Background – The Need Explained

- 600 million people live in rural China
- 242 million people lack access to improved drinking water systems
- Even where improved drinking water systems exist, fecal contamination of system is prevalent

Background – The Need Explained


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Background – The Need Explained

- Understanding of water quality and it's impact on human's is poorly understood

- Last year in a study at 15 primary schools
  - Average [E. coli] = 242 units/100ml
    (Median = 101 units/100ml)
  - 1 had [E.coli] < 1 unit/100ml
  - 1 school had 1389 units/100ml at the tap.

By definition, this is an example of an "improved drinking water system"

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School Drinking water faucet

- How improved is it when….
- The well is 2 meters deep
- In the middle of a wet rice patty
- Where they use “raw fertilizer” on the field?

There are thousands of villages without even an “improved” drinking water source

- >95% of all village water we've tested in more than 300 villages and schools have fecal contamination.

Treatment is Needed

- Village wide system
  - Completely unrealistic in most places in rural China today
  - E.g. Most schools have boilers but won't use them because too expensive or already broken.
  - I know of no village that has a water treatment system.
- Point of Use (POU) systems
  - Boiling
  - Slow sand filters
  - UV disinfection
    - SODIS
    - UV light
  - Membrane filters
  - Etc.

Treatment is Needed

- How do you help half a billion people have biologically safe water?
- Boiling = Cutting a lot of trees!
- Needs to be:
  - Acceptable
    - Culturally
    - Financially
    - Practically
  - Reproducible on a vast scale
  - Sustainable = market driven

Ceramic Water Filters

- Advantages
  - Provides a barrier
  - Turbidity removal
  - >99% removal of microbes
  - No chemicals
  - No electricity
  - Easy maintenance
  - Affordable
  - Made locally
    - By the thousands anually

History of our Factory

- Started production in 2010
- Produce about 7000 filters a year
- Enough filters to help about 50,000 people/yr

Complaints/Concerns

1. Which is better: Colloidal silver or Silver Nitrate? And how should it be applied?
2. Filters too fragile
3. Flow rate too slow
4. Filters too big and too heavy and TOO UGLY!

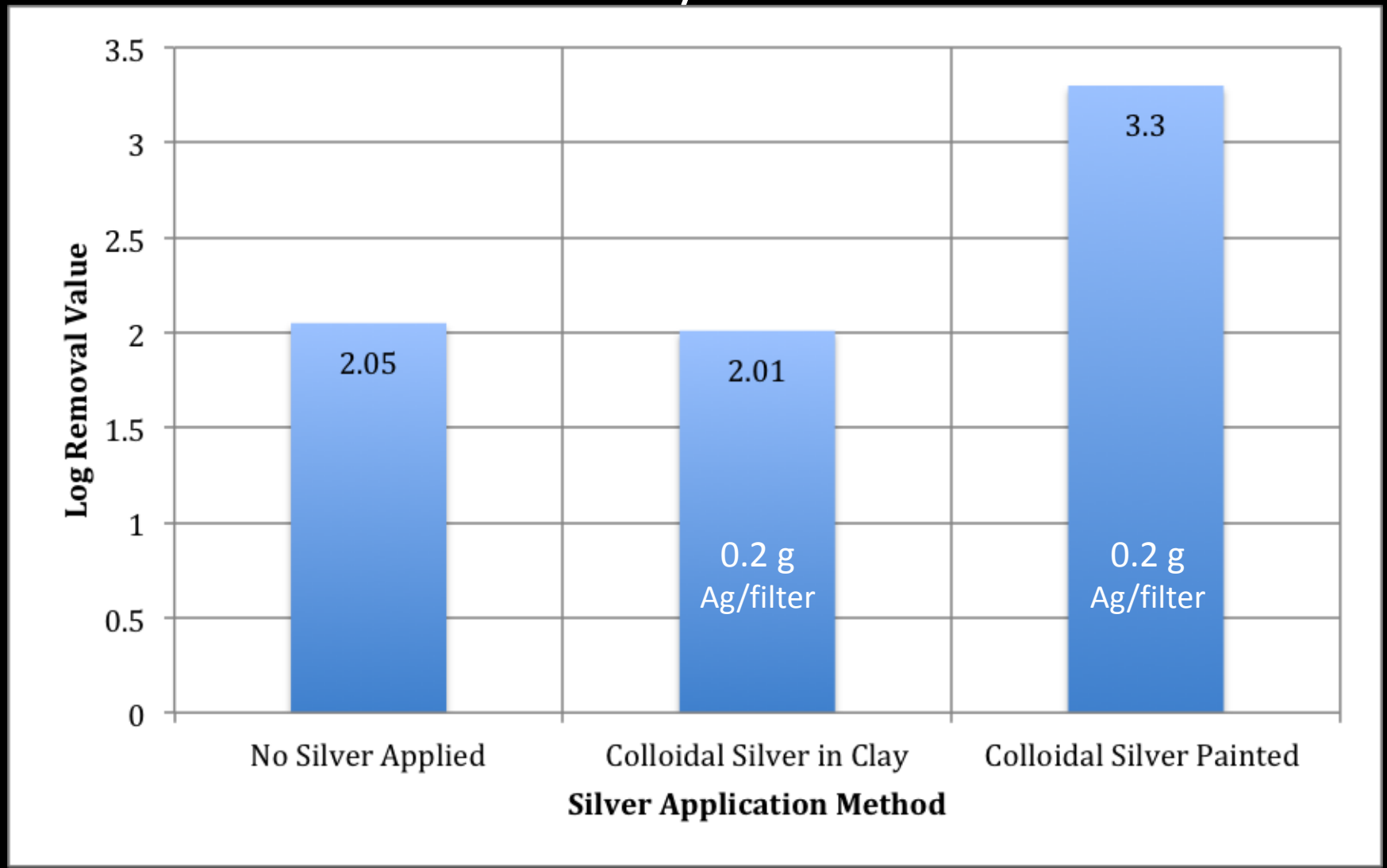
- Our research goals are to address these 4 issues.
- (Studies were done at our factory with real pot filters)

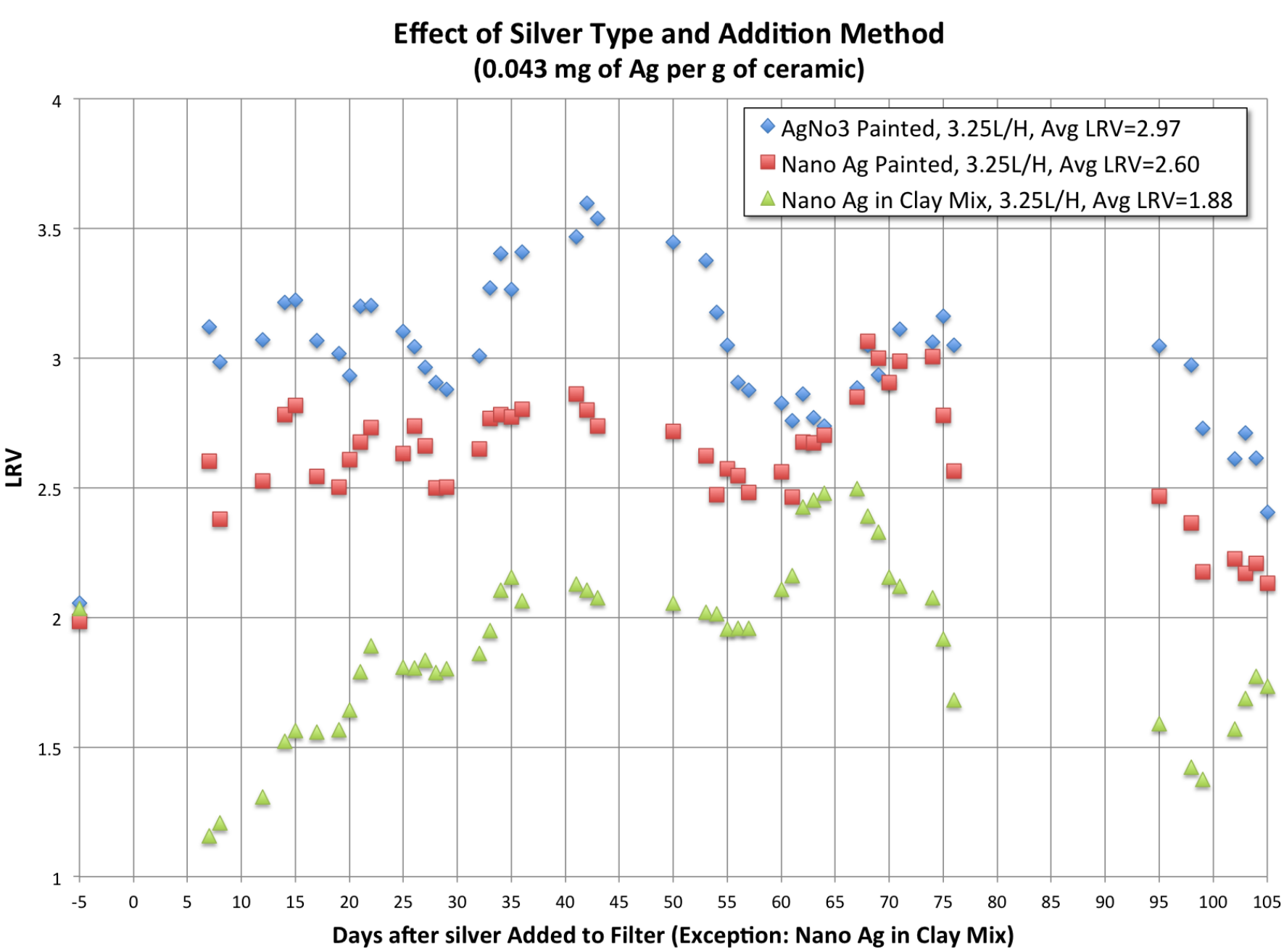
Log Reduction Value (LRV)

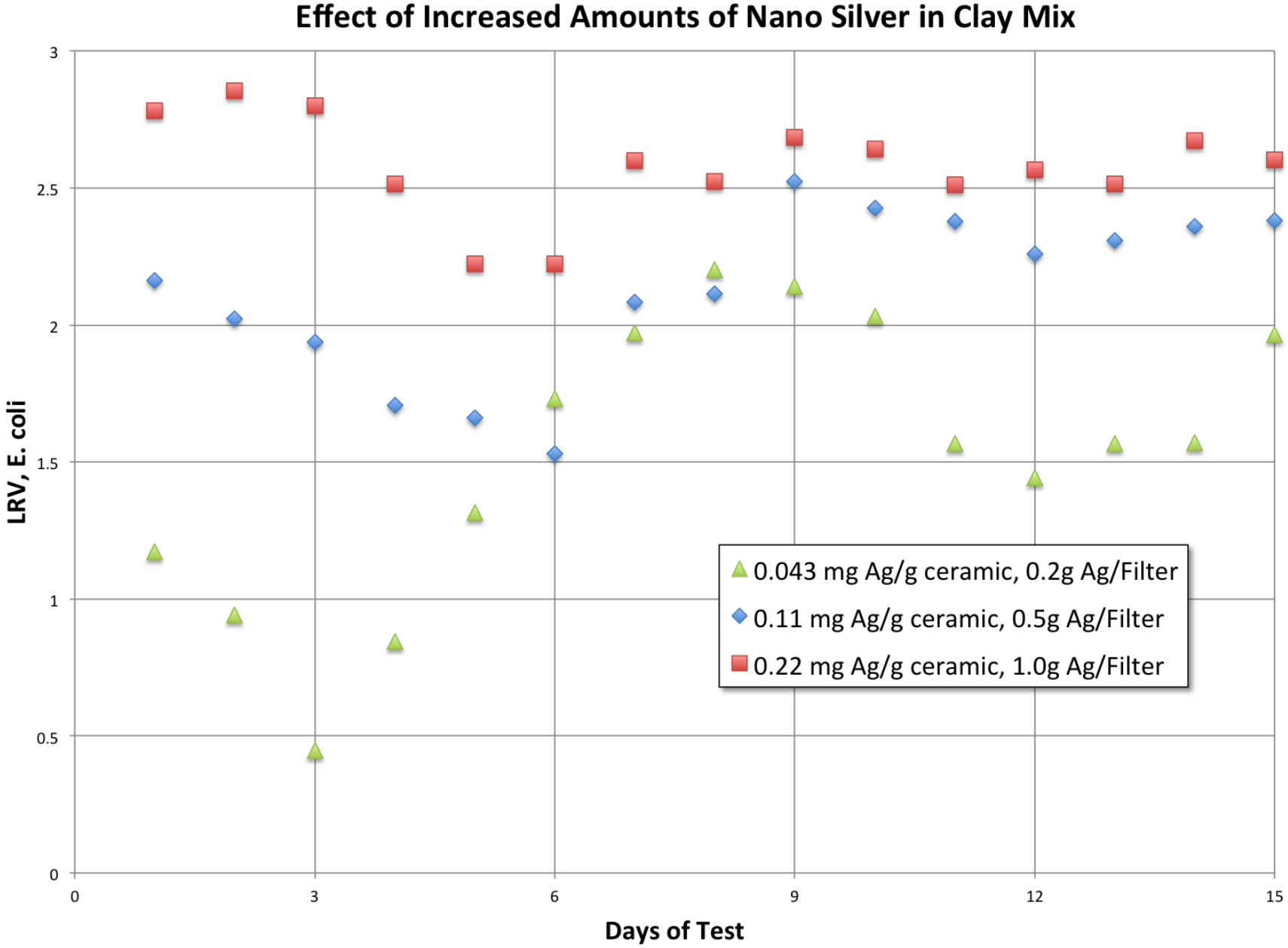
- $LRV = \log_{10}([\text{E. coli}]_{in}) - \log_{10}([\text{E. coli}]_{out})$
- So 90% removal efficiency => LRV = 1
- So 99% removal efficiency => LRV = 2
- So 99.9% removal efficiency => LRV = 3

Which is better: Colloidal Silver (CN) or Silver Nitrate (SN)? And how should it be applied?

- Initial Results: Silver in clay mix has no effect.




Effect of Silver Type and Addition Method
(0.043 mg of Ag per g of ceramic)
AgNo3 Painted, 3.25L/H, Avg LRV=2.97
Nano Ag Painted, 3.25L/H, Avg LRV=2.60
Nano Ag in Clay Mix, 3.25L/H, Avg LRV=1.88
LRV
4
3.5
3
2.5
2
1.5
1
-5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
Days after silver Added to Filter (Exception: Nano Ag in Clay Mix)


Effect of Increased Amounts of Nano Silver in Clay Mix
LRV, E. coli
Days of Test
0
0.5
1
1.5
2
2.5
3
0
3
6
9
12
15
0.043 mg Ag/g ceramic, 0.2g Ag/Filter
0.11 mg Ag/g ceramic, 0.5g Ag/Filter
0.22 mg Ag/g ceramic, 1.0g Ag/Filter

Which is better: Colloidal Silver (CN) or Silver Nitrate (SN)? And how should it be applied?

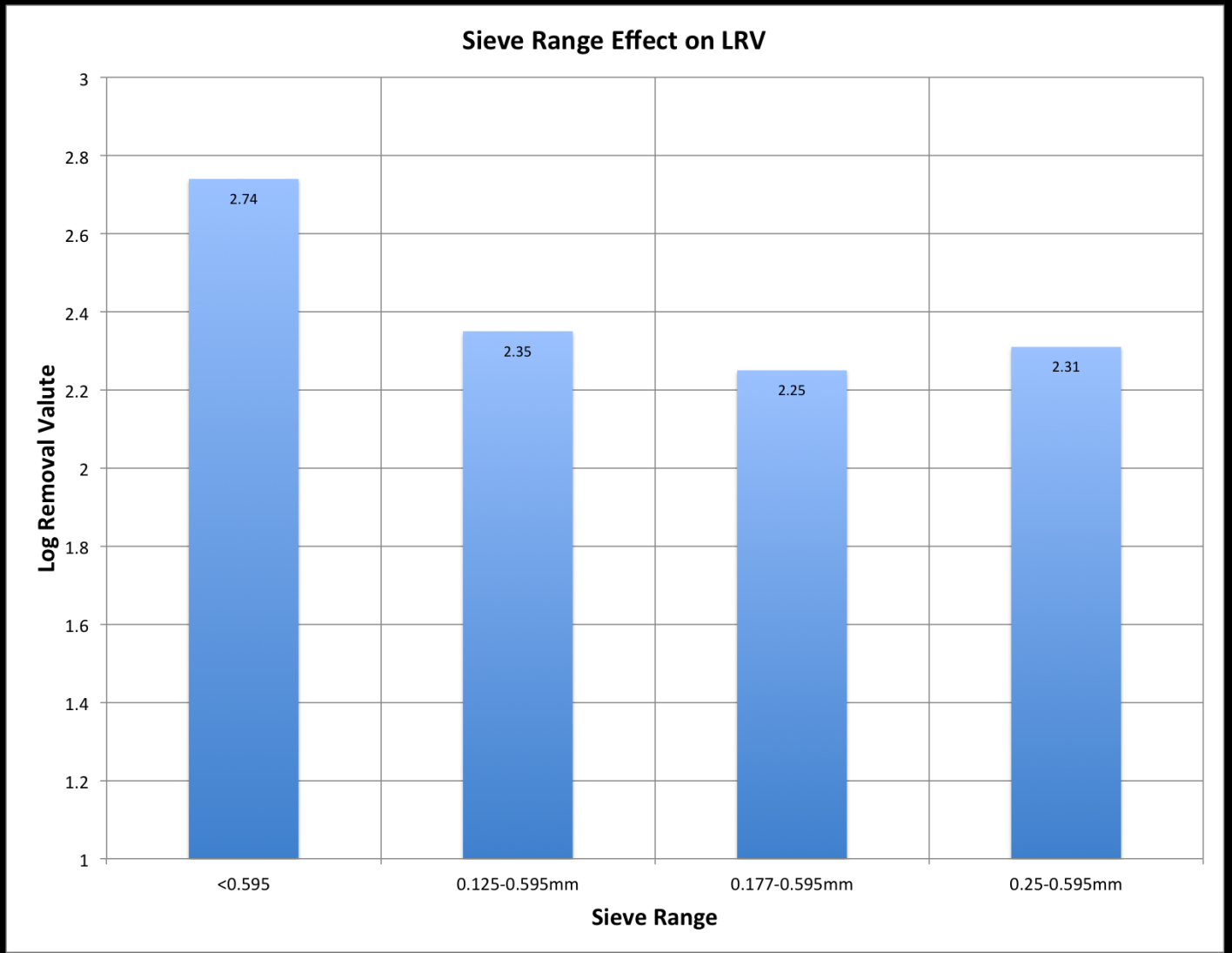
- Conclusions:
  - Silver added to the clay mix has limited impact on the LRV of E. coli
    - Even at very high doses.
  - SN was more effective than CS over 100 days of testing.

- Results
  - We switched from CS mixed in the clay to painting with SN.
  - Wasted time, but saved money and trouble of getting CS into China.

How to improve strength and flow rate?

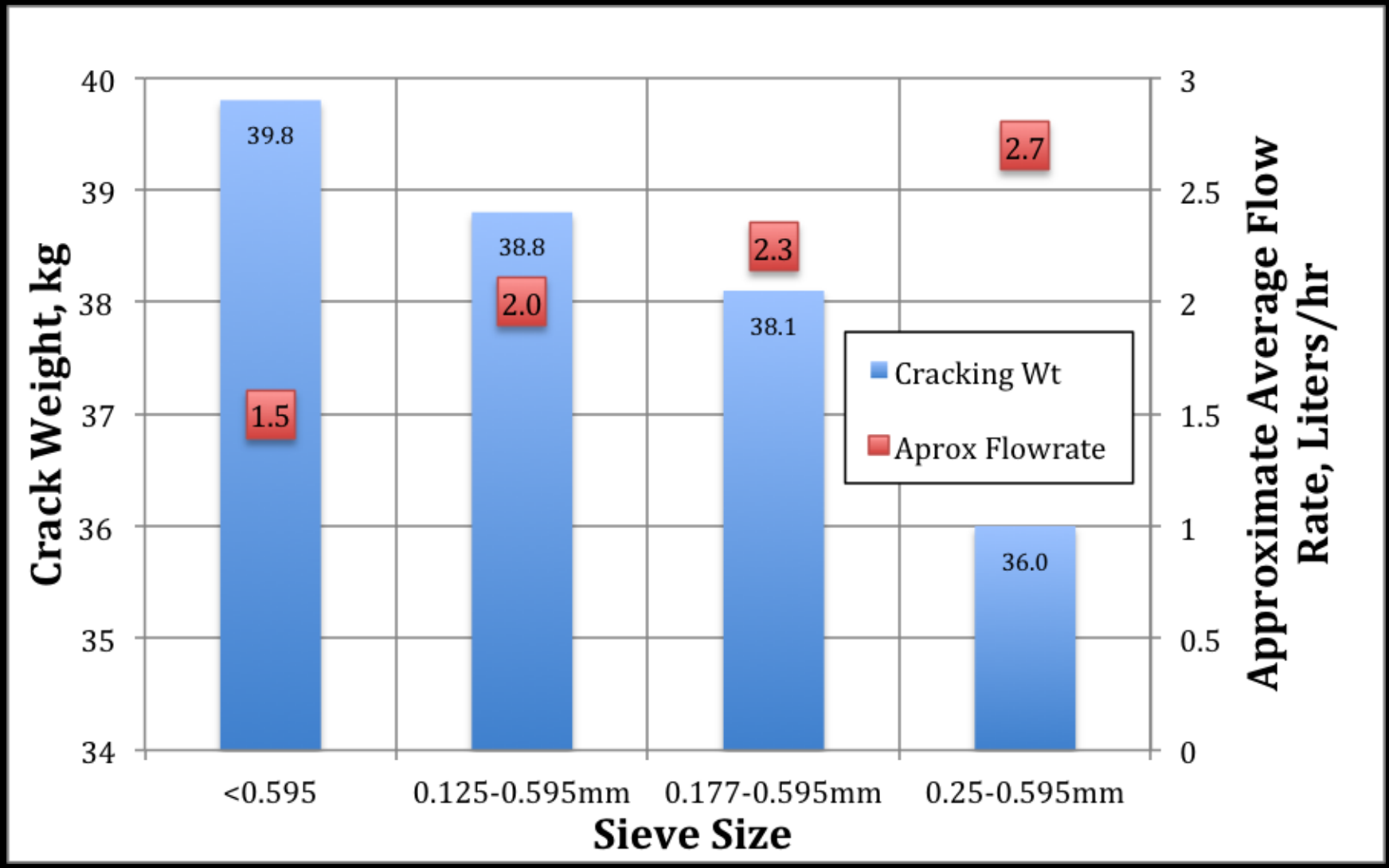
At 20% w/w rice husks, different sieves ranges.

Observation: Fines in rice husks seem to help improve removal efficiency



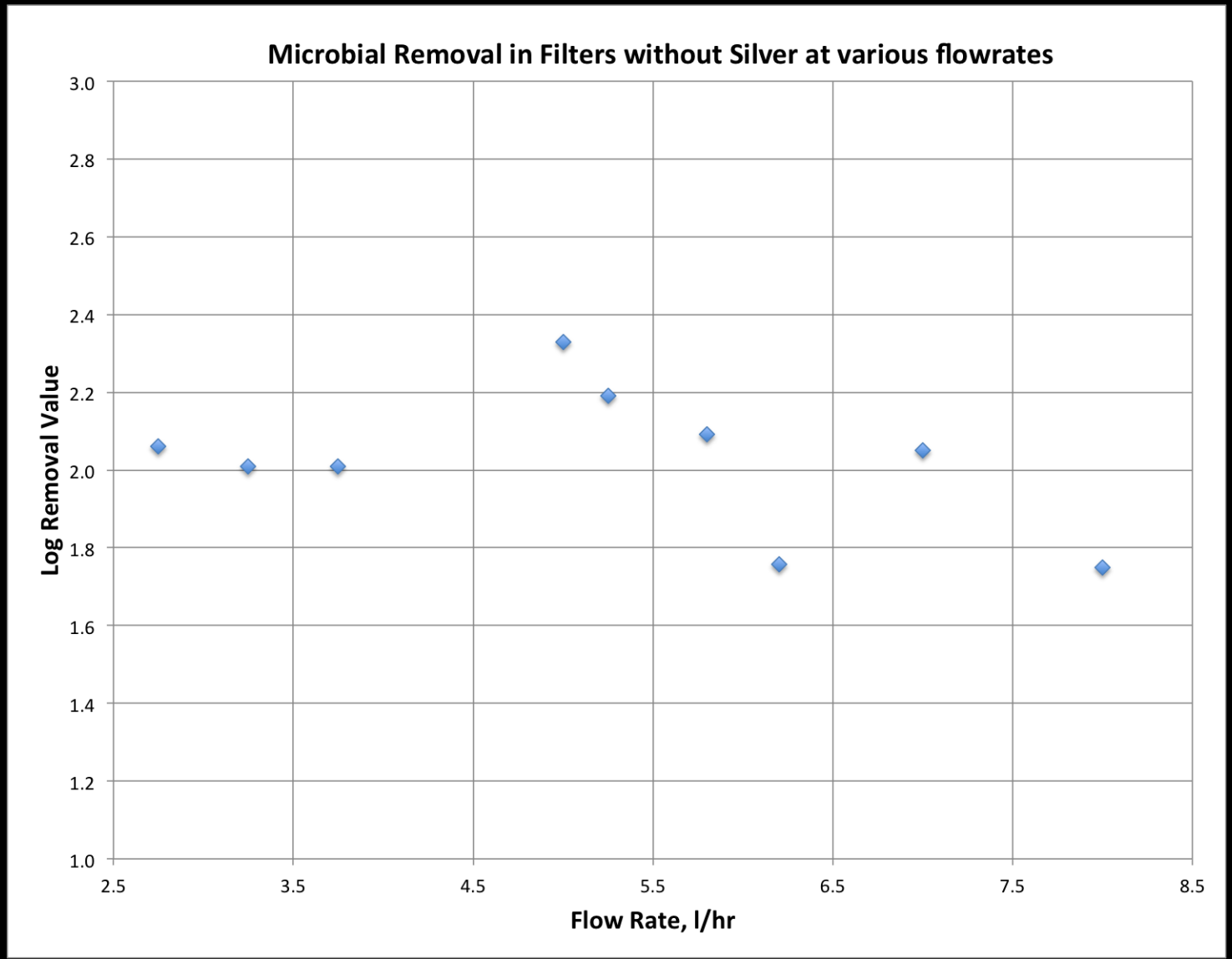
Observation 1: flow rate is decreased where there are fines

Observation 2: Large rice husks decrease strength of pot



How to improve strength and flow rate?

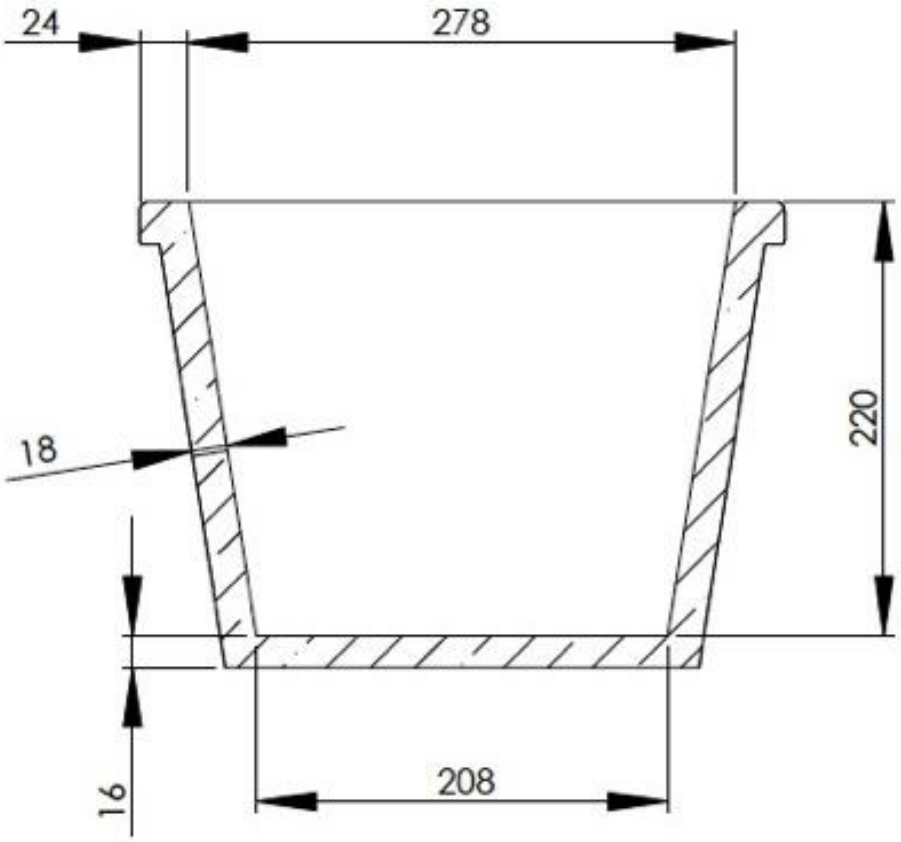
Observation: Flow rate does not effect LRV

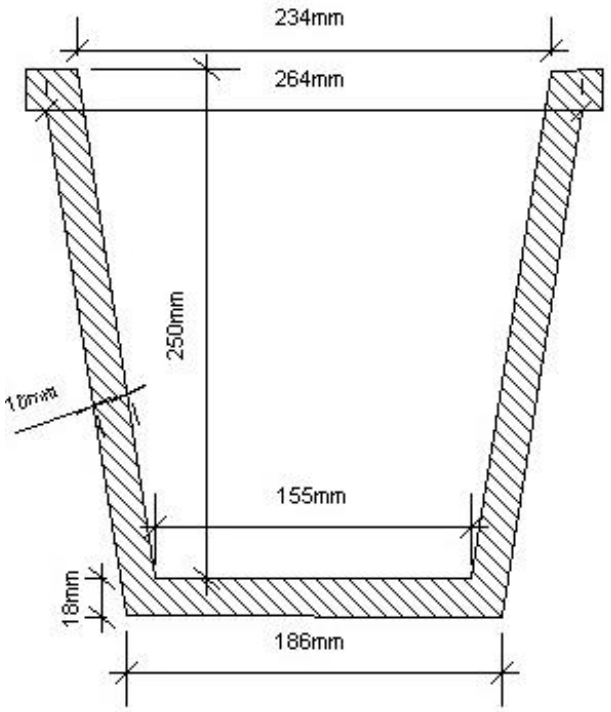


How to improve strength and flow rate?

- Conclusions
  - It's a balancing act
  - Larger rice husks increase flow rates but decrease strength
  - More rice husks give faster flow but weaker filters
- Other Considerations
  - Firing temperature – higher temperature, higher flow rate and stronger, but more warps and cracks
  - Additives to strengthen?
  - Change clay?

Too Big, heavy and ugly





Too Big, heavy and ugly

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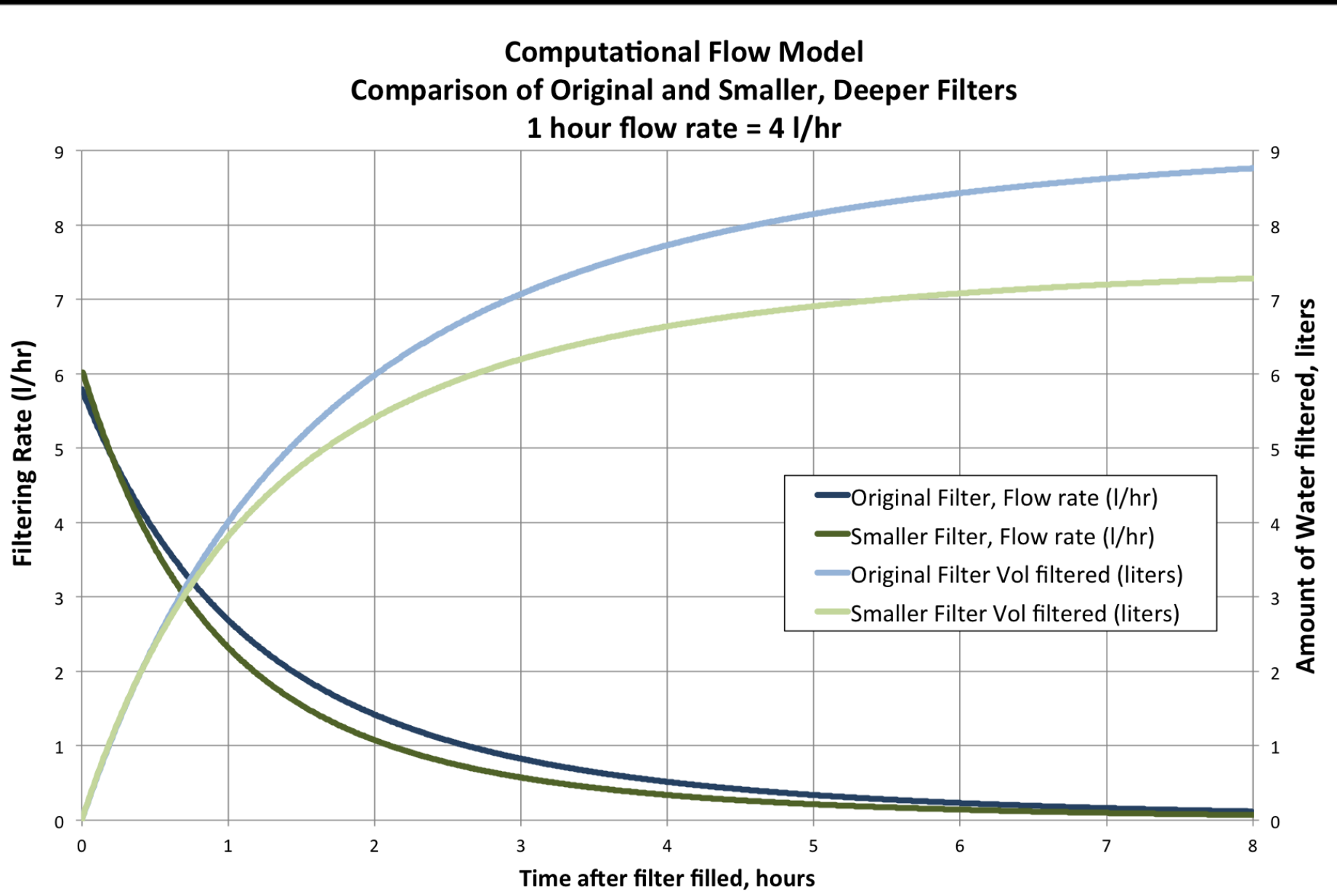
Computational Flow Model
Comparison of Original and Smaller, Deeper Filters
1 hour flow rate = 4 l/hr
Filtering Rate (l/hr)
Amount of Water filtered, liters
Time after filter filled, hours
0
1
2
3
4
5
6
7
8
9
Original Filter, Flow rate (l/hr)
Smaller Filter, Flow rate (l/hr)
Original Filter Vol filtered (liters)
Smaller Filter Vol filtered (liters)

New Design

- Because the rim diameter is small, it is stronger.
- So we can increase the rice husk content and flow rate.
- It allows a much smaller receptacle which locals want.
- It can fit on a water dispenser machine.
- It can also be attached to the house water.


Midea

THANK YOU!