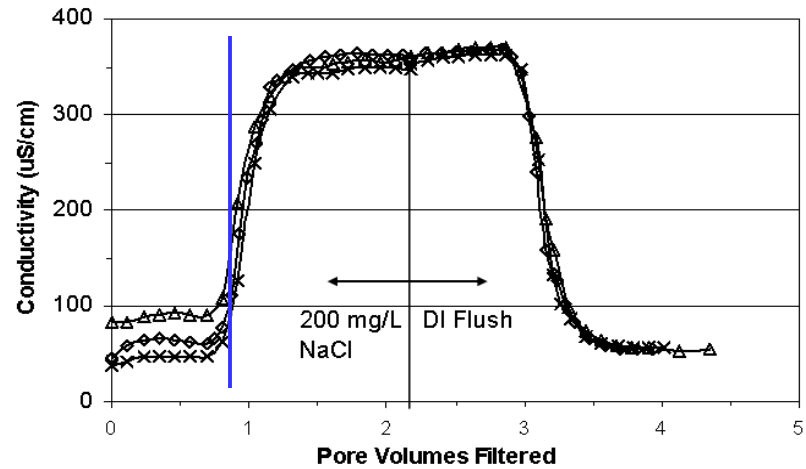
Accepted by *Water Research* in Jan. 2008:

Research Objective: “to gain insight into the key design and operational parameters that affect filter performance”

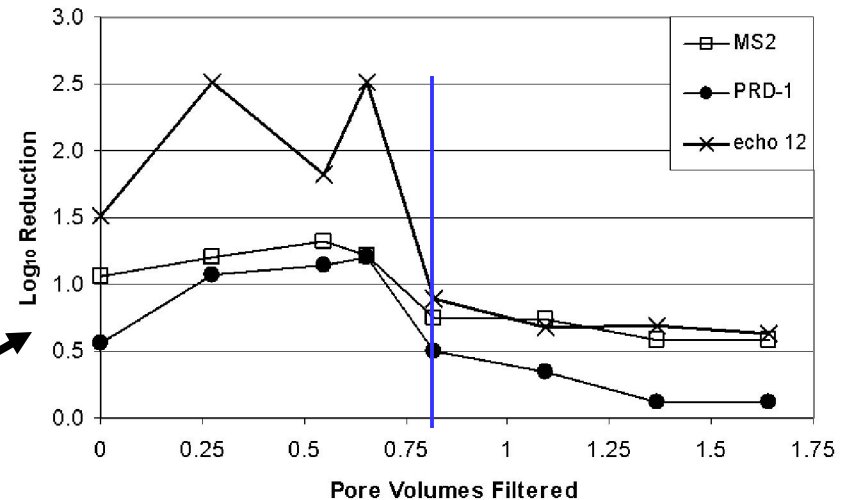
Conclusions:

- “BSF performance was best when less than one pore volume...was charged to the filter per day.”

Reductions in concentrations for three viruses with pore volumes filtered



Tracer Test on Plastic BSF

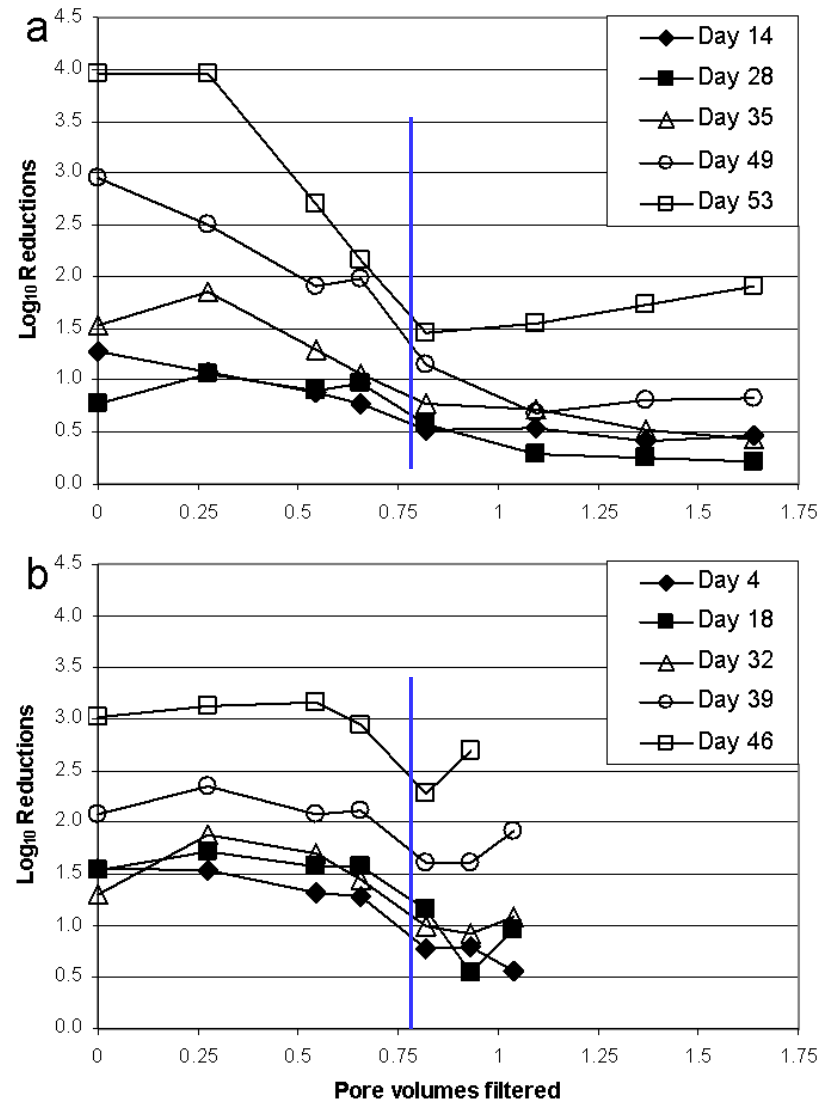


Mark Elliot et al in *Water Research* (2008)

Conclusions continued:

- “The results from these microbial challenge studies indicate that reductions could be increased by increasing the retention time of water in the filter”
- “...this has important implications for filter design and operation.”

Reduction in *E. coli* concentration with pore volumes filtered.



Tiwari, Jenkins and Darby, U. of Cal, Davis

...Factors Affecting Bacterial, Virus, and Turbidity Removal

Key Findings and Research Recommendations:

- The best design and operating combination; 0.17 mm fine sand, 10 cm head and long retention time, produced significantly better removal on all outcomes than the worst combination of 0.52 mm coarse sand, 30 cm head and short retention time
- Retention time has proven to be critically important for achieving higher ISSF performance.

Question: Why design Version 10 of the biosand filter?

Answer: To improve removal effectiveness.

Summary: Laboratory studies have shown that the portion of water that remained in the filter during the pause period, has much better E. coli and virus removal compared to the water that had no residence time during the pause period.

Conclusion: The removal effectiveness would be significantly better if all of the water from the previous dose is retained in the filter during the pause period.

Design objective:

Reservoir Volume (V_{RES}) =
Pore Volume (V_{POR})

Why is the Pause Period beneficial?

Principals of Removal:

Contact with sand grains:

First, the particles in the water, including microbes such as bacteria and virus, must contact (or collide with) the surface of the sand grains.

Attachment:

Second, the particles must attach to the sand media and biofilm where they can be metabolized by the micro-organisms (predation) or deactivate through natural die-off.

“Unless attachment occurs, there is no removal.”

- Manual of Design for Slow Sand Filtration, 1991, AWWA

In the filter sand media of the biosand filter, there are millions/ billions of pores or tiny ‘sedimentation cells’. The pause period allows the microbes more time to contact the sand grains and become attached.

Note that rapid water velocity, even for a short period of time, can scour the media and cause these particles to dislodge → **slower is better**.

Options for Version 10

1. Make the filter smaller (shorter)

- Reduce the size of the reservoir to match the pore volume of the filter media (including underdrain media)(8.9 L).

2(a). Make the filter larger (wider)

- Increase the pore volume of the filter media to match the volume of the reservoir (18.5 L).

2(b). Make the filter larger (wider)

- Increase the pore volume of the filter media to 15 L, while reducing the volume of the reservoir (15 L).

3. Same size – (change proportions) Decision; June, 2008

- Keep the filter the same size, but change the proportions so that the reservoir volume matches the pore volume (12 L).

Notes on Version 10

1. The maximum height of the filter has been kept at 91.5 cm (36”) equivalent to the height of the kitchen sink in most N. American homes – higher than this would make the filter too difficult to fill.
2. All options will result in lower initial flow rate (other things being equal) due to the reduced height of the reservoir (less head pressure). This is required to achieve: $V_{RES} = V_{POR}$.
3. All other dimensions remain the same as the current design (concrete thickness, etc.).