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Results of applied research in the production and performance of ceramic pot filters

Dutch research group on ceramic pot filters :

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The research context

Publication and implementation of results **2014**

Start Research: **2008**

Dutch research group had the opinion, that

- Better QC&QA system is needed to support implementation.
- More knowledge on production parameters is required for better QC.

Situation at the start of the research.

- Various studies on performance and field studies.
- Conclusion: pots have in general a good removal efficiency for bacteria but not for viruses.
- The filters have a low flow rate of aprox. 2L/h
- Great variability in the performance between countries and within factories
- Few studies on the parameters.

Purpose of the research

- Quality control and quality assurance

(to investigate critical production parameters)

→ A more constant product

- Filter improvement

(higher flow, improved bacteria removal, not compromising strength)

→ A better product

Focus of the research

- Silver application
- Clay to rice husk ratio
- Maximum firing temperature
- Particle size of rice husks

Essential: pilot plant at production site of RDI Cambodia

Real pots under controlled circumstances.

Gas heated batch killn; max capacity: 6pots

Reference: Standard recipe/performance of RDI

- For 6 pots:
  30 kg clay
  9,7 kg rice husks
  1,6 kg laterite
  14,5 l water

Max firing temp.
885 °C
Firing time 10h

- Performance:
  Flow rate: 2-3L/h,
  Log removal: LRV 2
  Material strength,
  (Modulus of rupture):
  2-2,4 MPa

16 batches of 6 pots were manufactured in the pilot plant

- Measurements on the performance of the pots were carried out at:

- The Technical University of Delft (TUD)
  - by Harmen van der Laan
- RDI in Cambodia
  - by Isabelle Gensburger

Measurements at the Technical University of Delft: The role of silver.

- Purpose of the study at the TU Delft:

  To determine the role of silver on the removal of *E*.coli and MS2 bacteriophages during :

  - the filtration step and
  - the subsequent storage in the receptacle

22 filters from Cambodia shipped to the Netherlands

- The filters contain 4 different ratio`s of rice husk to clay .

- Imitating household practice:
  - Long term Experiments during 16 weeks
  - Operating under falling head.
  - Daily filled with 5,3l of challenge water from a nearby canal (Temp 7,5-16°C).

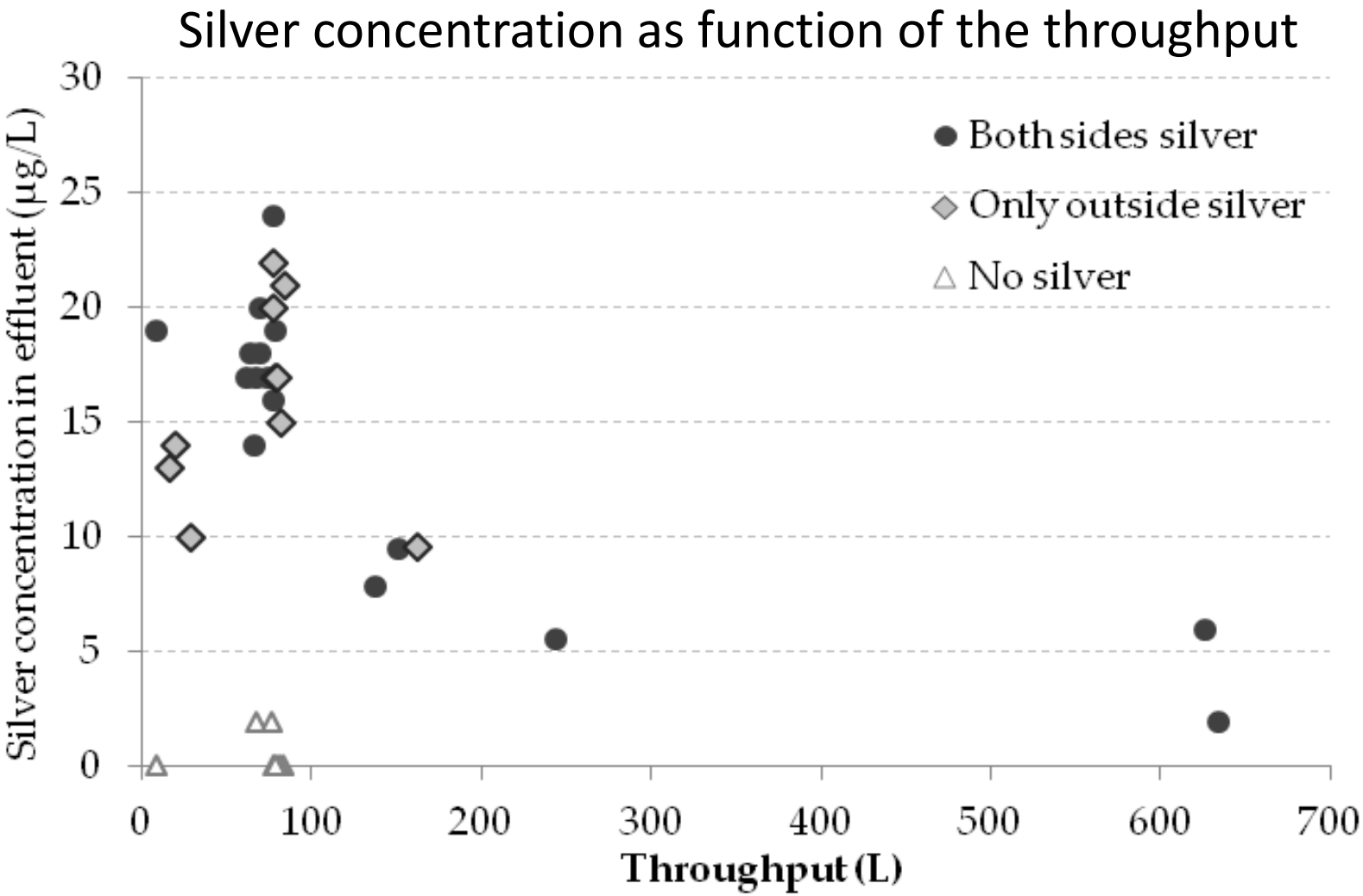
Three types of filters

- Ten filters with AgNO3 on the in & outside
- Six filters with AgNO3 on the outside only
- Six filters not impregnated with silver

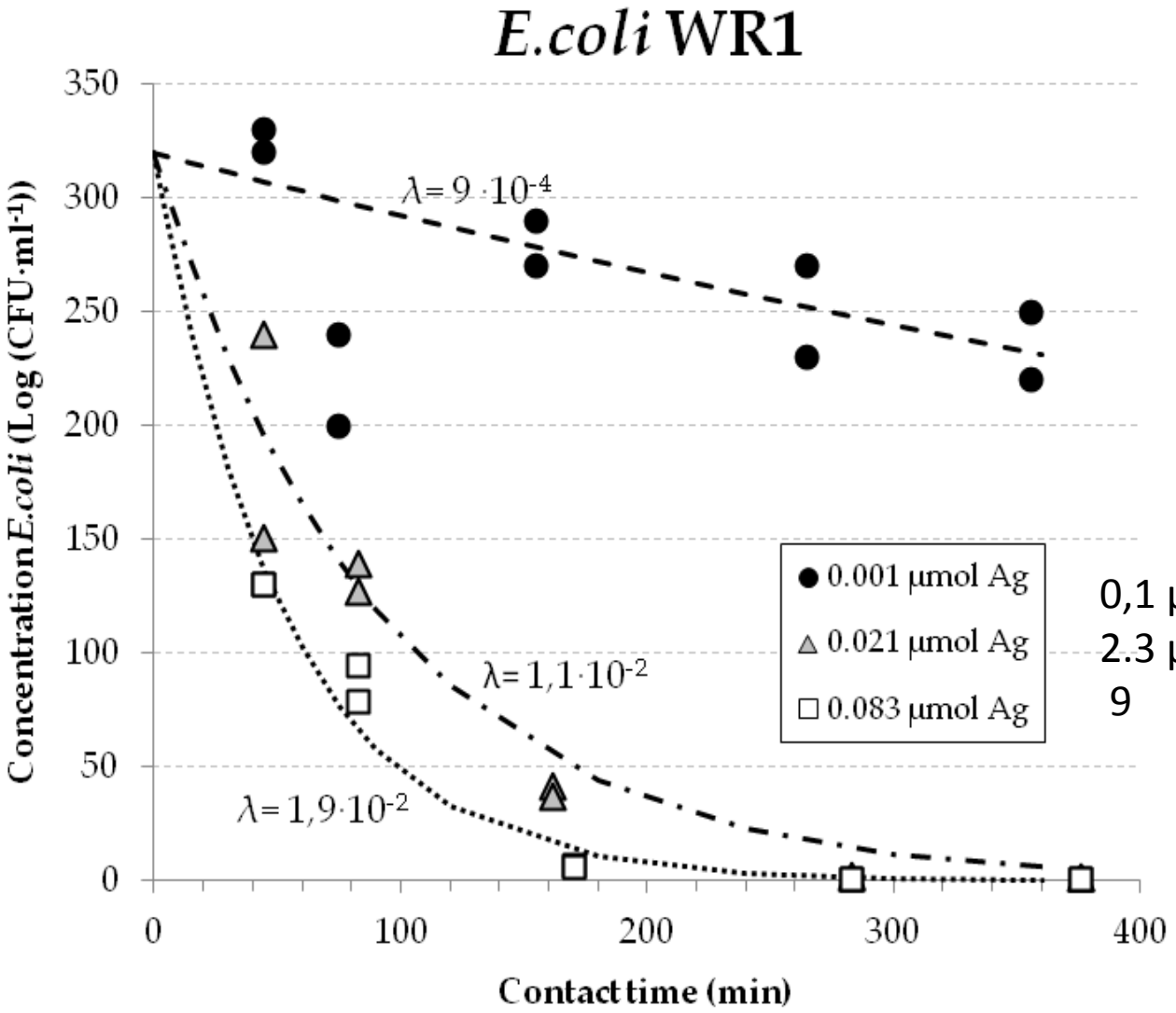
- Loading 70mg of Ag on pots with both sides coated

Experimental set-up at
TU Delft

Silver leaching during the experiment



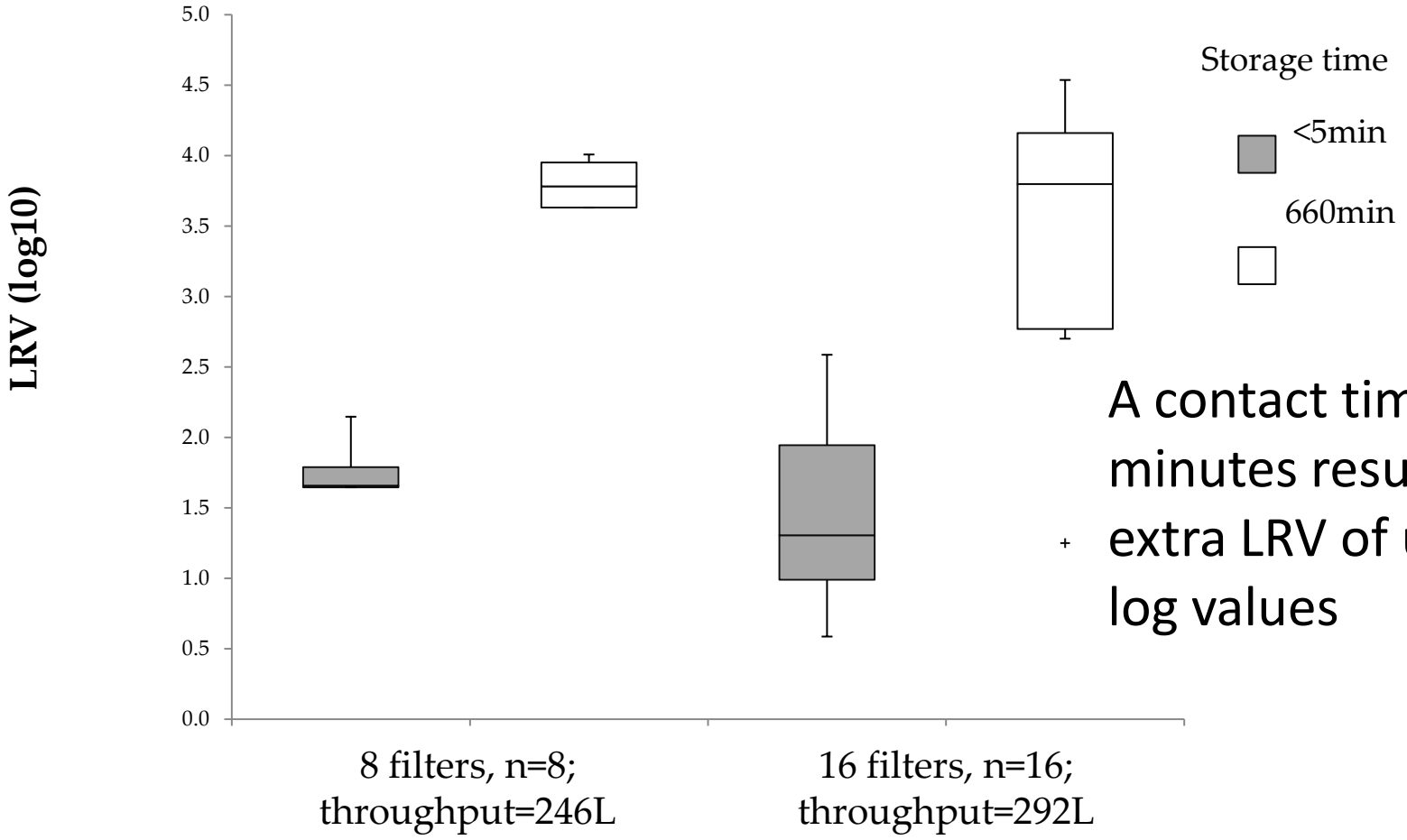
Deactivation of *E.coli* related to contact time



0,1 µg Ag/l
2.3 µg Ag/l
9 µg Ag/l

Effect of Ag: storage step compared to filtration step only

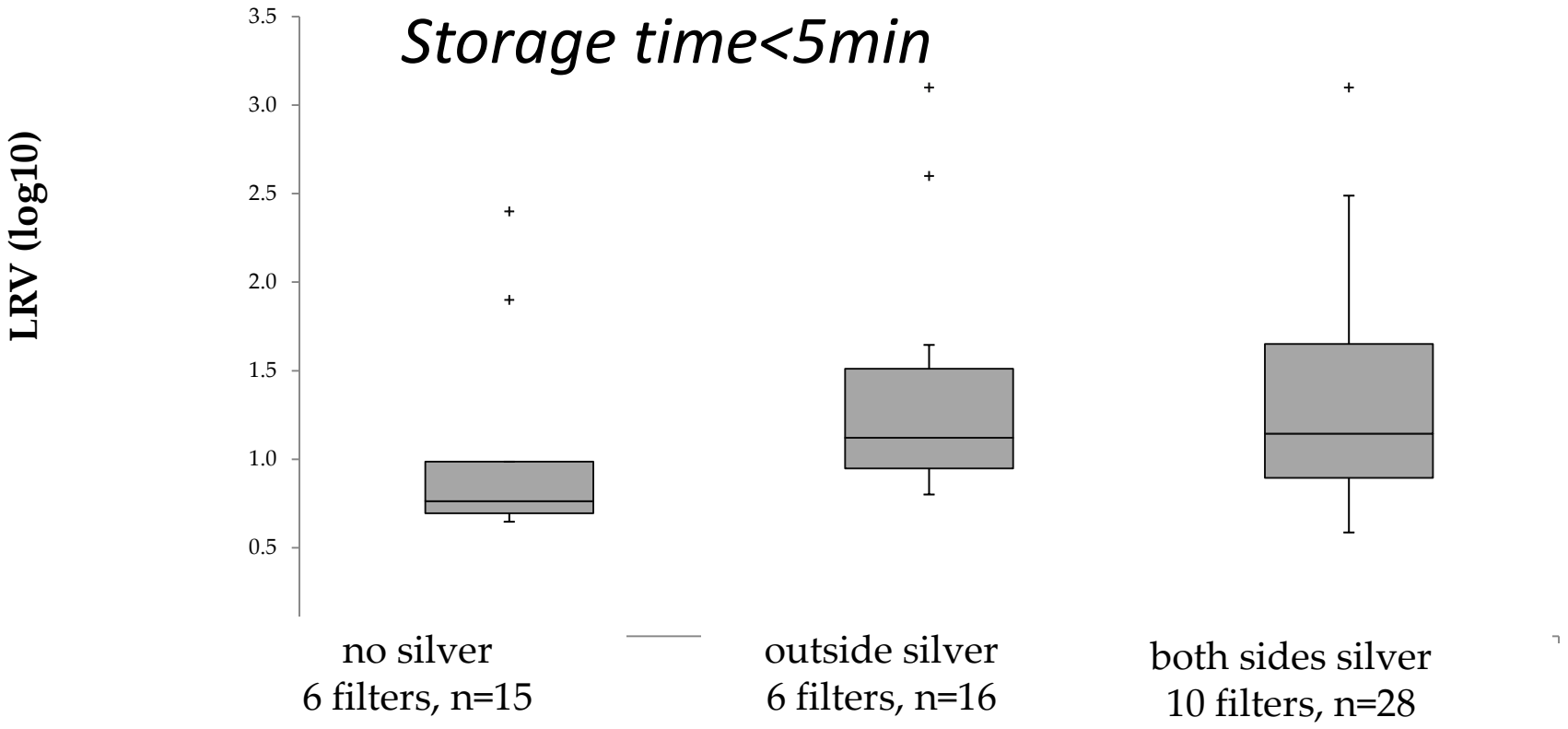
E.Coli removal at two different throughputs



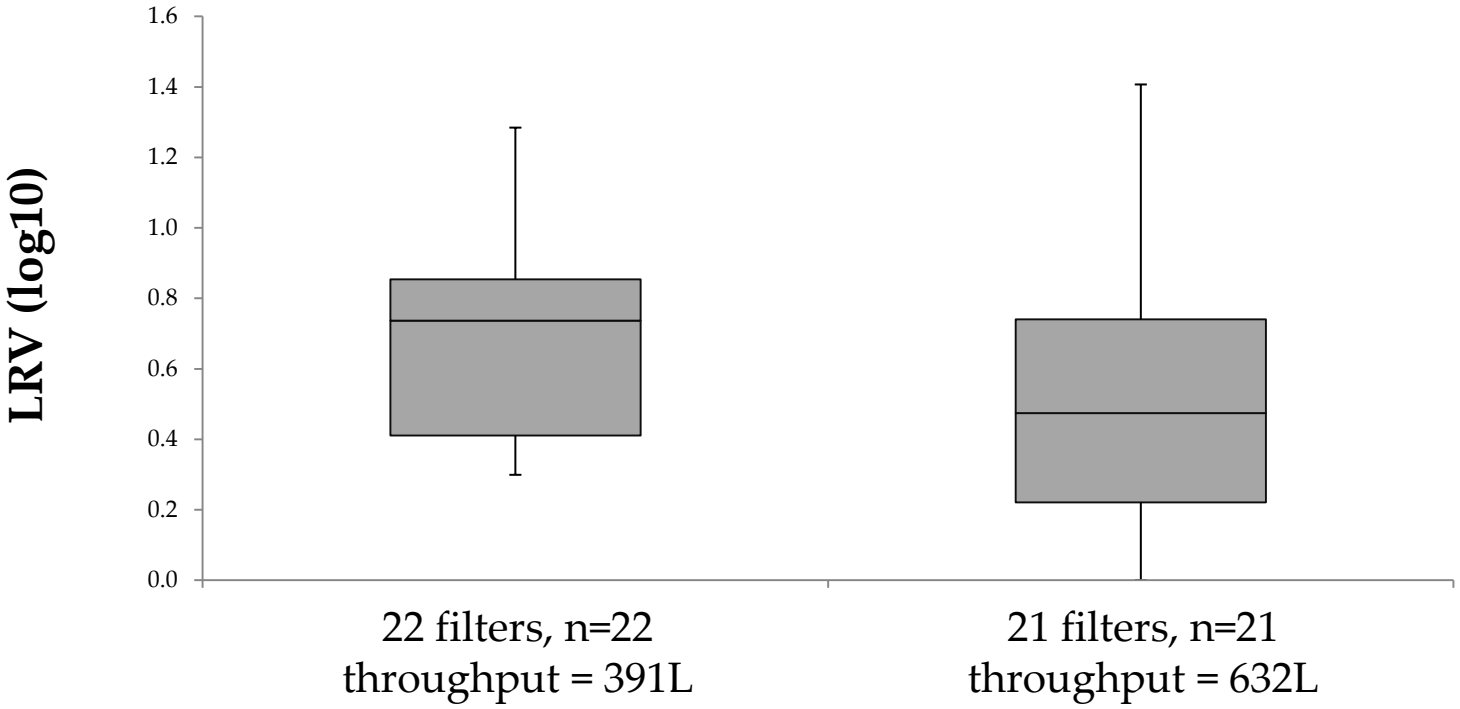
A contact time of 660 minutes results in an extra LRV of upto 2 log values

Effect of Ag during filtration step only

- Statistical analysis confirms: no significant difference between the three silver applications (outside, both sides and none).
- Ag does not play a dominant role in filtration step.



Removal of MS2 bacteriophages

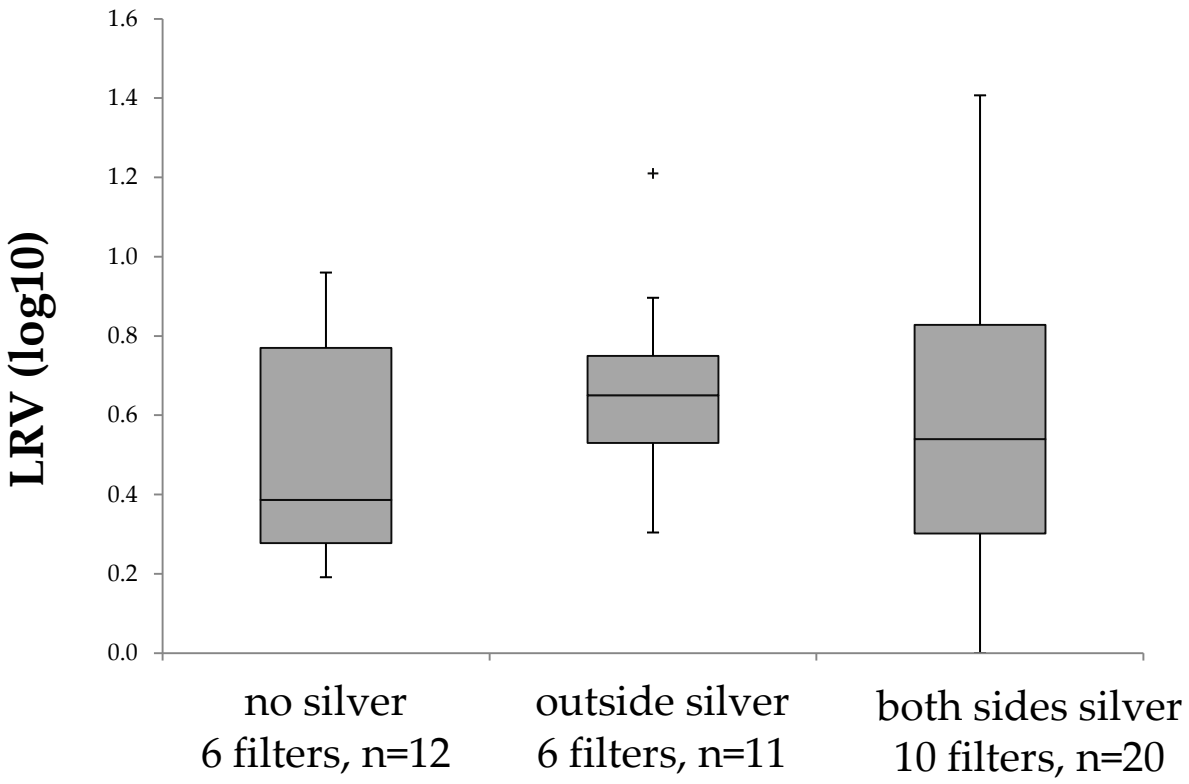


Removals for MS2 vary between a LRV of 0 - 1,4 and are lower than the LRV for E.Coli

Relation between 3 ways of silver application (no ,outside , both sides)

MS2 Removal effectiveness

Statistical analysis shows no relation between various silver applications and the LRV for MS2.



The absence of silver does not enhance MS2 removal

Various Remarks (1):

***E.Coli* removals are quite low (LRV1,2; STD=0,6) compared to other studies.**

Possible causes:

- Difference between naturally present *E.Coli* and lab grown as in this study
- The temperature in this study was rather low 7,5-16°C compared to tropical values

Various remarks (2):

- The influence of silver during storage is found to be crucial.
- The inactivation by silver is not the dominant mechanism during the filtration step, but physical removal mechanisms are.

  This creates chances for a higher flow rate pot.
- The filtration step still remains essential for the removal of suspended solids, and aggregated bacteria .

MS2 removal is still low

- An improved removal by bio-film formation in non silver pots is not found.
- The low temperature of the test water might have created suboptimal conditions for bio-film growth

Measurements at RDI in Cambodia

Variations in:

- Ratio clay to rice husks (30:9,7kg increased to 11, 12, 13 and 14 kg)
- Max firing temperature (665, 800, 885 and 950°C)
- Particle size

The following quality criteria are measured

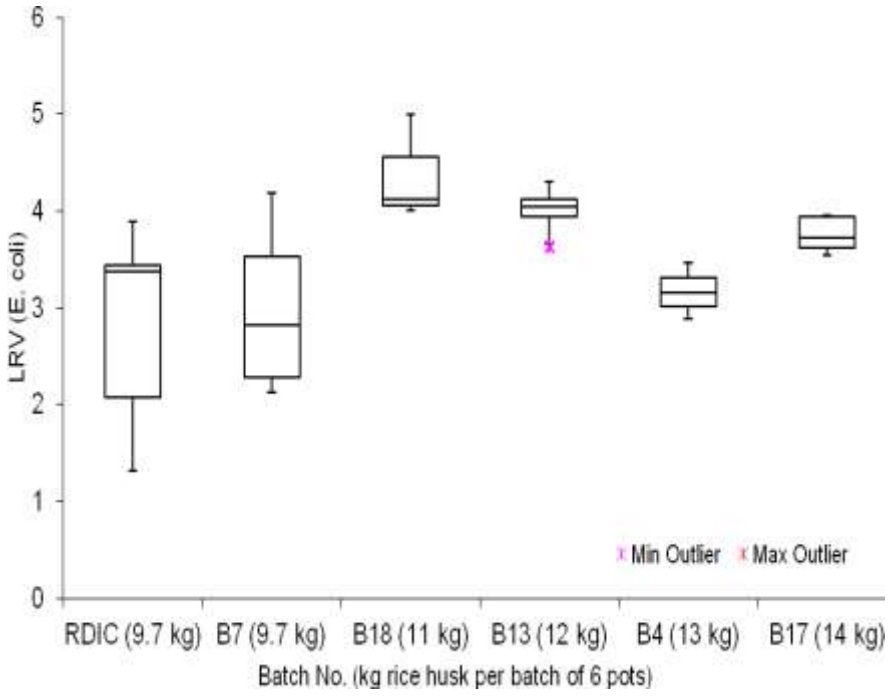
- Flow rate
- Bacteria removal (LRV)
- Material strength (Modulus of Rupture, MoR)

  Tested on discs cut out from the bottom

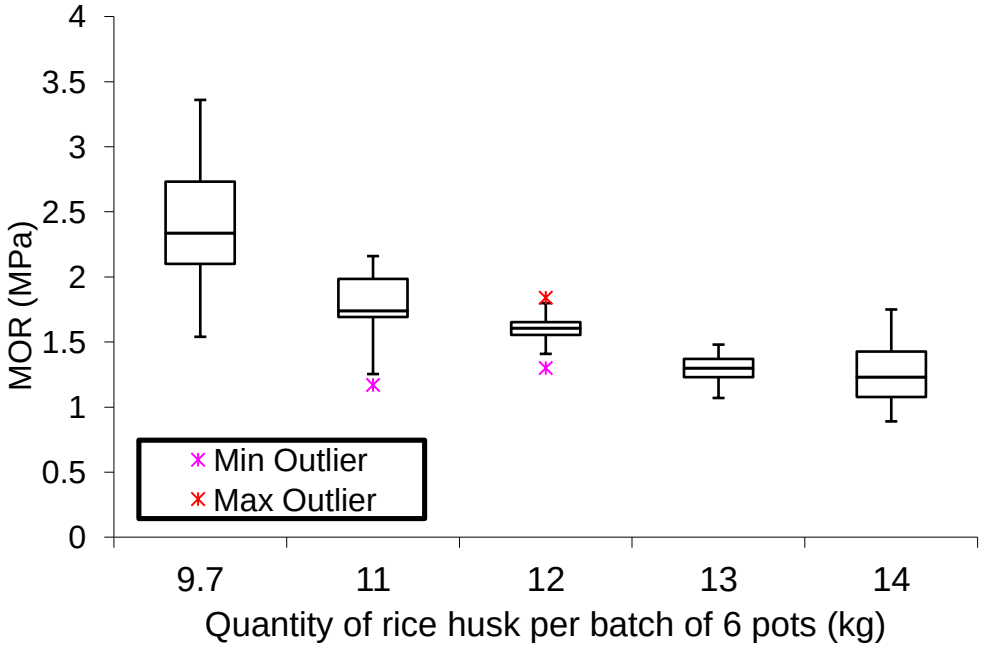
Variations in clay to rice husk ratio

1) Flow rate: steady increase from 3 to 15 L/h with increasing rice husk content.

2) Effect on LRV of *E.Coli*



3) Effect on the MOR

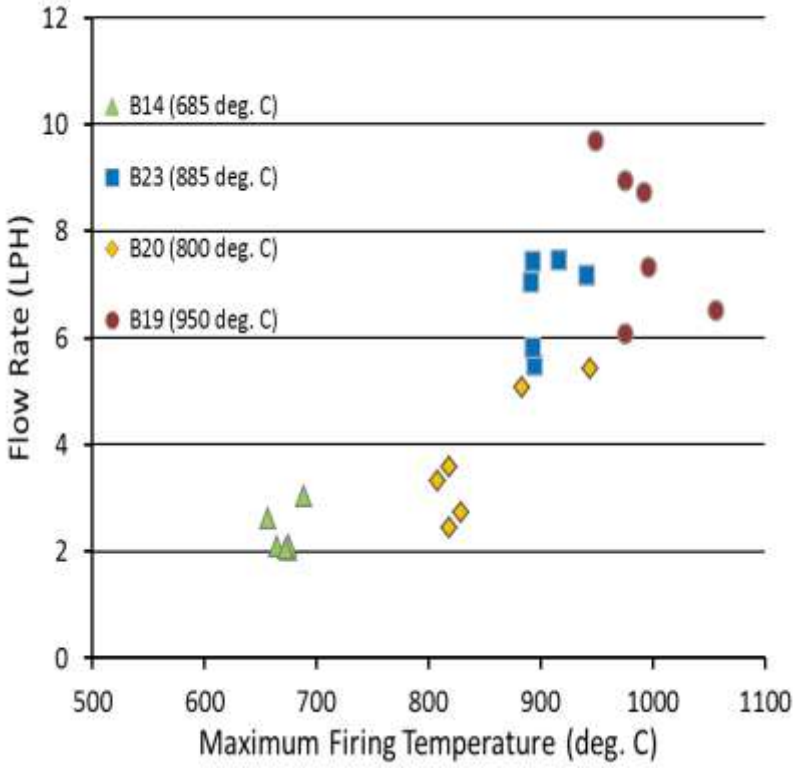


Ad2) No significant reduction in LRV

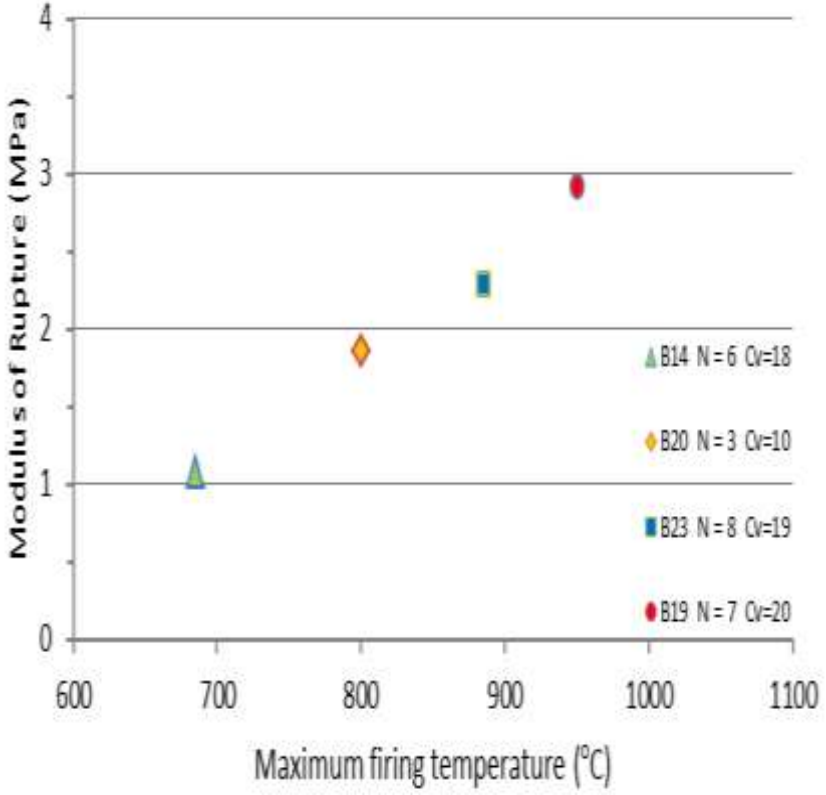
Ad 3) Lower strength with higher quantity of rice husks

Variation of maximum temperature

1) Flow rate



2) Material strength (MoR)



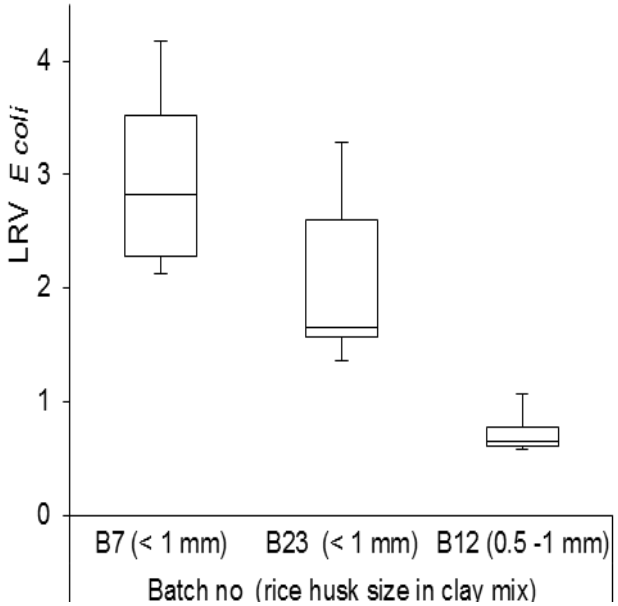
3) LRV: there is a slight reduction in LRV with increasing maximum temperature.

Variation in particle size

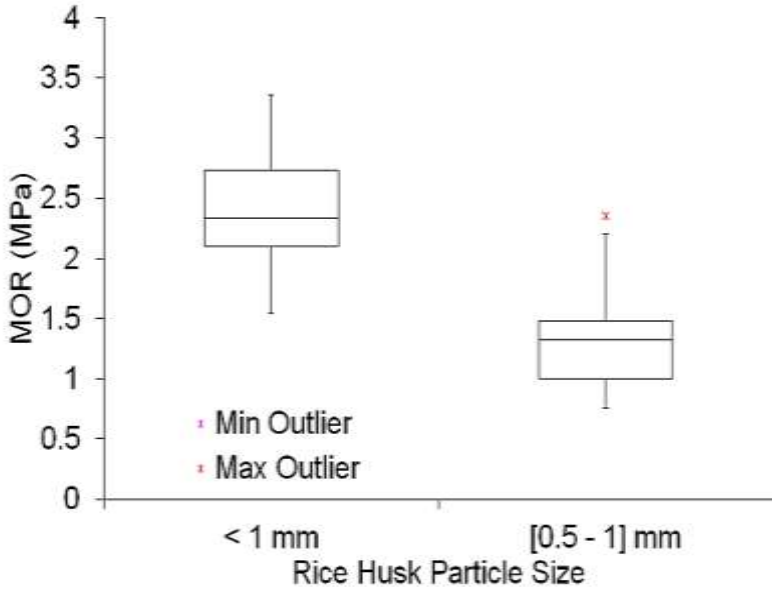
a) Normal distribution with particles from 0-1mm (smaller particles)

b) Extra sieved distribution with only larger particles 0,5-1mm.
Mean effective pore size is larger for larger particles.

1) LRV



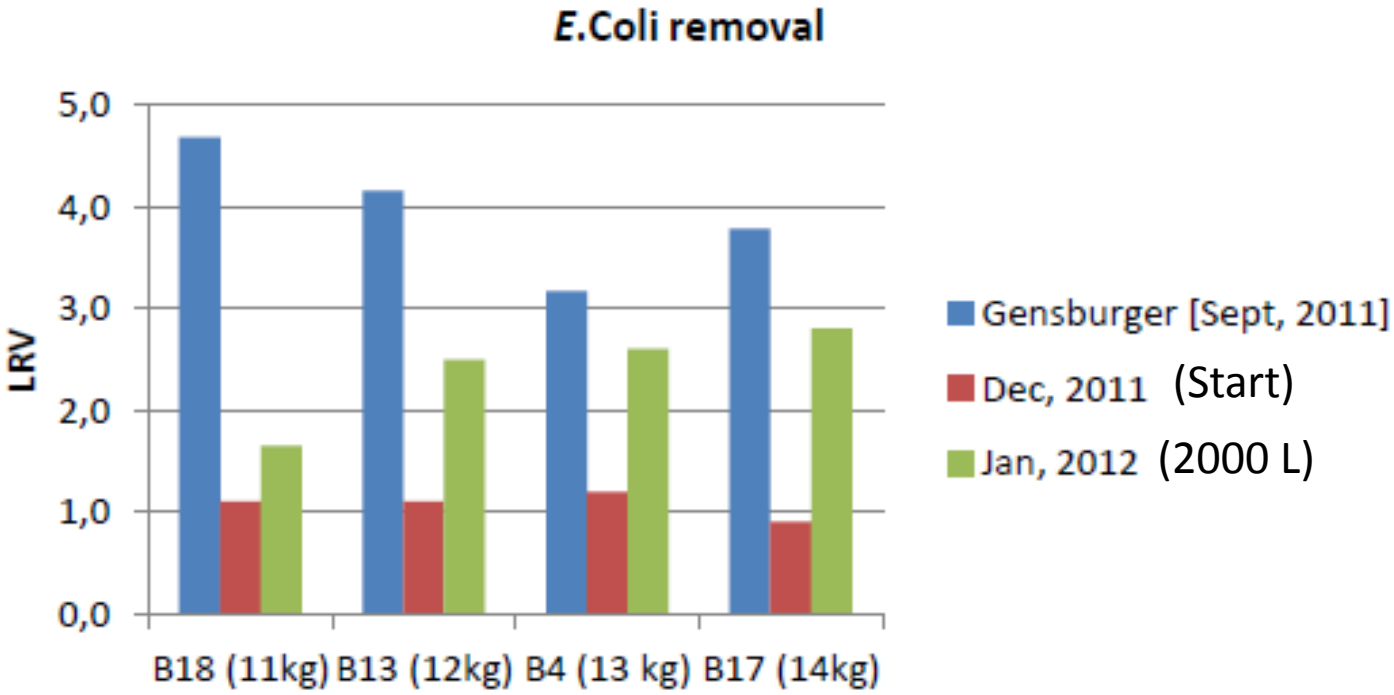
2) Strength (MoR)



3) Flow rate: Avarage flow rate is: for smaller particles 3L/h,
for the larger particles 10L/H

TUDelft:Constant head experiment with high flow rate filters

- Flow rate measurements during 2,5 week on filters with 4 different rice husk ratio`s (11 to 14 kg :30kg of clay)
- Scrubbing when flow <2L/h; throughput 1600 to 4000L.
- No single pot has been broken after transportation and various scrubbing sessions.



After a throughput of 2000L the LRV increases for all the ratio`s

Can we improve the filters?

- Filter improvement
  (higher flow rate, higher LRV, not compromising strength)

- Significant increase in flow rate is possible by increasing the ratio of husks to clay mix (increase of porosity) without reducing the bacteria removal efficiency.
- The effect of silver is not taking place during the filtration step; from this point of view a higher flow rate is not a problem
- However the material strength will be reduced.
- At a higher firing temperature greater strength will be obtained.

Higher flowrates

- There are good possibilities for a higher flow rate without compromising the LRV (bacteria removal)
- Local experiments will be required to find a good balance between increased flow rate and material strength.
- With flow rates up to 10 -15L/h it is not expected to compromise the LRV based on our research , but this should always be verified for the local conditions

Silver findings

- Inactivation of bacteria by silver in the wall of the ceramic filter is not the dominant factor.
- The effect of silver is the result of the Ct value (concentration x contact time) in the receptacle. LRV of 2 log values can be gained during storage

Other conclusions

- Ceramic pot filters seem rather robust regarding the bacteria removal capacity.

  A small deviation during production in the investigated parameters like firing temp. and ratio seem not to influence the bacteria removal capacity.
- The particle size distribution is the main responsible parameter for the LRV (determining the pore size), so a good selection and a good control of the particle size is critical.
- No production variable was found in this study to enhance the virus reduction.
- Crucial for the system is a receptacle for safe storage,

  that allows for the essential contact time with silver.

Sources of the presentation

The information, graphs and plots in this presentation are taken from the following literature and reports:

-Laan, H. van der, Halem, D. van , Smeets, P.W.M.H., Soppe, A.I.A., Kroesbergen, J., Wubbels, G., Nederstigt, J., Gensburger, I., Heijman, S.G.J..

Bacteria and virus removal effectiveness of Ceramic Pot Filters with different silver applications in a long term experiment. Water Research 51, (2014) 47-54.

Contact: harmen.van der.laan@oasen.nl

- Critical Parameters in the Production of Ceramic Pot Filters for Household Water Treatment in Developing Countries

A.I.A. Soppe[a,*], S.G.J. Heijman[b], I. Gensburger[c,d], A. Shantz[e], D. van Halem[b], J. Kroesbergen[f], G.H. Wubbels[g], P.W.M.H. Smeets[h]. Contact: gsoppe@planet.nl

-Gensburger, I., 2013. The Ceramic Water Filter, Investigation Critical Parameters in the Production of Ceramic Water Filters. Final Report, Dutch Research Group Ceramic Pot Filters.

-N.Waagmeester,2012,Constant head research, Batchelor thesis

Research partners

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