Slow Sand Filters

Remove TMV & Other Pathogens

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Photo: L. Oki

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University of California
Agriculture and Natural Resources

Slow Sand Filtration

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

What is Slow Sand Filtration?

Sand Filters
- Rapid sand filtration
- Slow sand filtration

What is Slow Sand Filtration?

Rapid sand filtration

- Coarse sand (>1mm)
- Removes larger particles only
- Does not remove pathogens or pollutants
- 2-20 gpm/ft^2
- Low maintenance

What is Slow Sand Filtration?

Slow sand filtration

- Removes pathogens
- Removes many pollutants
- Low maintenance
- Slow flow rates
  - 0.06–0.2 gpm/ft^2 (33-100× slower)
  - 12' dia tank can treat 10,000 gpd

Mechanism

- "Schmutzdecke"
Where most treatment occurs
  - A community of microorganisms
  - Sand bed surface to 6 inches below
- Organisms that have been identified:
  - algae, bacteria, diatoms, and zooplankton
- Mechanisms for removal are not fully understood
- Particulate removal before filtration

Capabilities

Can remove

- Pathogens
- Nutrients (reductions)
- Chemical pollutants

Specifications

- Uniform particle size
  - 30-60 mesh (0.425-0.3mm)
  - Uniformity Coefficient (UC)<3
- Round, not sharp
- 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
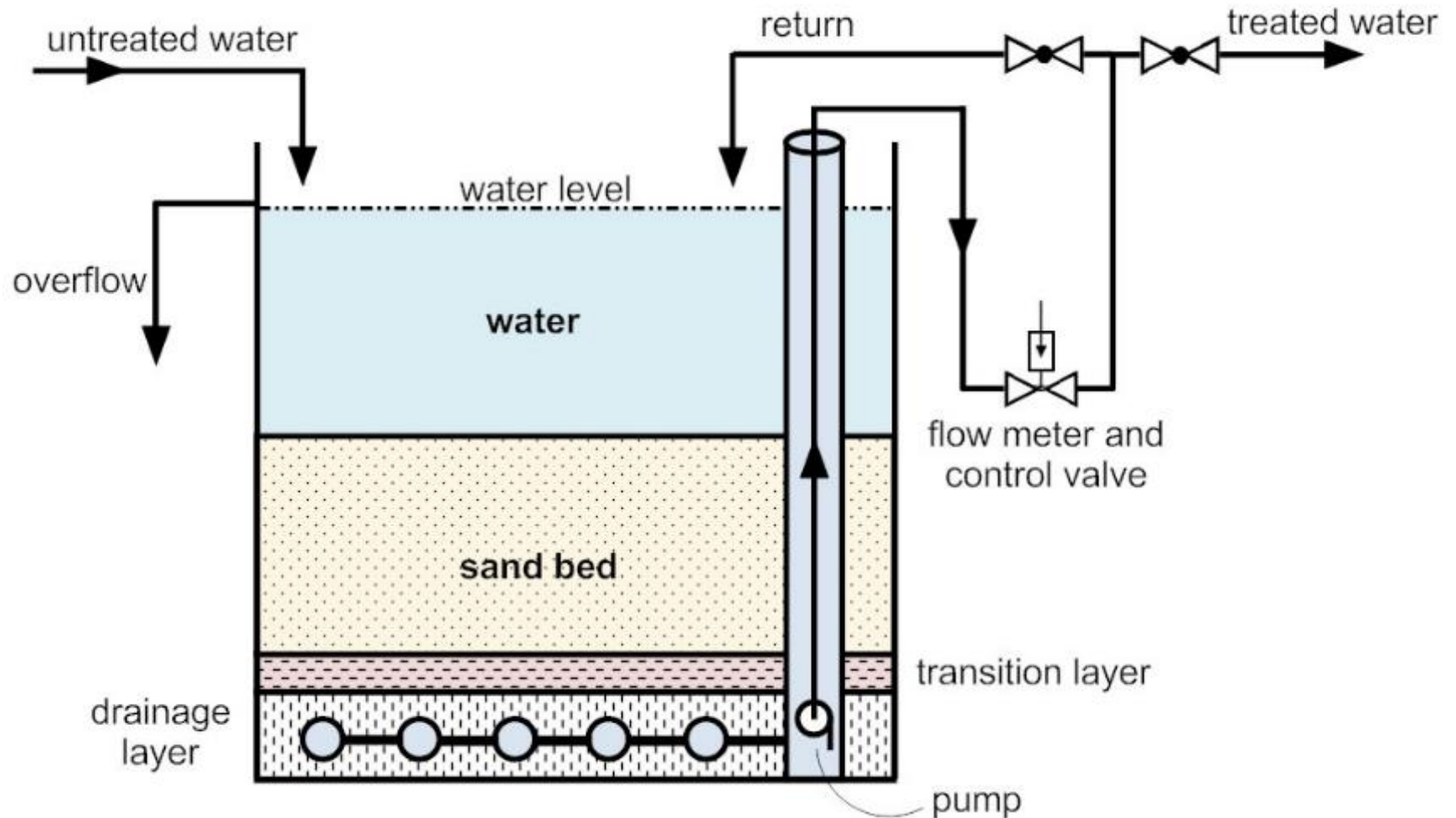
Installations

Estimated treatment capacity
≈ **50 ft^2** (5 ft x 10 ft)
@ 90 gpd/ft^2 → 4,500 gpd
@ 70 gpd/ft^2 → 3,500 gpd

Berylwood Tree Farm, Somis, CA

Installations

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

Roundstone Nurseries, UK

Horticultural Development Council, 2005

Installations

350,000 gpd
~4,440 sq.ft
@80 gpd/ft^2

Supernatant water

Filter Cover

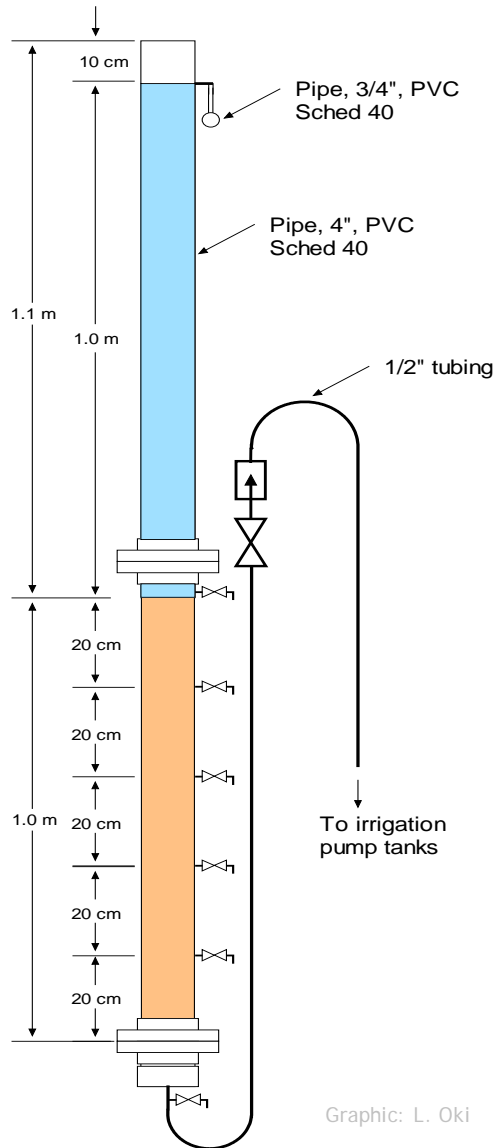**Filter surface (sand)**

Underdrain system (lowest level)

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

Experimental Design

Flow rates and time-to-treatment

- Generate and capture irrigation runoff
- Inoculate treatment water
  - *Phytophthora capsici*
- Collect water samples
  - Pretreatment
  - From within sand bed
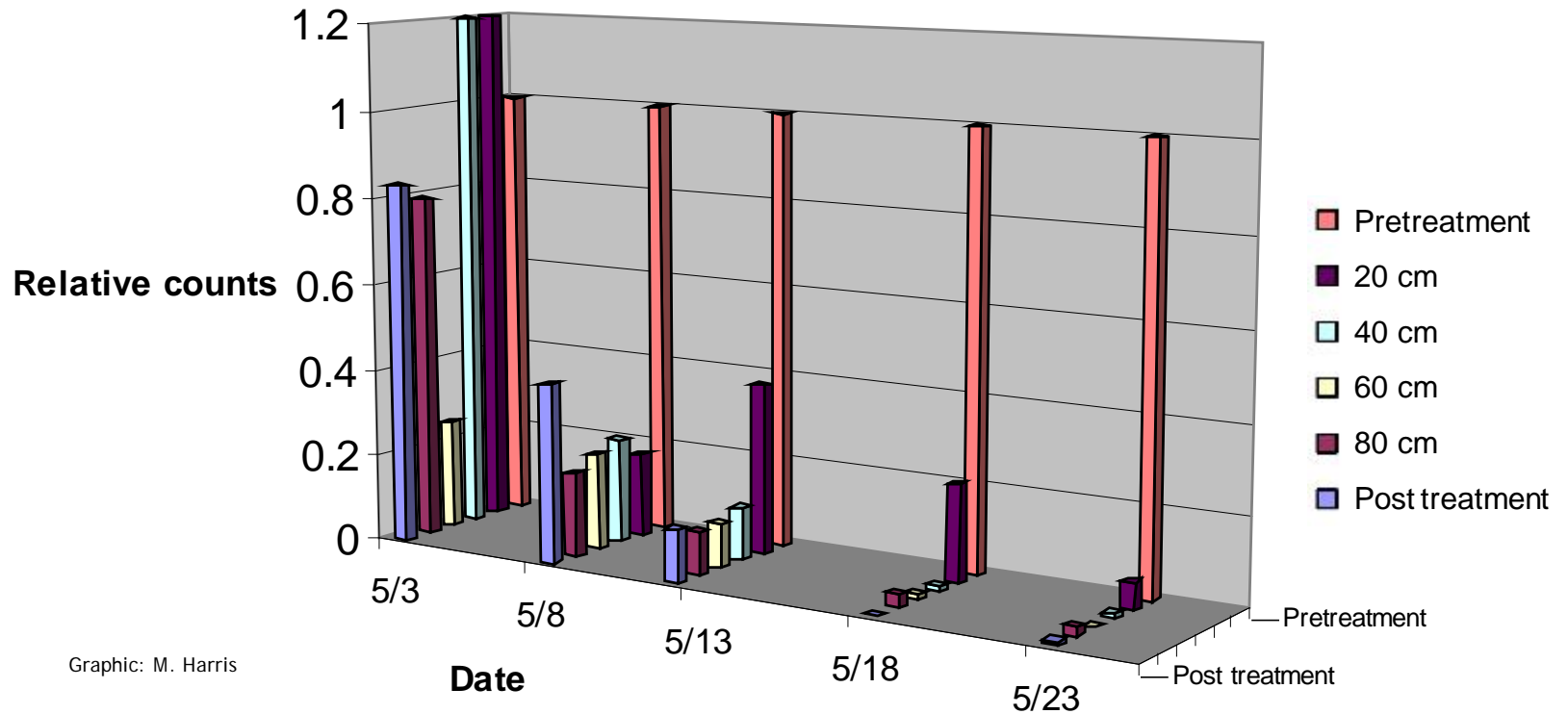 - Post treatment
- Analyze for *P. capsici*

SSF Studies

10 cm

Pipe, 3/4", PVC
Sched 40

Pipe, 4", PVC
Sched 40

1.1 m

1.0 m

1/2" tubing

20 cm

20 cm

1.0 m   20 cm

20 cm

To irrigation
pump tanks

20 cm

Graphic: L. Oki

Photo: L. Oki

Treatment Performance

Flow rate = 20 mL/min
equiv to 90 gpd/ft^2

Relative counts

1.2
1
0.8
0.6
0.4
0.2
0

5/3
5/8
5/13
5/18
5/23

Date

Graphic: M. Harris

Pretreatment
20 cm
40 cm
60 cm
80 cm
Post treatment

Pretreatment
Post treatment

Pathogen switch

And simulated pump failure

Group 1

Group 2

pumps off

0   14   28   42   57   71   85   99   113   127   141
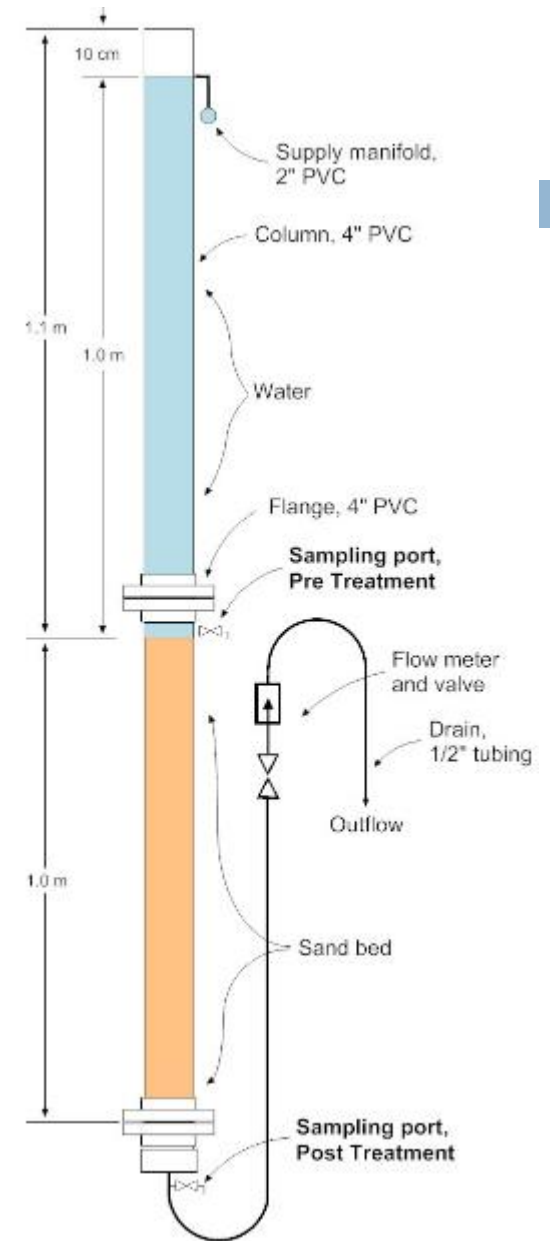
Days after inoculation
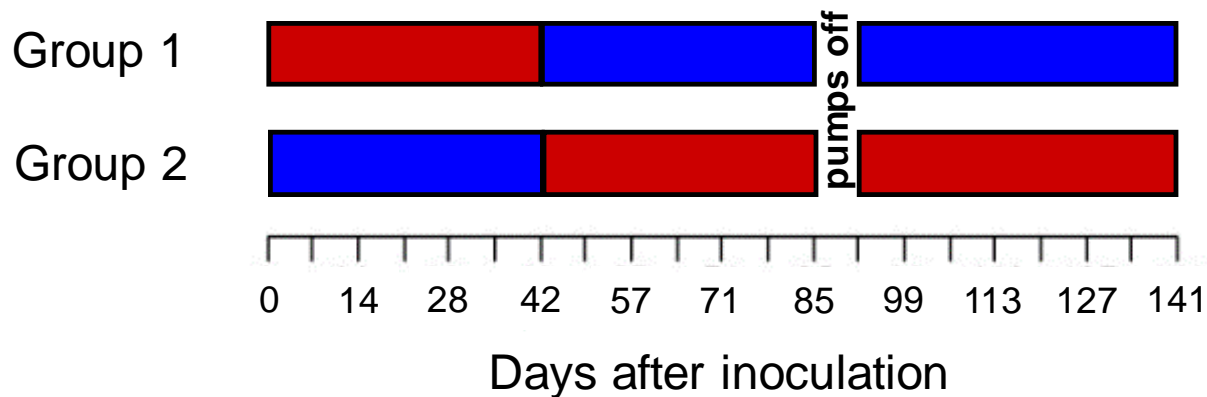
■ *Phytophthora capsici*

■ *Fusarium oxysporum* (added directly to filter)

TMV removal

SSF System setup

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*

- Required 6-9 weeks to achieve removal

TMV 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.)

Summary

- What is slow sand filtration?
  - Compare rapid and slow sand filters
  - How they work
- System design and operation
  - Flow control is critical
- Research results
  - *Phytophthora* and *Fusarium* control
  - TMV removal

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UCNFA.ucanr.edu

Thank you

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Photo: L.Oki