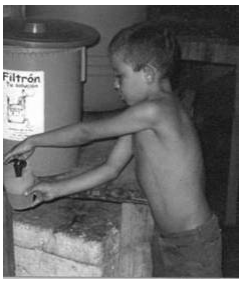
Evaluating the Water Treatment Effectiveness of the Filtrón

Angela R. Bielefeldt

Associate Professor, Dept. Civil, Environmental, & Arch. Engineering

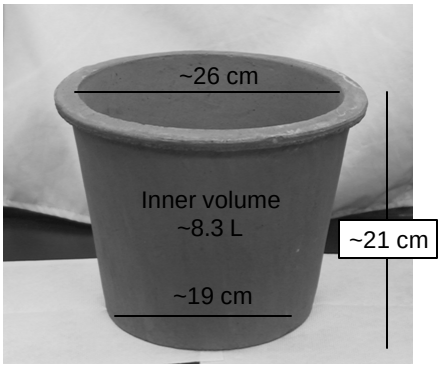
University of Colorado - Boulder

Professor R. Scott Summers,
Chris Fahlin, Suzanne Givler, Kate Kowalski,
Katie Medina, Lucas Hollenkamp,
Anisha Malhotra, Heather Wright



Filtrón

- Point-of-use water filter
  - Treats enough potable water for a family
- Advocated by Potters for Peace
  - Can be produced locally
- Mix clay + sawdust (or other fine organic)
- Fire, flow test (1-2 L/hr), coat with colloidal silver
- >12,000 in use in >16 countries worldwide



Previous Studies

- Daniele Lantagne, Alethia Environmental (currently with the US CDC)
  - Pore size determination
  - Pathogen removal
    - in laboratory
      - Bacteria; 1 test with protozoans and virus indicator
      - With and without colloidal silver
    - at residences
      - Bacterial removal at 24 homes in Nicaragua

Research Questions

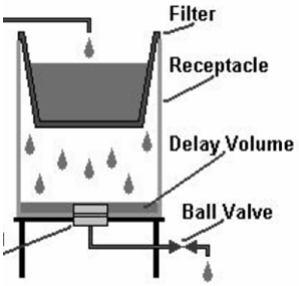
- Hydrodynamic conditions during flow
  - Contact time of pathogens with silver
- Physical removal vs Inactivation
  - Filtration (and impacts of accumulated dirt within the filter); if inactivation, potential for reactivation / repair
- Necessary to "pre treat" very turbid water?
  - Particles clog filter too rapidly and decrease flow rate
- Quantitative understanding of colloidal silver's ability to kill bacteria and viruses
  - "CT" concentration * contact time relationship?
  - Long term effectiveness, as silver leaches away
  - Bacterial "static" vs "cidal" – bioclogging over time?

CU Tests

- Intact Filters
  - 7 new produced in Managua. Nicaragua
  - 2 new from Nicaragua, w/o silver
  - 3 used by families in Nicaragua for ~3 yrs
- Continuous flow tests to determine hydraulic properties
- Batch tests (similar to field use) for turbidity removal and clogging
- Column tests with circular core samples from a used Filtrón

Hydrodynamics

- Experiments conducted with numerical modeling to determine the flow properties of the filters
- Continuous, constant flow tests conducted on 5 new Filtróns
  - 3 flow rates per filter
  - Hydraulic conductivity (K)
    2 to 7 cm/d
- Bromide tracer tests
  - Effective porosity, ?, 0.14 to 0.6
  - Tortuosity, ? , 4 to 18
  - Rough correlation between higher ? and lower ?

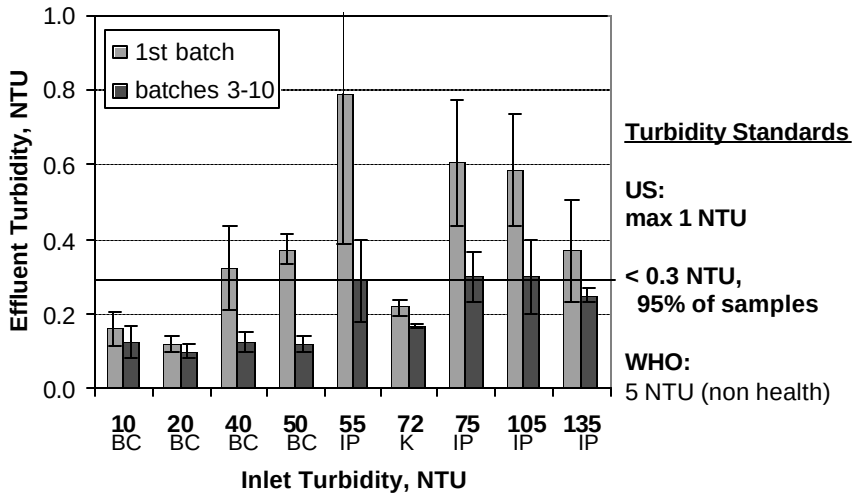


Turbidity Removal & Clogging

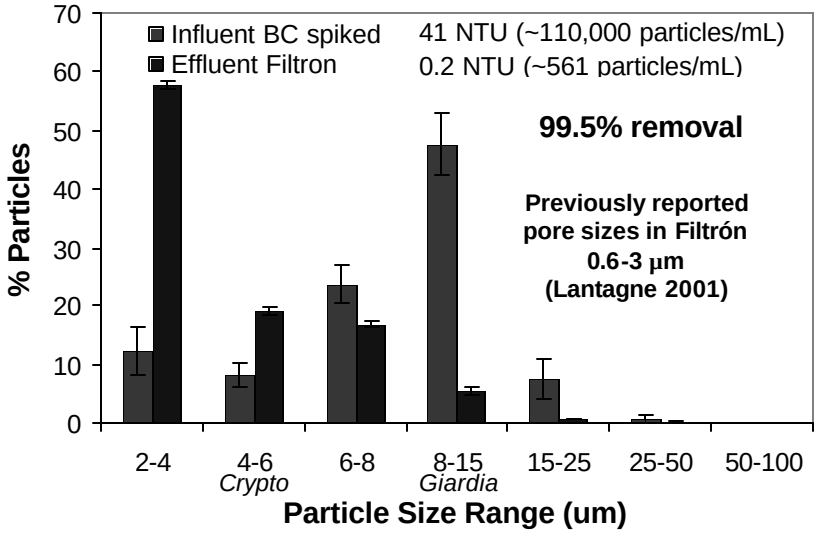
- Fill filters sequentially with 6-10 batches of each water type
- Measured effluent Q vs time; turbidity; accumulated solids
- Scrub filters to remove solids, then load with next water type

Turbidity Source	Water Turbidity, NTU	Filters Tested
Boulder Creek	10, 20, 40, 50	4 new, 1 new w/o Ag
Irrigation Pond	55, 75, 105, 135	3 new, 1 new w/o Ag, 2 used
Kaolin clay (lab grade)	75	2 new, 1 used

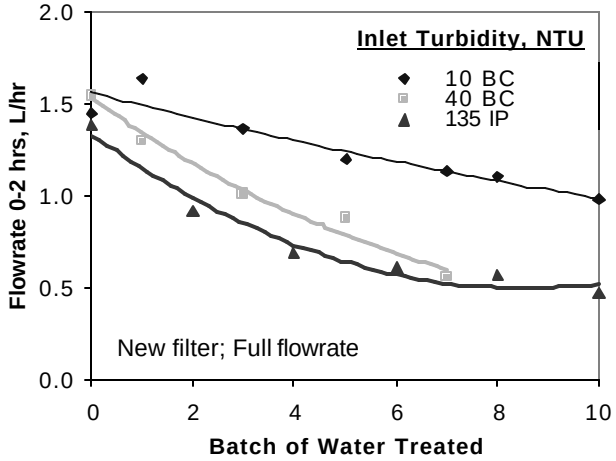
Turbidity Removal



Particle Size Distribution

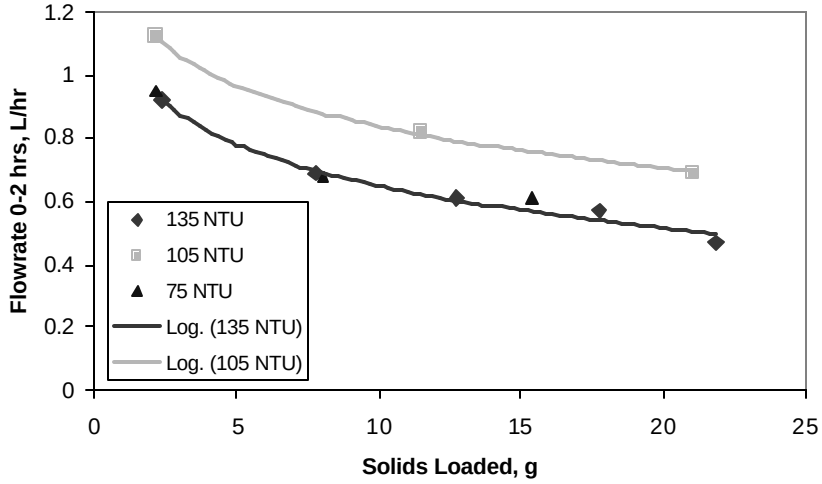


Impact of Turbidity on Flowrate

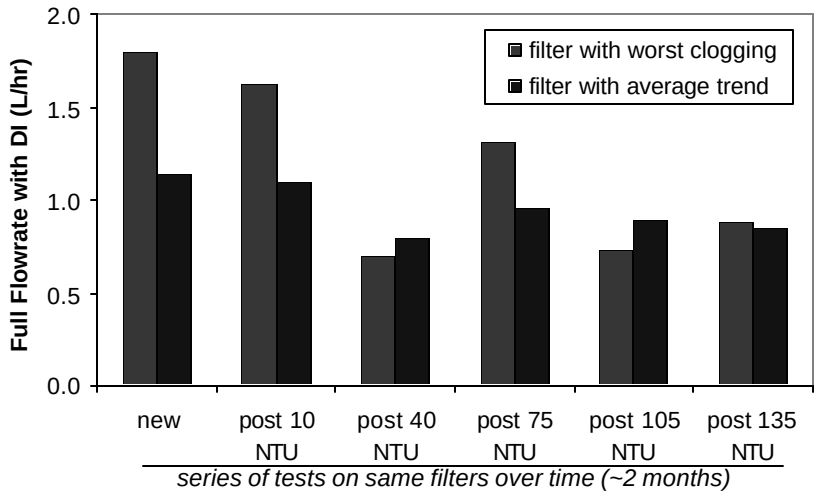


- accumulation of solids within the filter over time leads to increased headloss through the filter cake, and lower flowrates
- more clogging due to greater turbidity loading

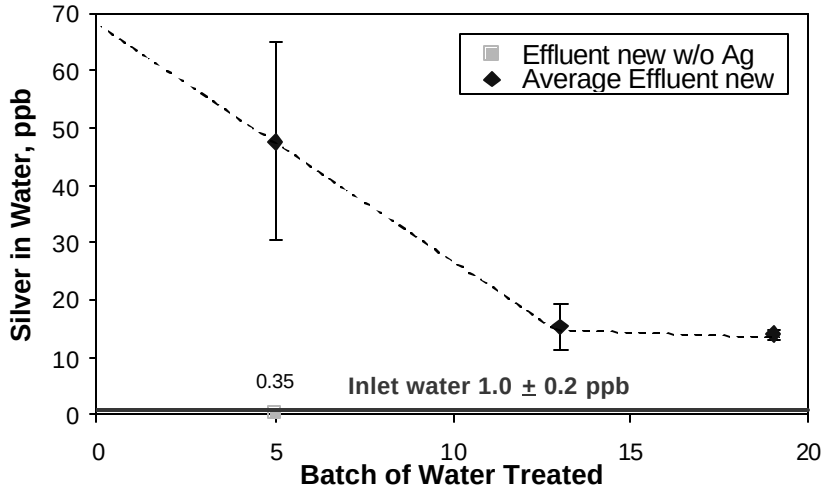
Impact of Solids Loading on Flowrate



Effectiveness of manual brush scrubbing



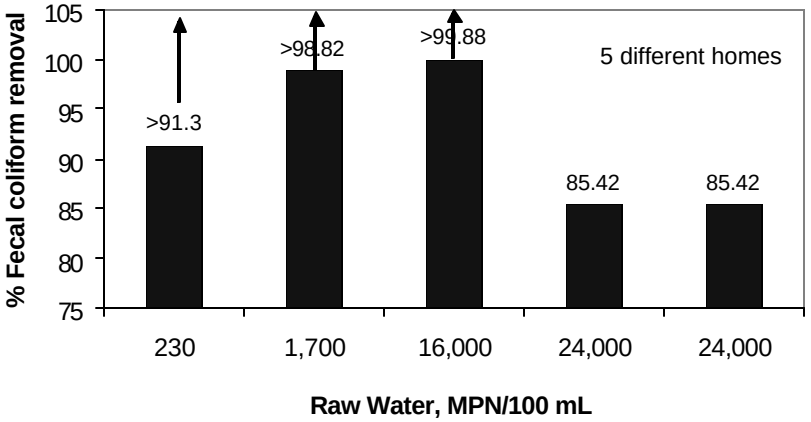
Silver Leaches out of Filters



US EPA Drinking Water Standard: 100 ppb silver, secondary MCL

Pathogen Removal – field use

- San Francisco Libré, Nicaragua

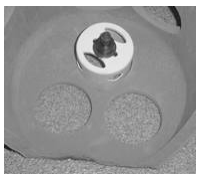


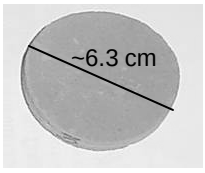
Pathogen Removal Tests

- Batch tests with aqueous solutions of colloidal silver and Fecal coliform bacteria
  - MPN method
  - Contact times 15 min – 2 hrs
  - Concentration 20-50 μg/L (with ~76% < 0.22 μm, possibly ionic silver)
  - Unreliable trends in F. coliform removal
  - Ionic silver 90-95% kill of E. coli by 50 μg/L after 60 min (Pedahzur et al. 1997; Kim et al. 2004)

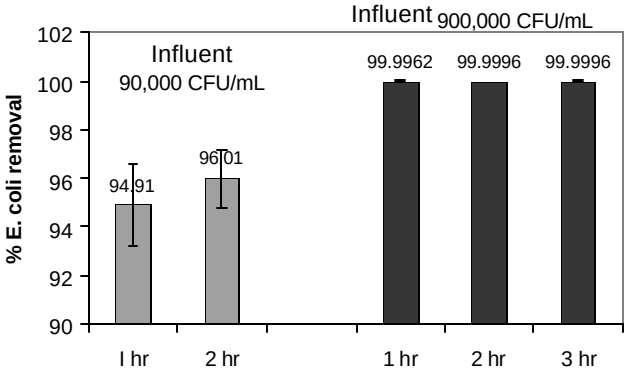
Pathogen Removal Tests

- Column tests with a “core” from a Filtrón used in Nicaragua for ~3 yrs
- Apparatus maintains constant head similar to intact Filtrón





Pathogen Removal



- Removal varied from 1.5 to 5 log
  - Cell clumping at high concentration may have led to higher filtration removal

- Other bacteria leached out of ceramic and grew on non-selective agar plates
  - may be due to shipping and handling of filters
  - decreasing type and number of non E. coli bacteria over time (~4-5 types to 1-2 types)
- Unlikely that these bacteria would be present over the long term

Further Work

- Compare live bacterial removal impacts of coating various concentrations of colloidal silver on the filter cores
- Characterize particle sizes removed by the Filtrón
  - Compare to typical bacteria, viruses, etc.
- Conduct virus removal/inactivation experiments with surrogate bacteriophage plaques (inactivation)

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