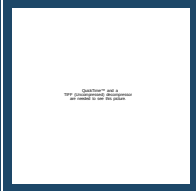
# Filtration of Virus, Bacteria, and Protozoan Sized Particles in the Filtron

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?

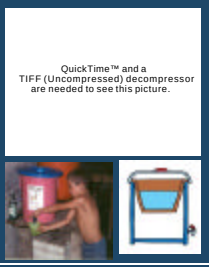
## Availability of clean water




- 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 hydrophilia |
| 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

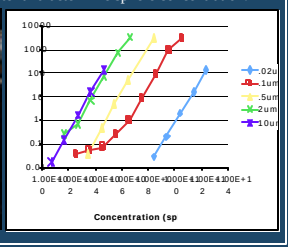
- Run water through filter. Measure depth and temperature at each sampling point

## Methods

- Collect influent, effluent, and raw samples

## Methods

- Analyze sampleswith fluorometer and determine sphere concentration.

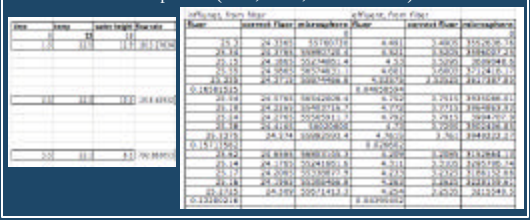


## Series of Experiments

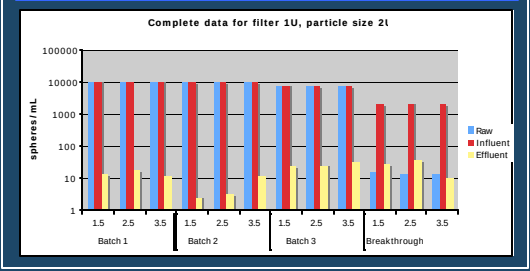
- All six filters were run concurrently
- Each filter has a complete data set
  - Batch = 3.5 hours runtime
  - 3 time points for each batch (1.5, 2.5, 3.5 hr.)
  - 3 batches of spiked water + 1 breakthrough batch for each sphere size
  - 5 sphere sizes (0.02 um, 0.1 um, 0.5 um, 2 um, 10 um)
  - 2 batches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



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

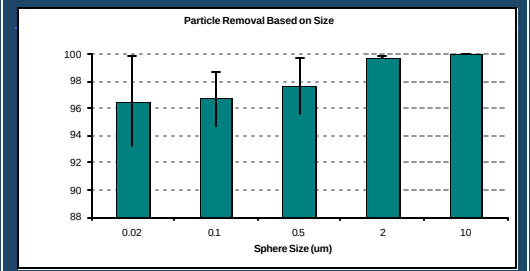



## How much of the total data does this represent?

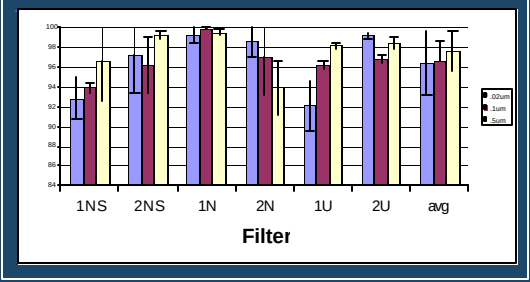
This table represents all the tests undertaken, with the previous data highlighted in green.

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

## Removal efficiency based on size




## Removal efficiency of each filter



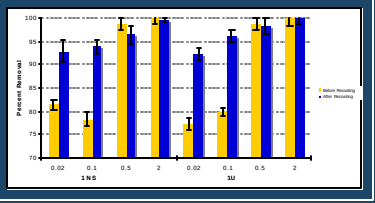
## What do these data say about removal efficiency?

- Larger particles (10, 2 um) are removed better than smaller particles
- Smaller particles (0.5, 0.1, 0.02 um) 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. |



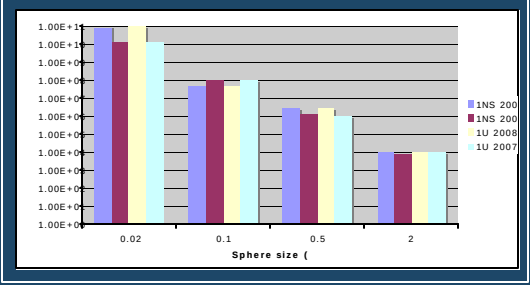

## Paired t test

- Compared each filter in 2007 and 2008

| comparison | 0.02, 0.1um | 0.5, 2um |
|---|---|---|
| 1U | 0.03321302 | 0.41990171 |
| 1NS | 0.09669899 | 0.45536781 |

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

## Influent concentration, 2007 & 2008



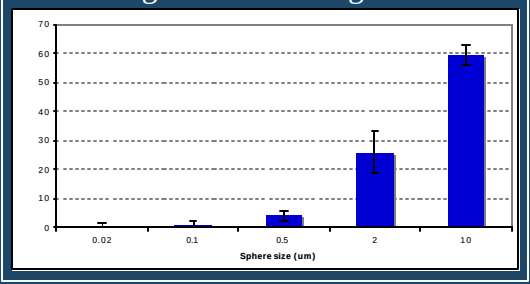

## Why does removal efficiency increase for both filters?

- 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

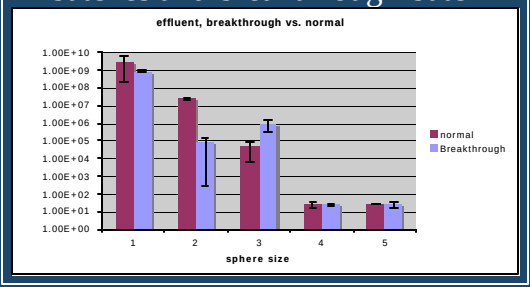
## Breakthrough Phenomenon

- 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 influnet/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 recoating 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!!!