Slow Sand Filters

Remove TMV & Other Pathogens

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Photo: L. Oki

California Nursery Conference
Watsonville, CA
June 19, 2018

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?

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
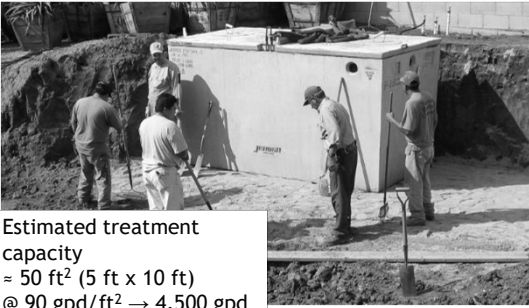- □ Pathogens
- □ Nutrients (reductions)
- □ Chemical pollutants

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
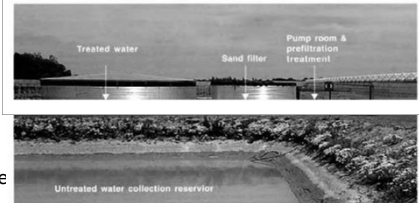- □ Recommend at least two filters

System Design

Graphic: L. Oki
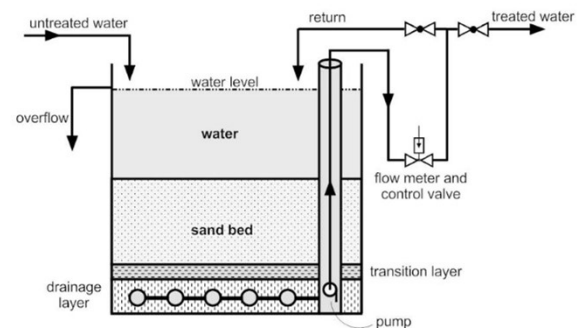
Installations

Estimated treatment capacity
≈ 50 ft^2 (5 ft x 10 ft)
@ 90 gpd/ft$^2 \rightarrow$ 4,500 gpd
@ 70 gpd/ft$^2 \rightarrow$ 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
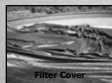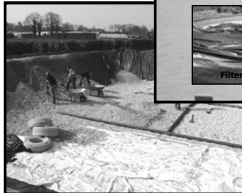□ Untreated storage
  ■ 1,720,000 gal
    5.3 ac-ft

Roundstone Nurseries, UK

Treated water   Sand filter   Pump room & prefiltration treatment

Untreated water collection reservoir

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
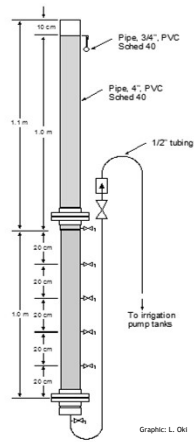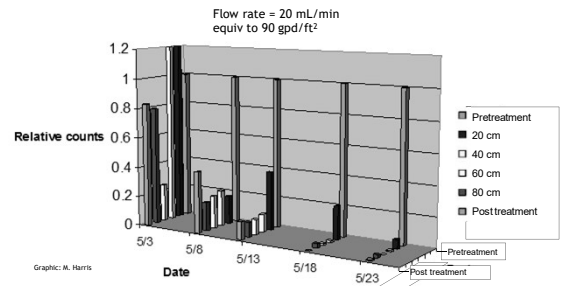for Agriculture and Forestry, Braunschweig, Germany

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
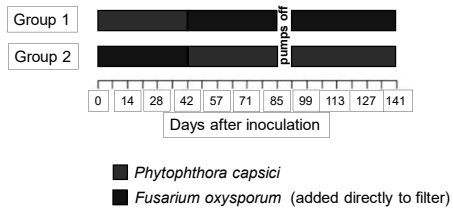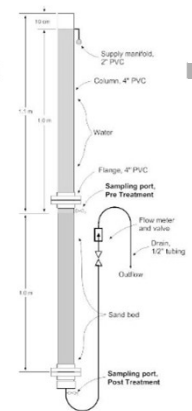 ■ Post treatment
□ Analyze for *P. capsici*

SSF Studies

Pipe, 3/4", PVC Sched 40
Pipe, 4", PVC Sched 40
1/2" tubing
To irrigation pump tanks

Graphic: L. Oki

Treatment Performance

Flow rate = 20 mL/min
equiv to 90 gpd/ft²

Relative counts

- Pretreatment
- 20 cm
- 40 cm
- 60 cm
- 80 cm
- Post treatment

Date: 5/3, 5/8, 5/13, 5/18, 5/23

Graphic: M. Harris

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

Supply manifold, 2" PVC
Column, 4" PVC
Water
Flange, 4" PVC
Sampling port, Pre Treatment
Flow meter and valve
Drain, 1/2" tubing
Outflow
Sand bed
Sampling port, Post Treatment

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	-/-	-/-	-/-	←Before TMV addition
24 hrs	+/+	+/+	+/+	
Wk 1	+/+	+/+	+/+	
Wk 2	+/+	+/+	+/+	Samples collected
Wk 3	+/+	+/+	+/+	from below sand bed
Wk 4	+/+	+/+	+/+	Systemic hosts
Wk 5	-/+	+/+	+/+	*Nicotiana benthamiana* (N.b.)
Wk 6	-/-	-/-	-/-	and *N. tabacum* (N.t.)
Wk 7	-/-	-/-	-/-	
Wk 8	-/-	-/-	-/-	
Wk 9	-/-	-/-	-/-	
Wk 10	-/-	-/-	-/-	
Wk 11	-/-	-/-	-/-	
Wk 12	-/-	-/-	-/-	

TMV removal, ELISA results
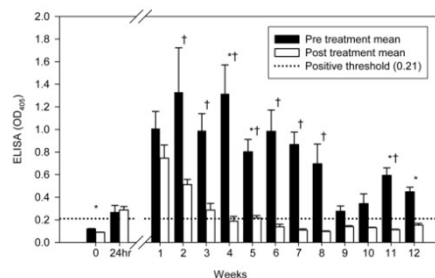
Coupled Vegetated and Slow Sand Filters

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

Acknowledgements

- Mike Harris
  Eric Lee
  Bruno Pitton
  Dept. Plant Sci, UCD
- Darren Haver
  Grant Johnson
  UC South Coast Res & Ext Ctr
- Deb Mathews
  Sohrab Bogadi
  Dept. Plant Pathology
  UC Riverside
- Harold Leverenz
  Dept. Civil & Environ.
  Engineering

- Steve Tjosvold
  UCCE Santa Cruz County
- David Chambers
  UCCE Santa Cruz County
- Jim MacDonald
  Dept. Plant Path
- Ed Caswell-Chen
  Dept. Plant Path
- Linda Bolkan
  Dept. Plant Path
- Dave Rizzo
  Dept. Plant Path

Thank you

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Photo: L. Oki

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