Centre for Affordable Water and Sanitation Technology

Operating Parameters for the Biosand Filter

CAWST Learning Exchange

June 2012

OUTLINE

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2. Source water
   - What kind of water can you use in the filter?
3. Ripening time
   - When is the filter fully effective?
4. Flow rate
   - Why does it matter?
5. Pause period
   - How long is enough?
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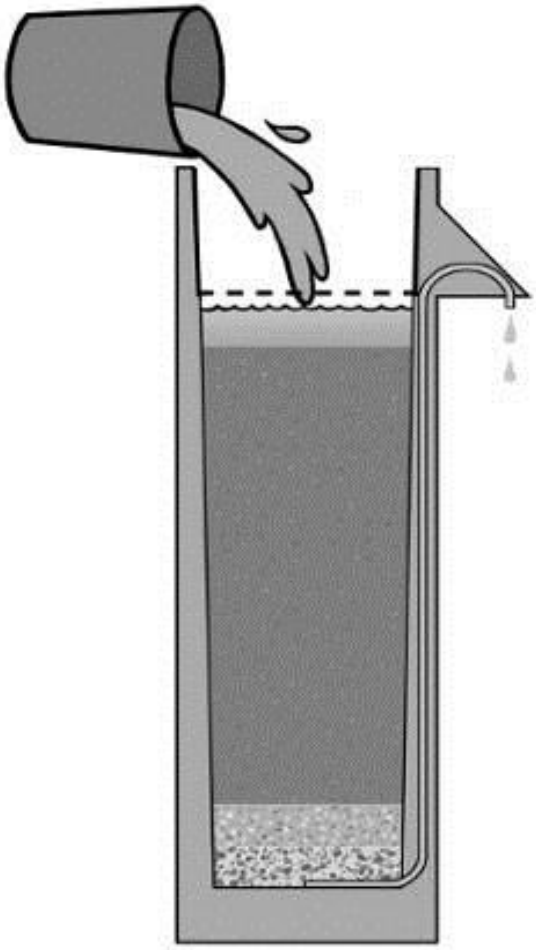


Filter mechanisms: How does the filter work?

1. Physical straining
   - mechanically trapped by the pore spaces in the sand
2. Adsorption / attachment
   - sticking to the sides of the sand grains
3. Predation
   - an ecological system sustained by nutrients and oxygen
4. Natural die-off
   - unfavourable conditions for continued life
   - Inactivation/ non-viable/ non-reproductive

Source water:
What kind of water can you use in the filter?

1. Use the best water source available:
   - Surface water is most common but often most biologically contaminated
   - Deep borehole water may lack oxygen and nutrients (to develop biolayer)
   - Rainwater may lack nutrients
2. Should not contain high turbidity
   - <50 NTU – roughly 1 foot visibility
   - Use sedimentation first [otherwise filter maintenance becomes excessive]
3. Should not contain dissolved toxic contaminants
   - fluoride, arsenic and nitrate are the most common toxic contaminants
   - iron and manganese are the most common aesthetic/ taste contaminants
4. Avoid changing water sources frequently
   - It appears the BSF needs time to 'adjust' to a new source

Palmateer, 1997– "*The development of a good biofilm is essential for maximum efficiency... The more biologically productive the waters used to develop the filter biofilm, the quicker and more efficiently the filter operates.*"

Ripening time: When is the filter fully effective?

Ripening time can be defined in many ways but a filter could be considered ripened when the E. coli bacteria removal reaches 90%

Slow Sand Filters

- 2 to 4 weeks running continuously

Nepal (Dipina study of 4 filters)

- 3 weeks

Haiti (Duke, 2006 5 filters)

- within 3 to 4 weeks

Lab study of BSF at UNC (Stauber, 2006):

"Ripening time varies, probably due to influent water quality"

Evidence of 'deep bed maturation' over longer period (i.e. a year) will significantly improve virus removal (Elliot, 2011 and Bradley, 2011)

Flow rate:
Why does it matter?

- The flow rate determines the velocity of the water moving through the filtration sand.
- The 'torturous' route that the water takes through the sand means that actual velocities are much higher than 0.4 m/hr [plug flow rate]
- High rates cause 'shear forces' which will dislodge pathogens from the surface of the sand grains and also scour the biofilm. This means that a high flow rate for a short time (at the start of the run) can be very detrimental.

"*Without attachment there is no removal*"

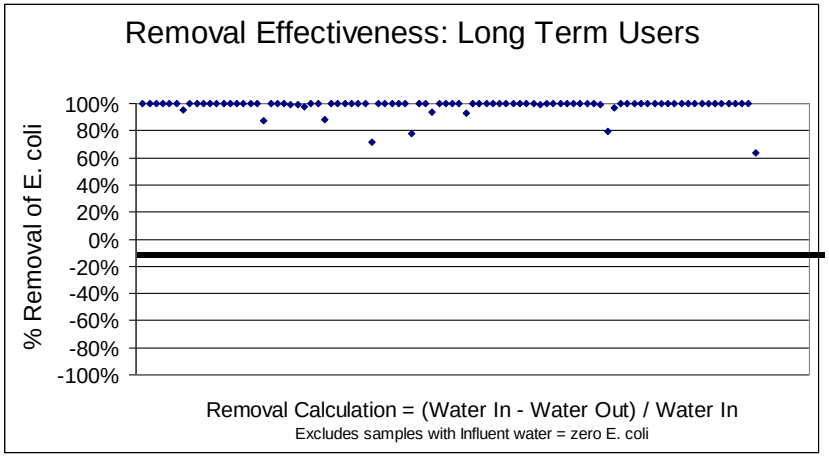
-Manual of Slow Sand Filtration

- Lower filtration rates are always better. As a filter plugs up with use and the flow rate slows down the water is actually getting better.
- Achieving the target flow rates of 0.4 L/minute (measured when the filter is first installed) is critical to the effectiveness of the BSF. [high flow rate is the most common problem in implementation]

Biosand Filter:
Bacterial Removal Effectiveness

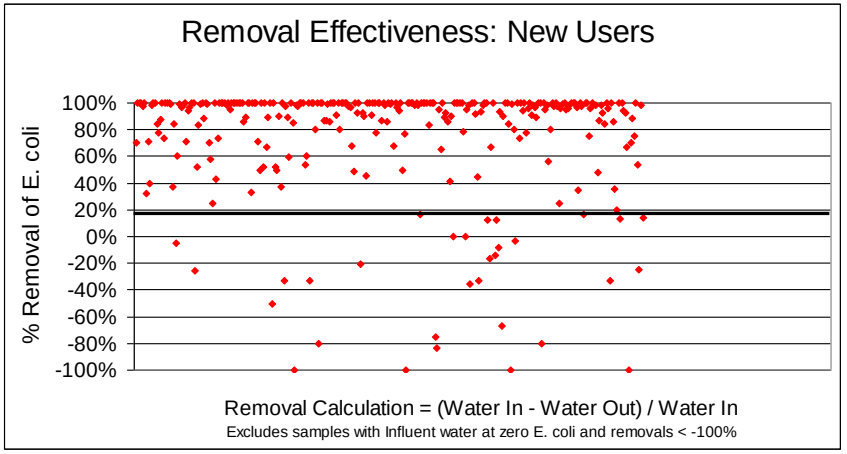
Long Term Users:

- Filters in use 1-5 years
- Media: crushed rock
- Flow rate: avg. 0.55 L/min
- Effectiveness: avg. = 98.5%



New Users:

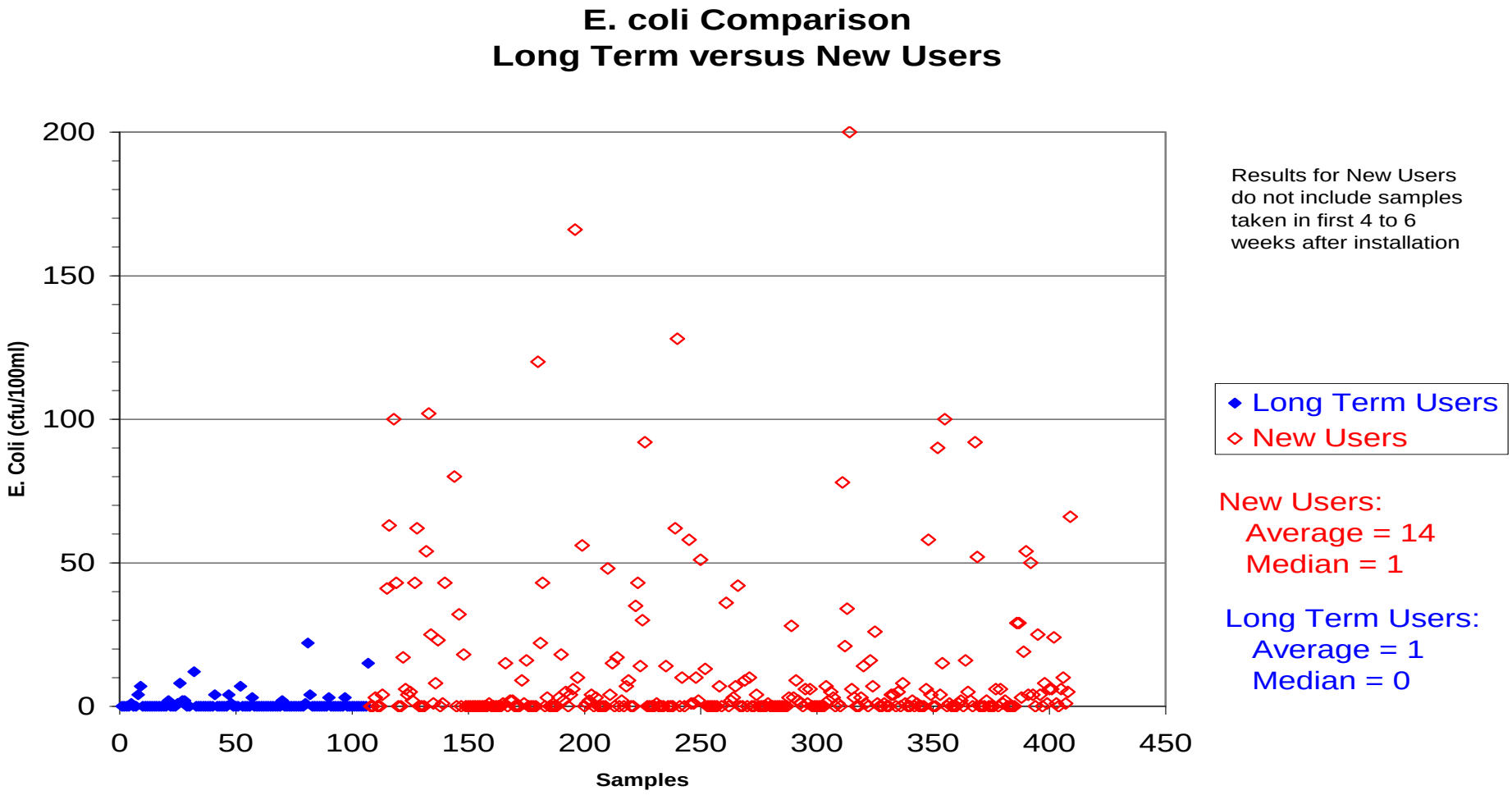
- Filters in use 1 ½ - 3 months
- Media: river sand
- Flow rate: 1.5 L/min
- Effectiveness: avg. = 76%



From: Duke, 2006

"The Flow Rate of the biosand filters was the single major observed and measured variance between the New Users and the Long Term Users"

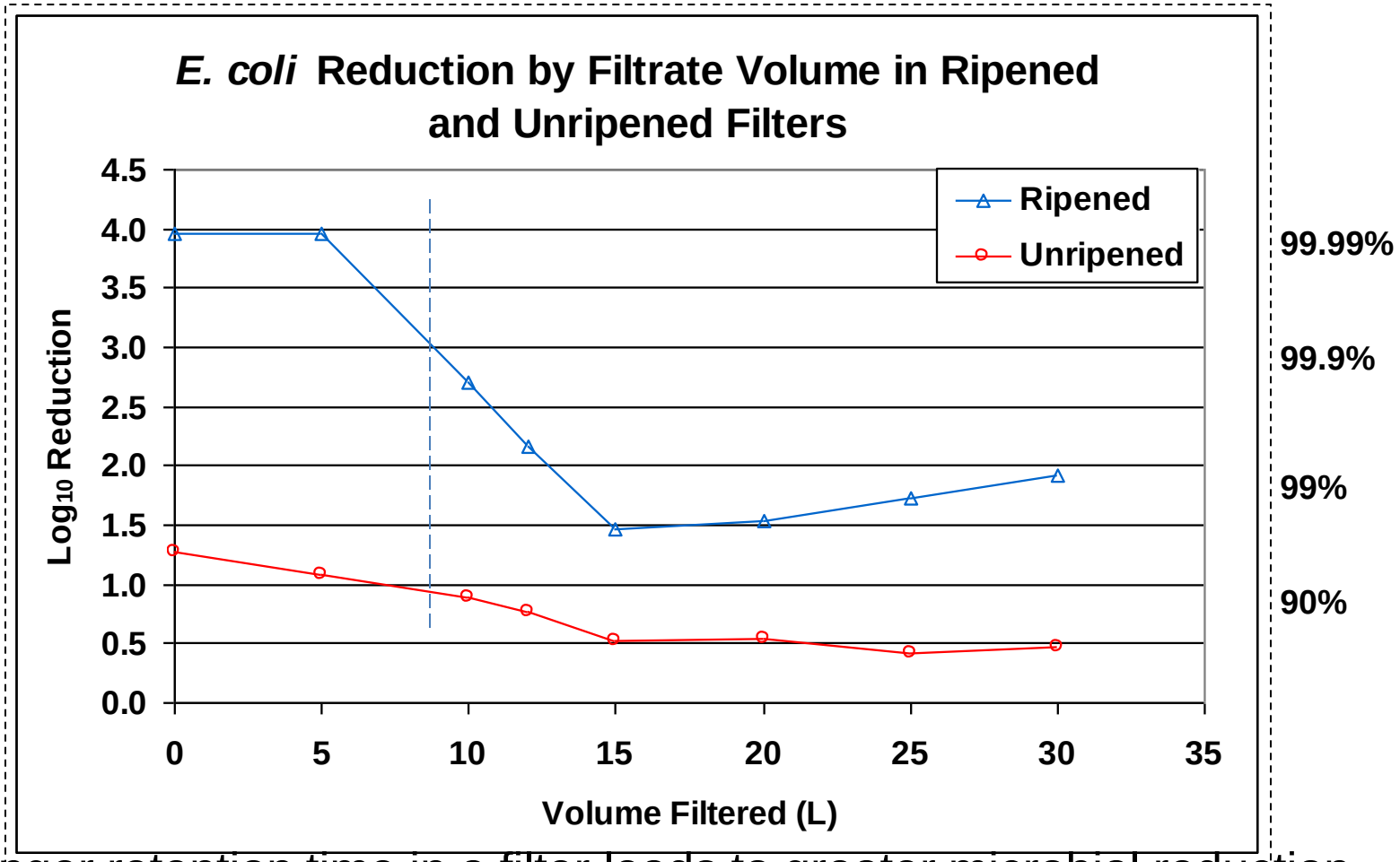
From: Project BRAVO



Pause period

- The pause period has been shown to be important to the effectiveness of the filter
- A pause period of at least one hour is beneficial because this gives time for the filter mechanisms to work.
- There seems to be little or no benefit for pause periods greater than 12 hours [further research on pause period is coming from Lehigh U.]
- Instructions to users are frequently forgotten or ignored – people tend use their filter according to their needs not our instructions. [Any specified pause period is probably not followed consistently in practice.]
- Using the filter frequently has the advantage that it will increase nutrients to the biolayer.
- The 'best' water is the water that has been resident in the filter overnight (12 hour pause period).

Filtered water quality is affected by ripening and residence time in the filter



Longer retention time in a filter leads to greater microbial reduction

Source: C.E. Stauber, M.A. Elliott, F. Koksal, G.M. Ortiz, F.A. DiGiano and M.D. Sobsey. Characterisation of the biosand filter for E. coli reductions from household drinking water under controlled laboratory and field use conditions. *Water Science Technology*. 2006; 54(3): 1-7.

Oxygen in the standing water layer

From: Buzanis, 1996

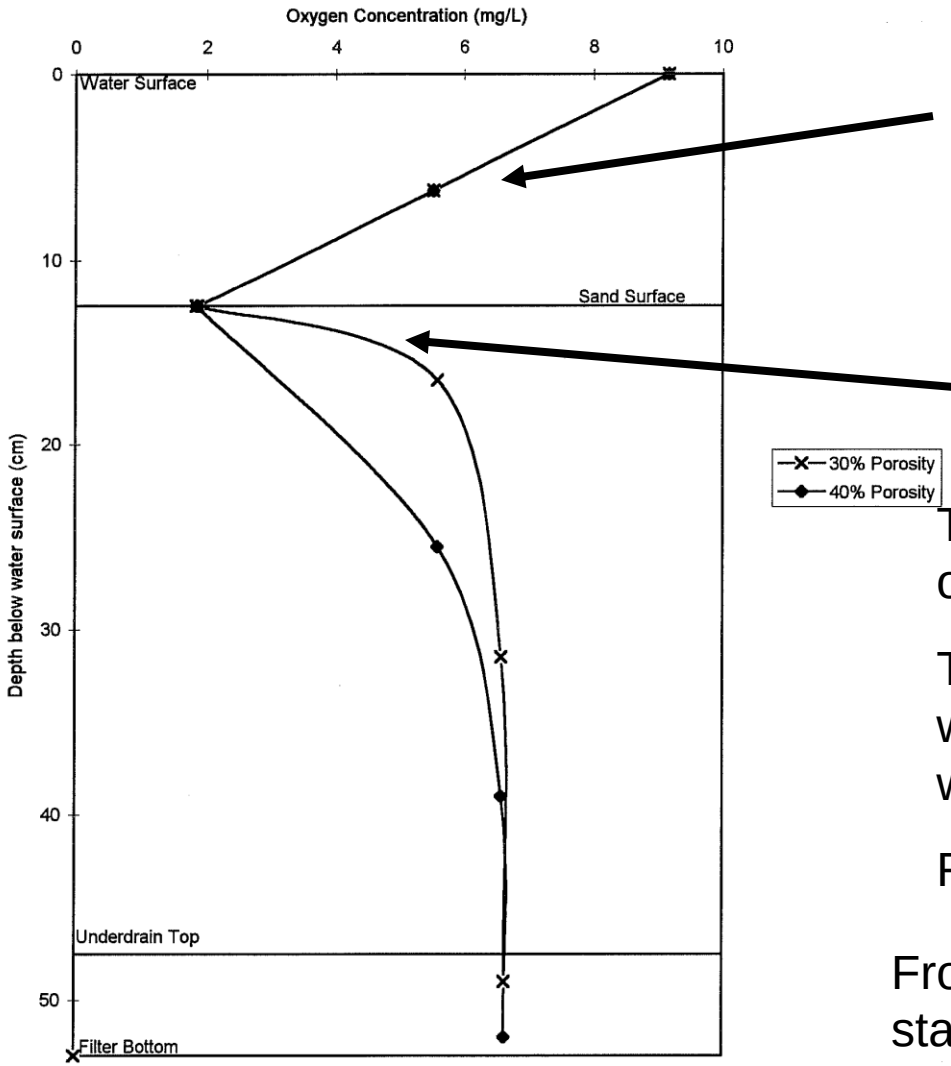


Figure 8.14 Typical Oxygen Concentrations through Filter after Pause Time

Oxygen concentration drops as the water depth increases

Biolayer is consuming oxygen during pause period

The deeper the water, the less the oxygen to the biolayer

This is a concern especially if the water has low oxygen levels to begin with (deep well, stored water)

Recommend NOT greater than 5 cm

From Palmateer - the height of the standing water may be important in the development of the biofilm; 2-3 cm appears to be an efficient level.

The 8 Operating Parameters:

1. The filter was installed more than 30 days ago.
2. The filter is used at least once every day.
3. The water poured into the BSF is not too dirty.
4. The filter box does not have cracks and is not leaking.
5. There is a diffuser.
6. When the water stops running, the water surface is 5cm above the top of the sand.
7. The top of the sand is flat and level.
8. When the filter is full, the flow rate is 400 mL or less per minute.