

Filtration of Virus, Bacteria, and Protozoan Sized Particles in the Filtron

Simon Schreier, Brandeis University '10
REU, CU Boulder '08

Outline

- What is the Filtron and why do we need it?
- What were the goals of this research?
- How was the research conducted?
- What were the results?
- What do the results mean?

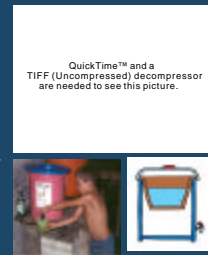
Availability of clean water



- Over 1 billion people w/o access to clean water
- 1.8 million people die every year from diarrhoeal diseases. (WHO)
- Problem is in big cities and small villages
- Women and children must walk miles to access clean water

The Filtron - what is it?

- Point-of-use device
- Porous ceramic pot
- Gravity filtration (no pumps)
- Easy to make
- Inexpensive (\$10-\$15)
- No technical expertise needed
- Long life w/ proper care
- In use in over 14 countries



The Filtron - what do we know?

- Pores range in size from 0.6-3 microns
- Previous experiments have shown over 99% removal of pathogens (2-Log)
- Silver coating on filter inactivates pathogens
- As filter is used, sediments accumulate on the surface, causing a decrease in flow rate
- Breakthrough phenomenon

Objectives

- 1) Assess the Filtron's ability to remove various sized particles, spanning virus through protozoan sizes
- 2) Determine whether recoating with silver effects removal efficiency
- 3) Make a quantitative description of the breakthrough phenomenon

Methods

- 6 filters: 1NS, 2NS, 1N, 2N, 1U, 2U

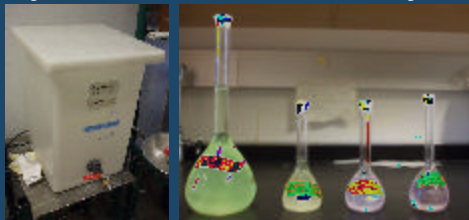


Microspheres

Size (µm)	suspension	calculated microspheres/mL	excitation/emission	pathogen of similar size
.02 NR	2.00%	2.60E+15	535/575	Rhinovirus
.1 Y/G	2.00%	3.64E+13	535/575	Influenza virus
.5 Y/G	2.00%	2.91E+11	505/515	Aeromonas hydrophila
2 Y/G	2.00%	4.55E+09	505/515	Encephalitozoon spores
10 Y/G	2.50%	4.55E+08	441/486	Giardia lamblia

Methods

- Spike influent water with fluorescent microspheres



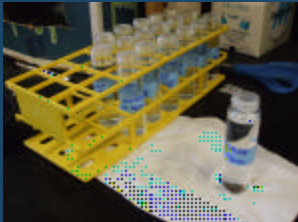
Methods

- Run water through filter. Measure depth and temperature at each sampling point



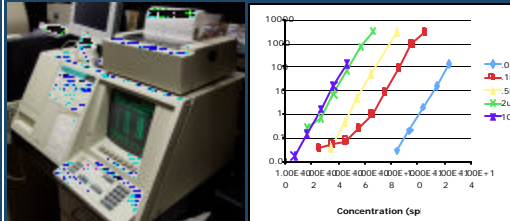
Methods

- Collect influent, effluent, and raw samples



Methods

- Analyze samples with fluorometer and determine sphere concentration.



Series of Experiments

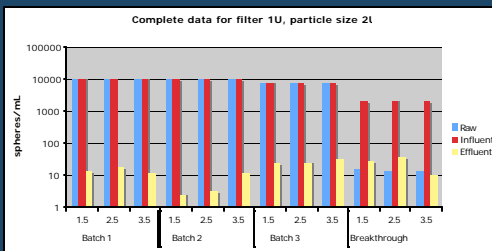
- All six filters were run concurrently
- Each filter has a complete data set
 - Batch = 3.5 hours runtime
 - 3 time points for each batch (1.5, 2.5, 3.5 hr.)
 - 3 batches of spiked water + 1 breakthrough batch for each sphere size
 - 5 sphere sizes (0.02 um, 0.1 um, 0.5 um, 2 um, 10 um)
 - 2 batches of unspiked water in between sphere sizes

What do you get from all that sampling?

- For every microsphere size, there are 3 batches. Each batch has 3 or 4 time points. (1NS, .1um, second batch)

Time	Batch	Filter	Sphere Size	Raw	Influent	Effluent
1.5	1	1NS	0.02um	100000	100000	100000
2.5	1	1NS	0.02um	100000	100000	100000
3.5	1	1NS	0.02um	100000	100000	100000
1.5	2	1NS	0.02um	100000	100000	100000
2.5	2	1NS	0.02um	100000	100000	100000
3.5	2	1NS	0.02um	100000	100000	100000
1.5	3	1NS	0.02um	100000	100000	100000
2.5	3	1NS	0.02um	100000	100000	100000
3.5	3	1NS	0.02um	100000	100000	100000
1.5	4	1U	0.02um	100000	100000	100000
2.5	4	1U	0.02um	100000	100000	100000
3.5	4	1U	0.02um	100000	100000	100000
1.5	5	1U	0.02um	100000	100000	100000
2.5	5	1U	0.02um	100000	100000	100000
3.5	5	1U	0.02um	100000	100000	100000

Data for filter 1U, particle size 2um, all batches and all time points

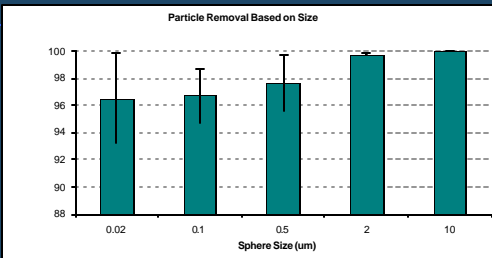


How much of the total data does this represent?

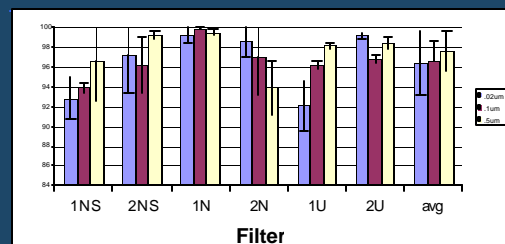
This table represents all the tests undertaken, with the previous data highlighted in green.

filter	1NS	2NS	1N	2N	1U	2U
particle size						
.02um	1NS, .02NS, .02N	1NS, .02NS, .02N	1NS, .02NS, .02N	1NS, .02NS, .02N	1U, .02U, .02U	1U, .02U, .02U
.1um	1NS, .1NS, .1N	1NS, .1NS, .1N	1NS, .1NS, .1N	1NS, .1NS, .1N	1U, .1U, .1U	1U, .1U, .1U
.5um	1NS, .5NS, .5N	1NS, .5NS, .5N	1NS, .5NS, .5N	1NS, .5NS, .5N	1U, .5U, .5U	1U, .5U, .5U
2um	1NS, 2NS, 2N	1NS, 2NS, 2N	1NS, 2NS, 2N	1NS, 2NS, 2N	1U, 2U, 2U	1U, 2U, 2U
10um	1NS, 10NS, 10N	1NS, 10NS, 10N	1NS, 10NS, 10N	1NS, 10NS, 10N	1U, 10U, 10U	1U, 10U, 10U

Removal efficiency based on size



Removal efficiency of each filter



What do these data say about removal efficiency?

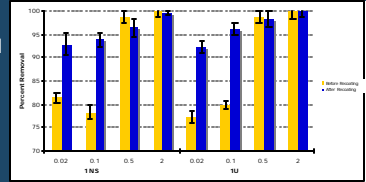
- Larger particles (10, 2 μm) are removed better than smaller particles
- Smaller particles (0.5, 0.1, 0.02 μm) can be effectively removed by the Filtron
- Removal of small particles varies greatly from filter to filter without pattern

Effect of Recoating Silver

- During the previous REU season, data was collected before recoating

- 1U
 - Recoated
- 1NS
 - No silver

filter	1NS	1U
year		
2007 (pre)	0.015	0.0
2008 (post)	0.032	15



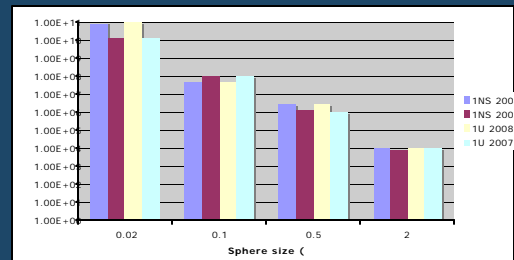
Paired t test

- Compared each filter in 2007 and 2008

comparison	0.02, 0.1 μm	0.5, 2 μm
1U	0.03321302	0.41990171
1NS	0.09669899	0.45536781

- High confidence for small sizes
- Low confidence for large sizes

Influent concentration, 2007 & 2008



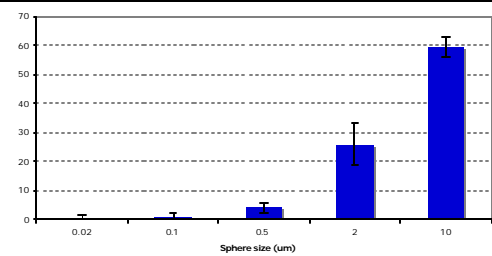
Why does removal efficiency increase for both filters?

- Filter history between REU '07 and REU '08
- Several batches of water were run between these data
 - Bacteria and microspheres
- Buildup of material in the filter (filter cake) could increase removal efficiency

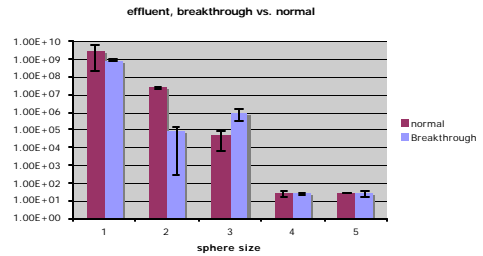
Breakthrough Phenomenon

- Unspiked water was poured into the filter after the 3 spiked batches were run
- Sampled in same way as spiked batch
- Were there spheres in influent/effluent?

Dissociation of particles in the Filtron during the breakthrough batch



Effluent concentrations, spiked batches and breakthrough batch



Breakthrough phenomenon

- Influent: larger spheres dissociate more readily into influent
- Effluent: sphere concentrations in breakthrough batch effluent are comparable to concentrations in spiked batch effluent

Breakthrough phenomenon

- Large spheres stick to filter surface
- Easily disassociate into influent
- Small spheres stick to interior pore spaces
- Difficult to disassociate into influent
- Both large and small spheres travel through the filter into the effluent

Conclusions

- 1) Virus sized particles can be removed, but not as efficiently as larger particles
- 2) Factors other than silver re-coating are responsible for the difference between pre- and post-coating removal efficiencies.
- 3) Breakthrough can cause significant recontamination of previously unspiked water.

Further Work

- Extensive testing of various particle sizes
- Testing *new* silver coated filters against *new* uncoated filters
- Attempting to recreate breakthrough with live organisms (i.e. bacteria)

Acknowledgements

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- SCIENCE!!!