Slow Sand Filters

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SCRI - CLEAN WATER^3
REDUCE, REMEDIATE, RECYCLE

UCDAVIS
PLANT SCIENCES

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Slow Sand Filtration

- What is slow sand filtration?
- System design and operation
- Research results

Rapid Sand Filtration

- Coarse sand (>1mm)
- Removes particulates only
- Does not remove pathogens or pollutants
- 80-800 Lpm/m^2 (~2-20 gpm/ft^2)
- Low maintenance

Slow Sand Filtration

- Remove pathogens
- Removes many other pollutants
- Low maintenance
- Slow flow rates
  - 2.4-8 Lpm/m^2
  - 4m dia tank can treat 43 – 145 m^3/d

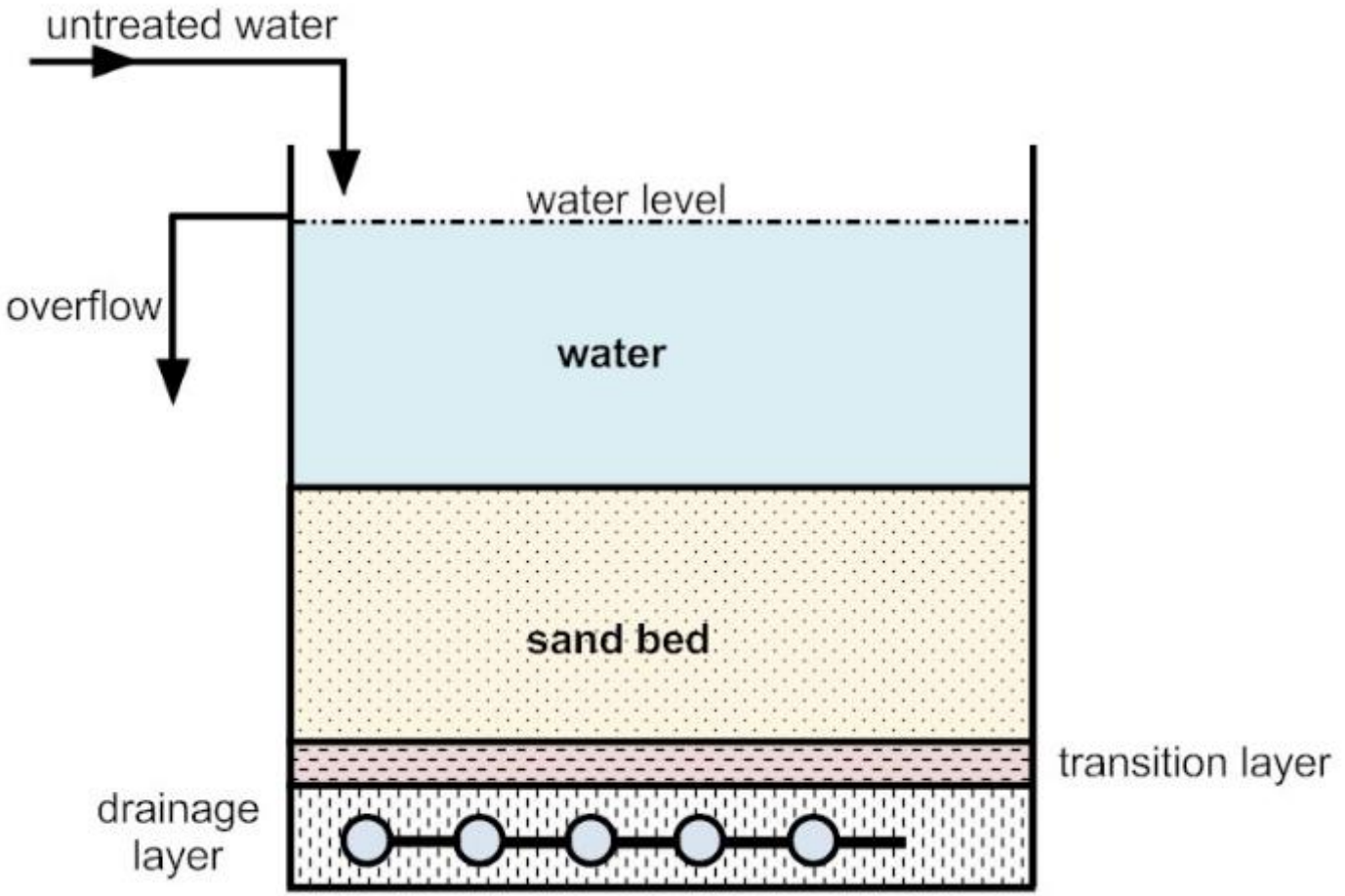
Mechanism

- "Schumtzdecke"
  where most treatment occurs
  - A community of microorganisms
  - Sand bed surface to 15 cm below
- Organism that have been identified:
  - Bacteria, diatoms, zooplankton, algae
- Mechanisms not fully understood
- Particulates should be removed first

Specifications

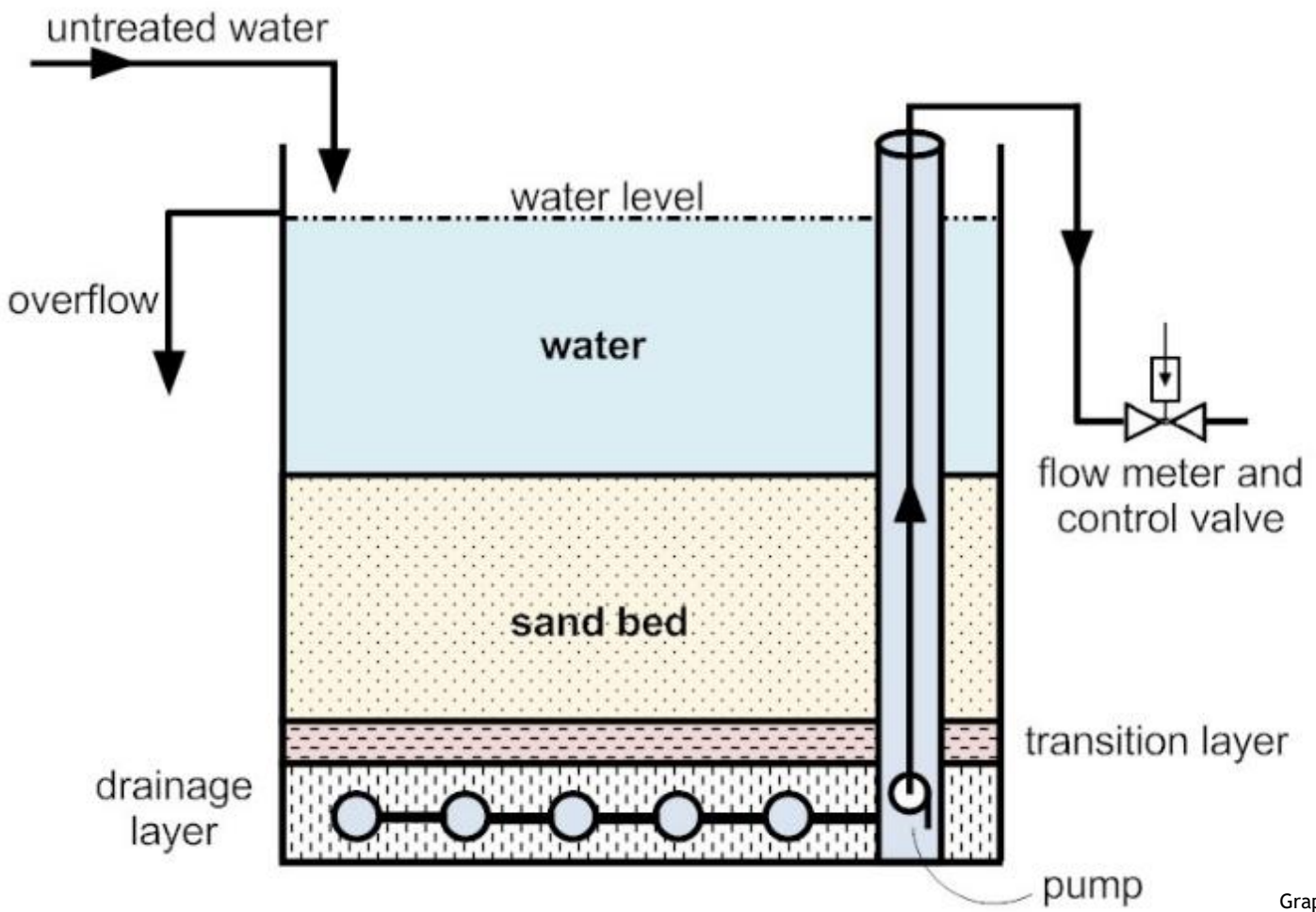
- Uniform particle size
  - 30-60 mesh (0.425-0.3mm)
  - Uniformity Coefficient (UC)<3
- Round, not sharp grains
- 1m water head over sand
- Sand must stay submerged
- Sand surface must not be disturbed
- Flow control
- Recommend 1m sand depth
- Recommend at least two filters

System Design



Graphic: L. Oki

System Design



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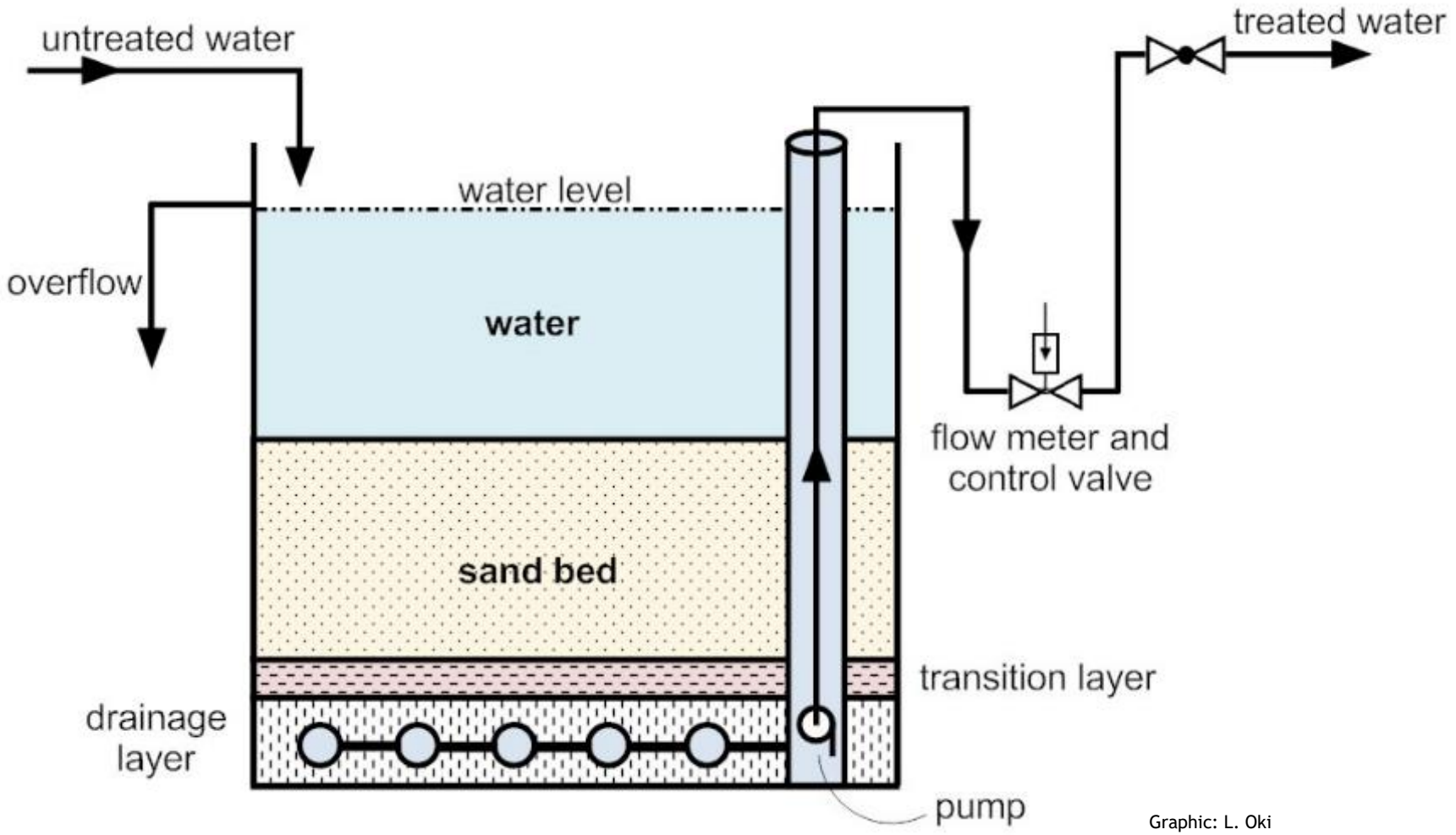
System Design



Graphic: L. Oki

Installations

Estimated treatment capacity
≈ 50 ft^2 (5 ft x 10 ft)
@ 90 gpd/ft^2 → 4,500 gpd

Berylwood Tree Farm, Somis, CA

Installations

- 850 ft^2 surface
  - 33 ft dia.
- 60,000 gpd
- Treated storage
  - 132,000 gal
- Untreated storage
  - 1,720,000 gal

Roundstone Nurseries, UK

Photo: L. Oki

Horticultural Development Council, 2005

Installations

350,000 gpd
~4,440 sq.ft

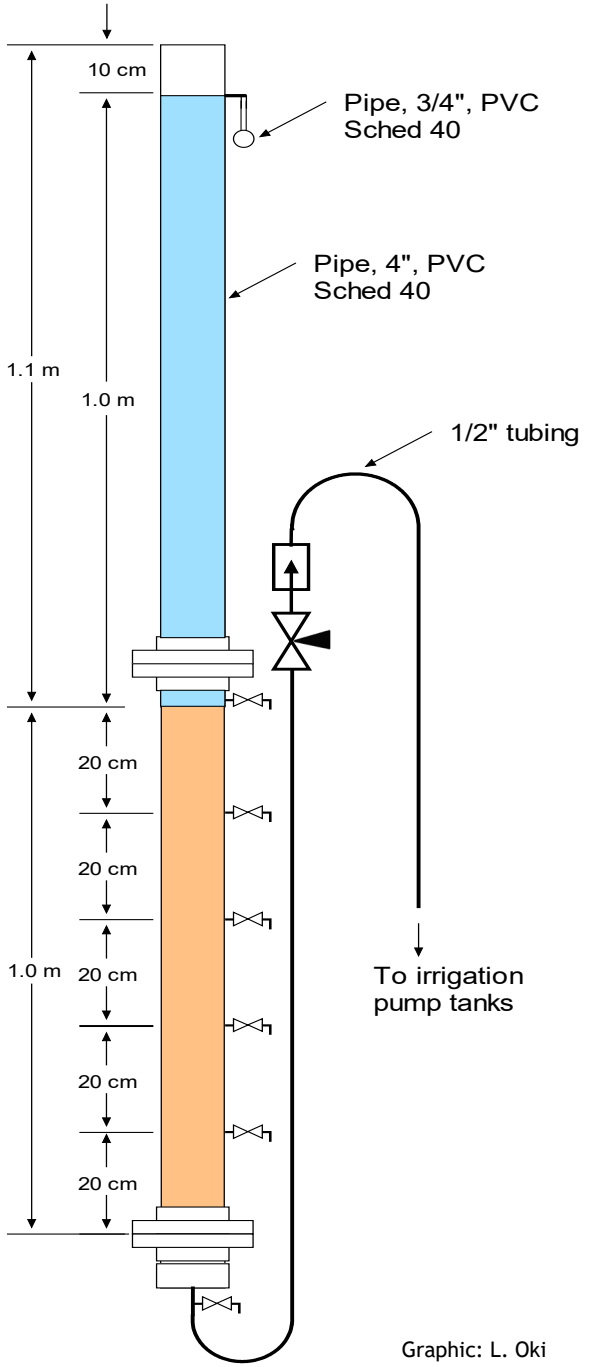
Supernatant water

Filter surface (sand)

Underdrain system (lowest level)

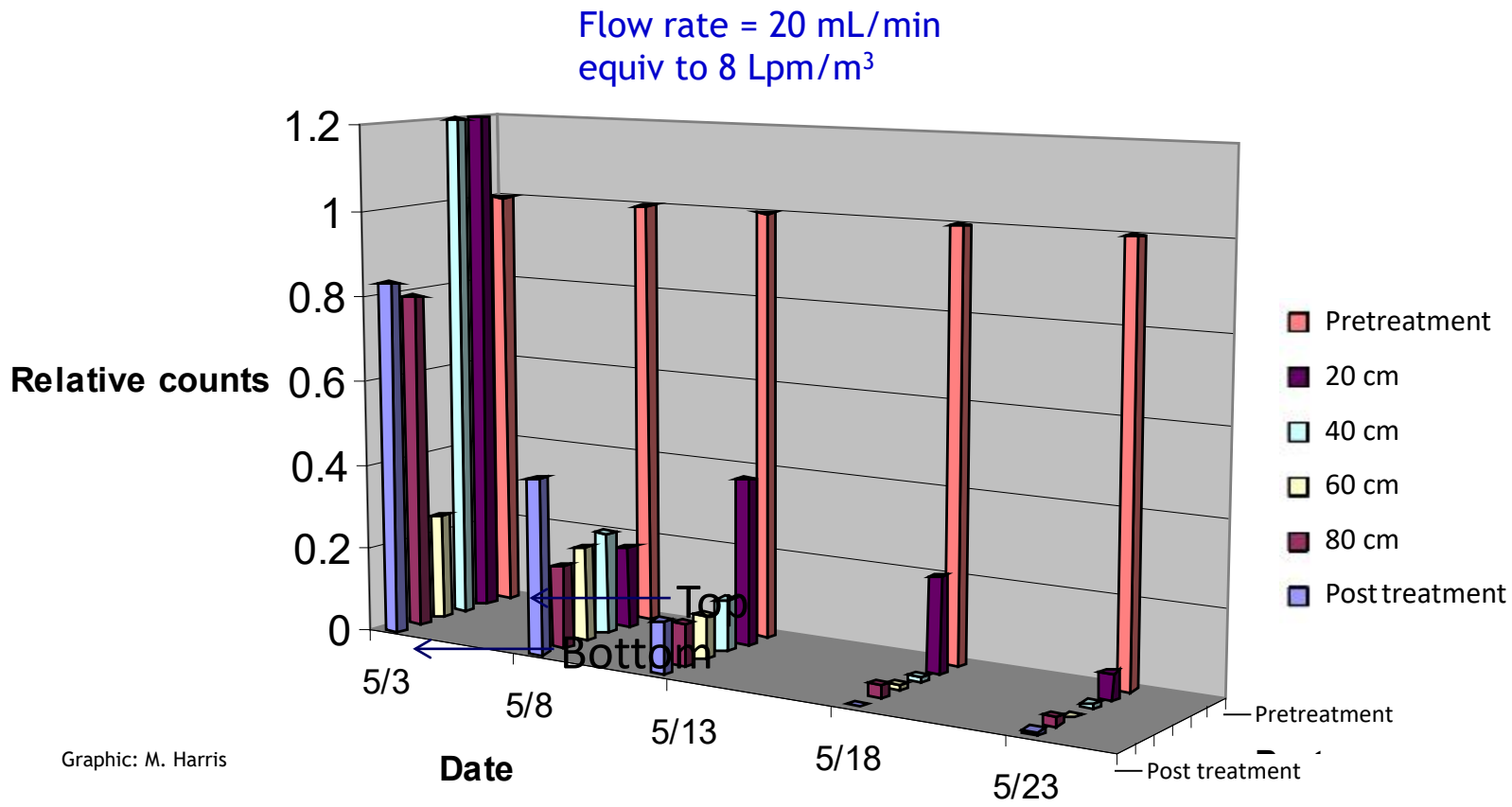
From: Sabine Werres, Federal Biological Research Center for Agriculture and Forestry, Braunschweig, Germany

SSF Studies



Graphic: L. Oki

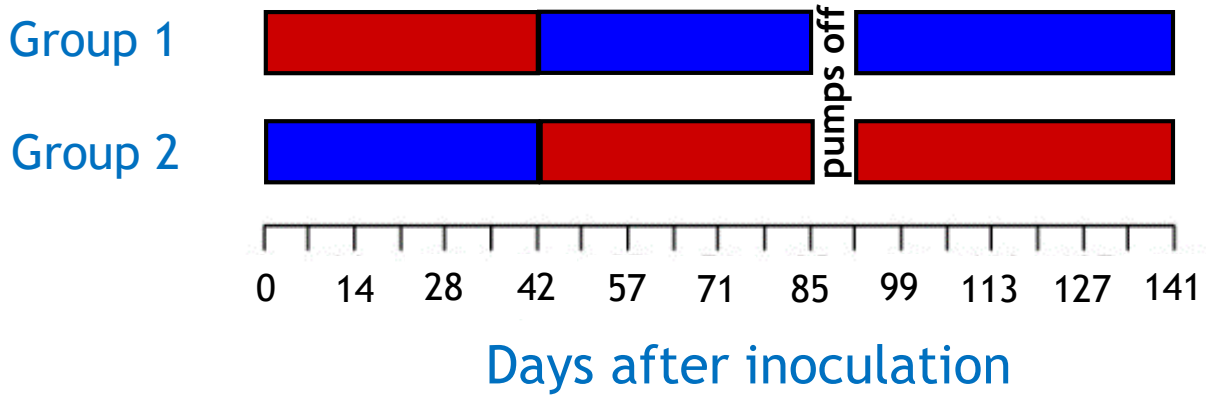
Treatment Performance



Graphic: M. Harris

Pathogen switch

And simulated pump failure



Phytophthora capsici

Fusarium oxysporum (added directly to filter)

TMV removal

- Purified TMV added to columns
- Collected water samples weekly
- Testing via
  - ELISA
  - bioassay
    - *Leaf- N. glutinosa, C. quinoa*
    - *Whole plant- N. tabacum, N. benthamiana*
- 6-9 weeks to achieve removal

Virus removal

- Purified TMV added to columns
- Collected water samples weekly
- Testing via
  - ELISA
  - bioassay
    - *Leaf- N. glutinosa, C. quinoa*
    - *Whole plant- N. tabacum, N. benthamiana*
- Required 6-9 weeks to achieve removal

Virus removal, bioassay results

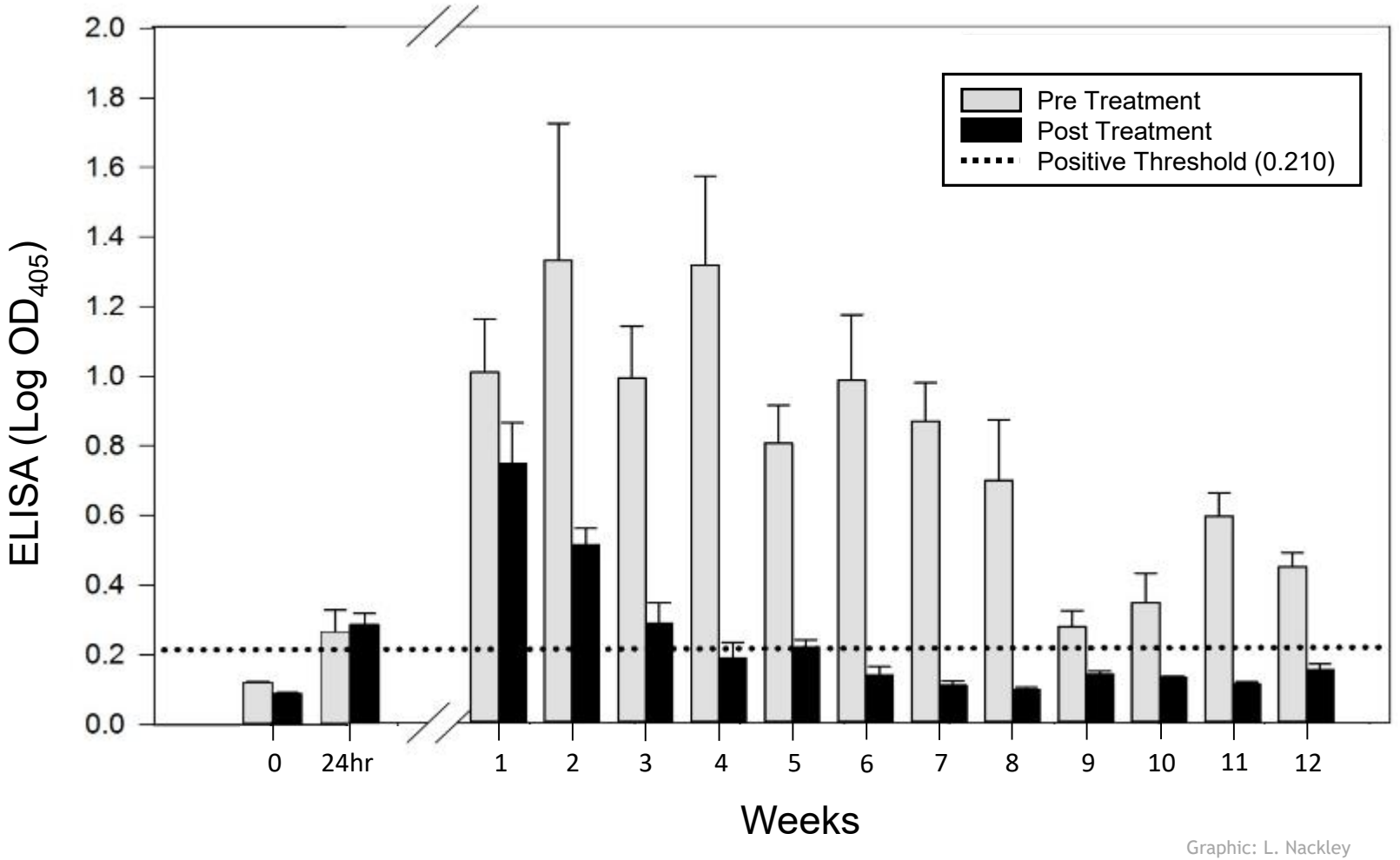
TIME	Column 2 N.b./N.t.	Column 3 N.b./N.t.	Column 4 N.b./N.t.
-0	-/-	-/-	-/-
24 hrs	+/+	+/+	+/+
Wk 1	+/+	+/+	+/+
Wk 2	+/+	+/+	+/+
Wk 3	+/+	+/+	+/+
Wk 4	+/+	+/+	+/+
Wk 5	-/+	+/+	+/+
Wk 6	-/-	-/-	-/-
Wk 7	-/-	-/-	-/-
Wk 8	-/-	-/-	-/-
Wk 9	-/-	-/-	-/-
Wk 10	-/-	-/-	-/-
Wk 11	-/-	-/-	-/-
Wk 12	-/-	-/-	-/-

← Before TMV addition

Samples collected from below sand bed

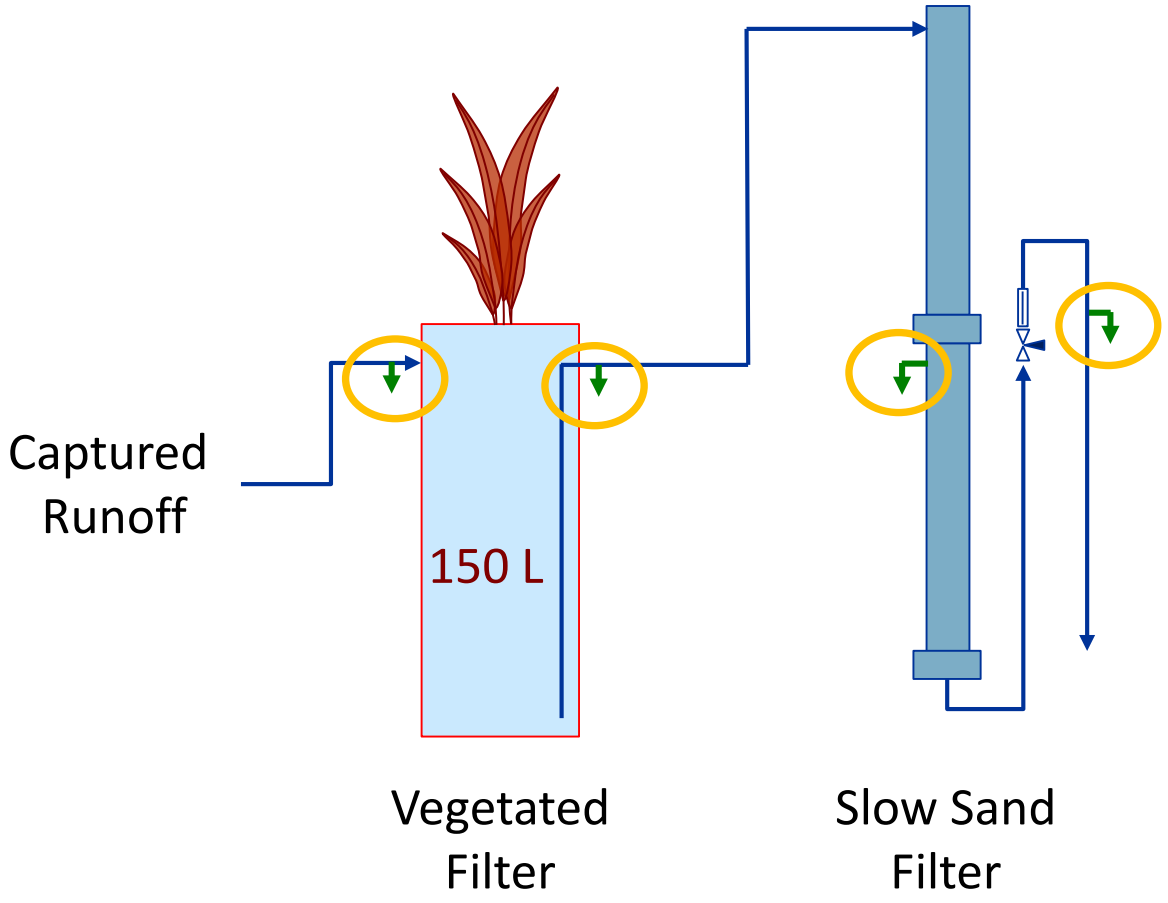
Systemic hosts *Nicotiana benthamiana* (N.b.) and *N. tabacum* (N.t.)

ELISA Assay

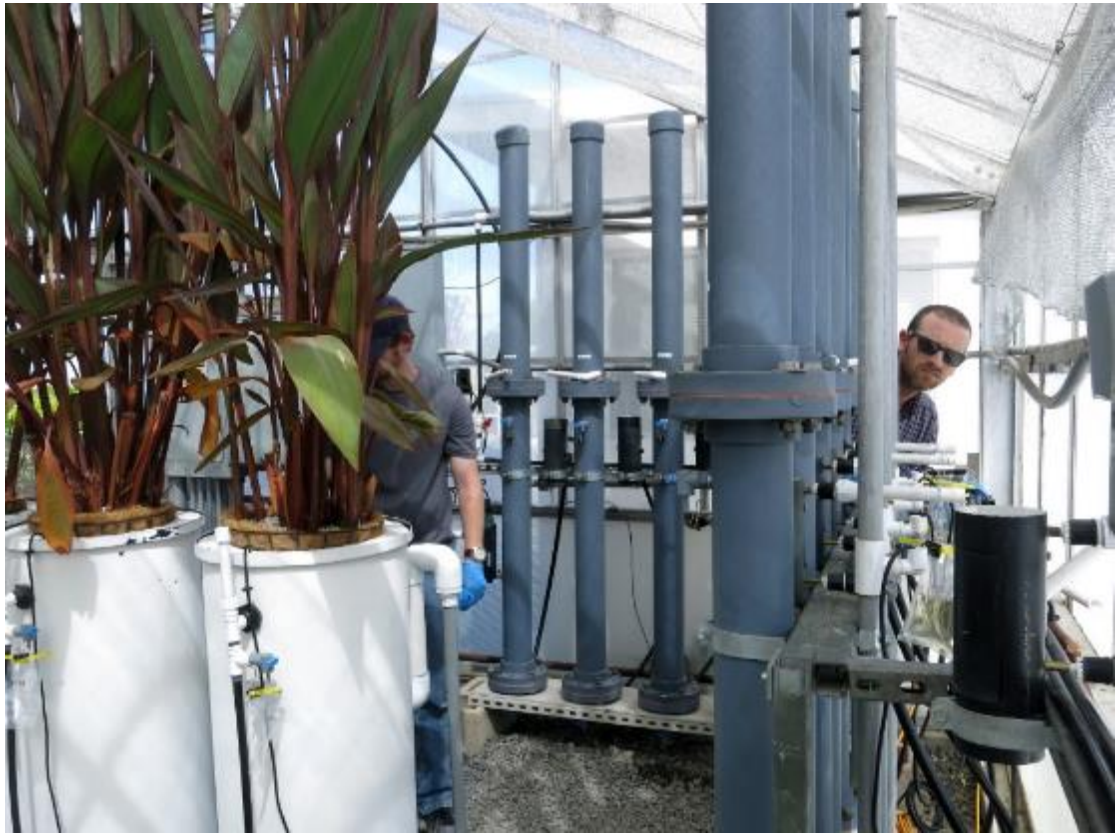


Graphic: L. Nackley

Coupled Vegetated Filters and SSFs



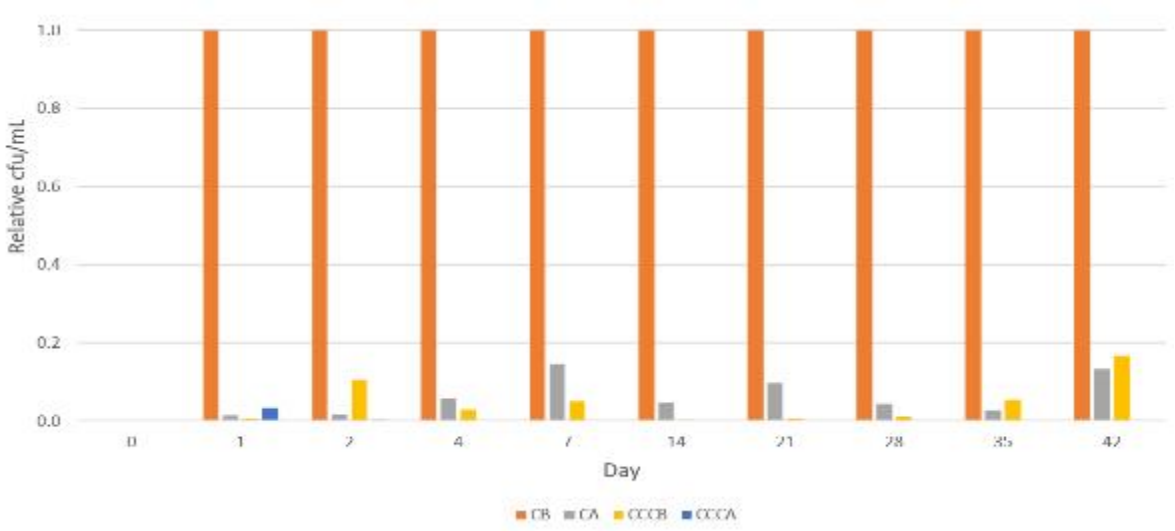
Coupled Vegetated Filters and SSFs



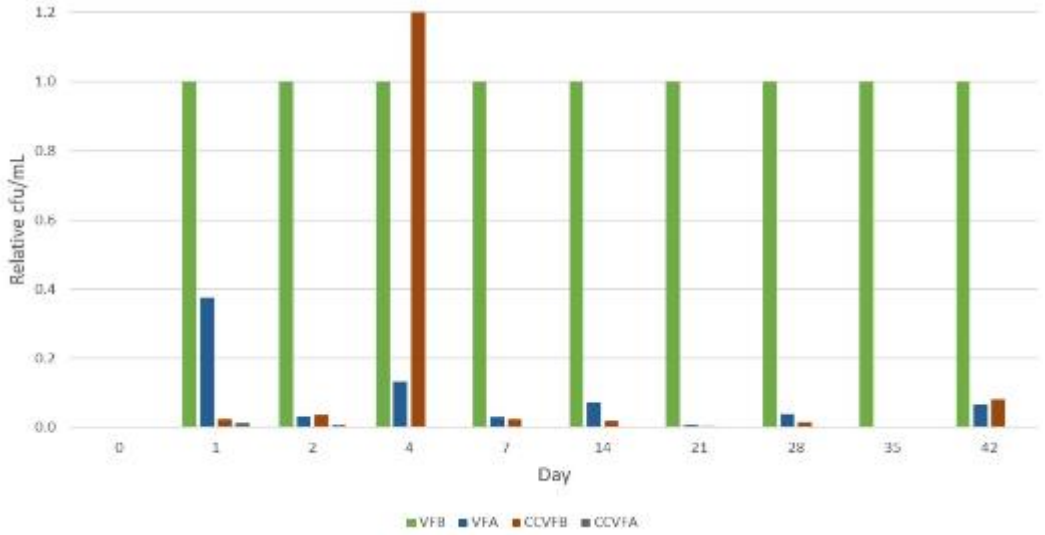
Coupled Vegetated Filters and SSFs

Coupled Vegetated Filters and SSFs

Without plants



With plants



Coupled Vegetated Filters and SSFs

- Plants didn’t matter
- Likely slow exchange rate
- Stratification of inoculum to upper depth of tank
- Settling of particulates

Capabilities

- Can Remove
  - Pathogens
  - Nutrients (reductions)
  - Chemical Pollutants
    - Plant growth regulators (PGRs)
    - Paclobutrazol (Bonzi)


Thank you
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