Ceramic Water Filters for Rural China: 
Research Results and Resulting Filter Pot Redesign

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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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• Understanding of water quality and its 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”
By definition this is an example of an improved drinking water systems.
• 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?
Waterfall water gets to school looking like this.
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 annually
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} ([E. coli]_{in}) - \log_{10} ([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.
Which is better: Colloidal Silver (CN) or Silver Nitrate (SN)? And how should it be applied?
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

[Graph showing crack weight and approximate flow rate by sieve size]
How to improve strength and flow rate?

Observation: Flow rate does not effect LRV

Microbial Removal in Filters without Silver at various flowrates
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
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Computational Flow Model
Comparison of Original and Smaller, Deeper Filters
1 hour flow rate = 4 l/hr

- **Original Filter, Flow rate (l/hr)**
- **Smaller Filter, Flow rate (l/hr)**
- **Original Filter Vol filtered (liters)**
- **Smaller Filter Vol filtered (liters)**

**Axes:**
- **Y-axis:** Filtering Rate (l/hr)
- **X-axis:** Time after filter filled, hours
- **Y-axis (right):** Amount of Water 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.
THANK YOU!