Managing Water Quality of Nursery Runoff Using Constructed Wetlands

OCLWA Annual Conference

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BIOSYSTEMS AND AGRICULTURAL ENGINEERING

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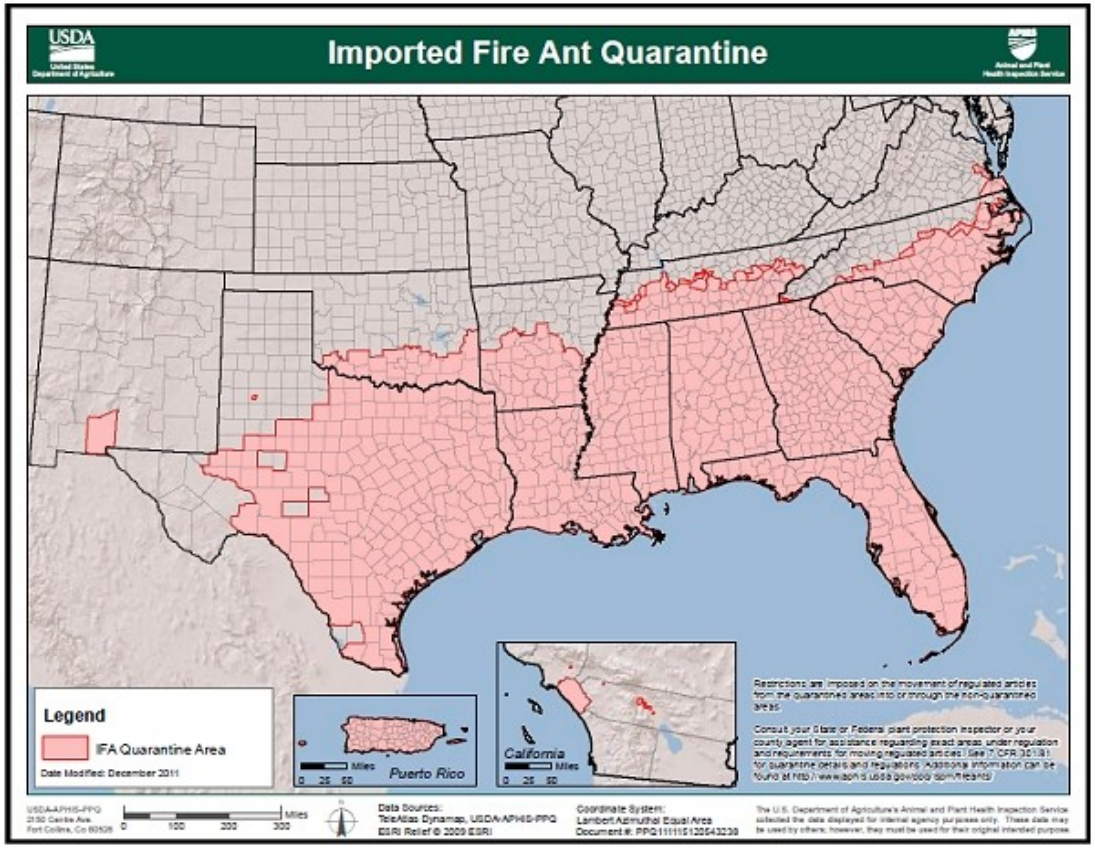
Background

Nursery Industry Impact

- US Economy (Hodges et al., 2015)
  - 2 Million jobs (1.11% US workforce)
  - $136 Billion direct industry output (0.72% US GDP)
- Oklahoma Economy (Hodges et al., 2015)
  - 19,300 jobs
  - $1.3 Billion direct industry output

Nurseries are required to incorporate insecticide into product leaving the quarantine area.

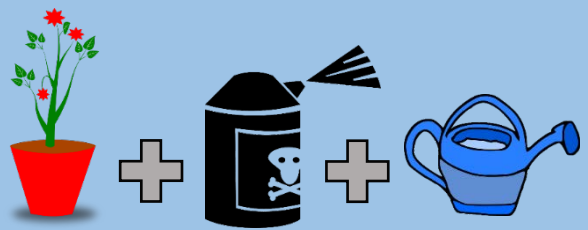


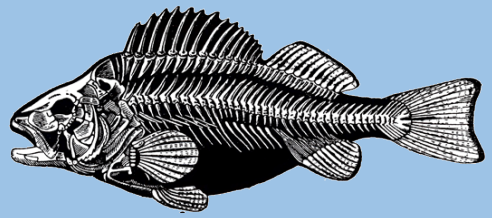
Bifenthrin concentrations in leachate 100x greater than LC_{50} for *H. azteca* (Graves et al., 2014)

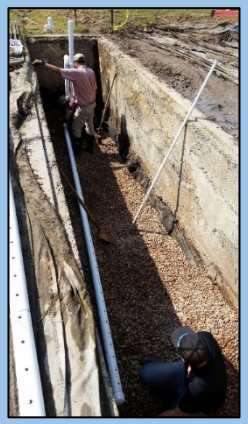
Are pesticides a problem in urban streams?

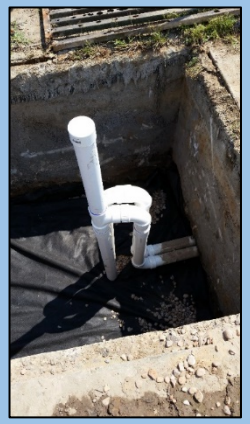
- Comparison of pesticides in eight U.S. urban streams (Hoffman et al., 2000)
  - Insecticides and herbicides present in all streams
  - Carbaryl and diazinon exceeded aquatic life protection standards
  - Estimated that U.S. insecticide contributions are similar between agricultural and urban areas
- Range of properties, difficulty targeting individual pesticides

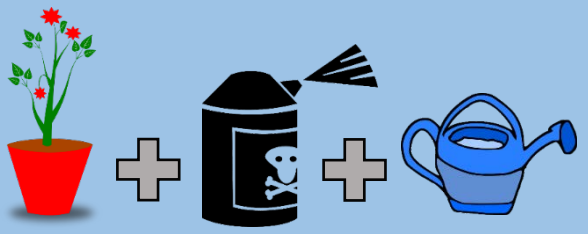
Are constructed wetlands effective for removing pesticides and nutrients from greenhouse and nursery runoff?





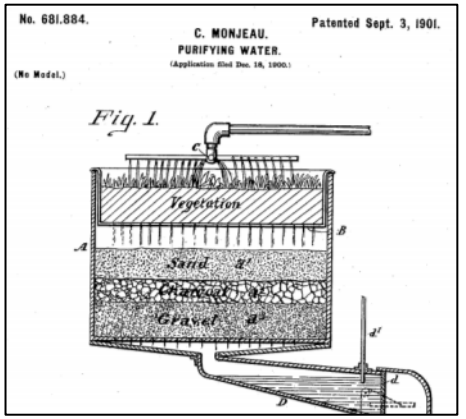






Constructed Wetlands

- First documented use – 1901 patent for wastewater treatment
- Käthe Seidel – early 1950s in Germany
- Early applications revolved around plants
- Introduced for wastewater treatment in 1950s
- Agricultural runoff 1980s, 1990s



Wikimedia Commons

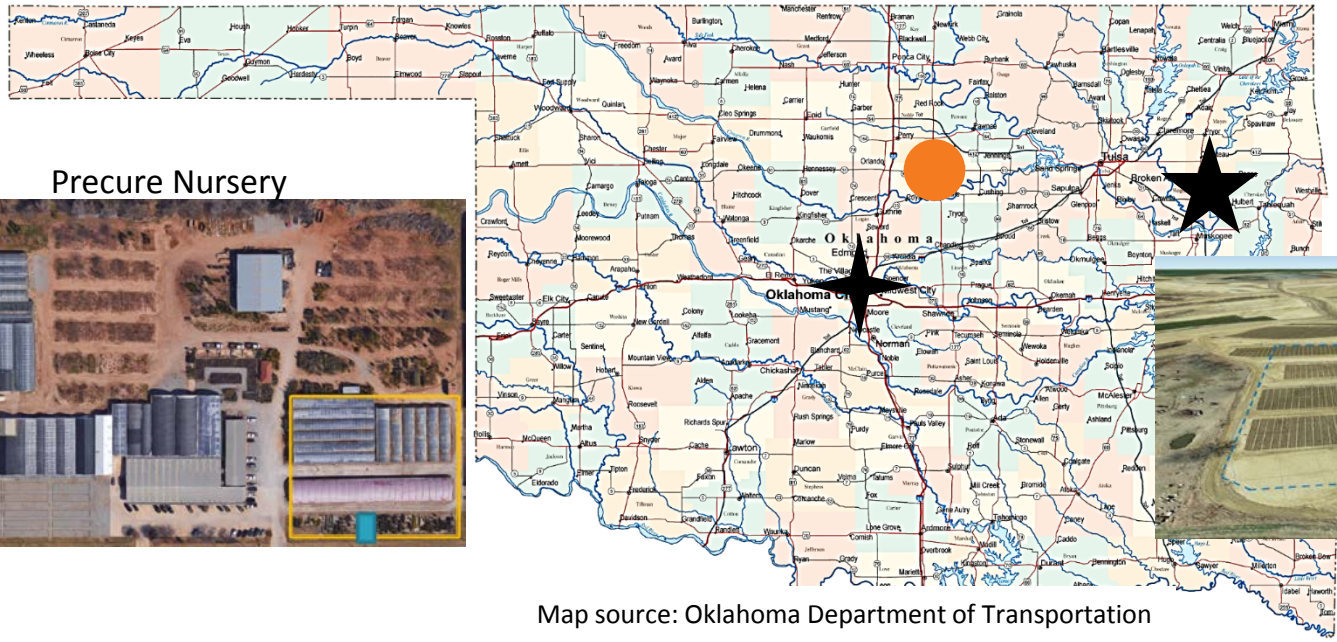
Constructed Wetlands

- Two common designs
  - Free surface constructed wetlands – remain saturated with ponded water
  - Subsurface flow constructed wetlands – a layer of soil remains saturated and a layer of soil is able to drain
- Imitates natural wetland conditions
- Continually saturated
- Pollutant removal mechanisms
  - Filtration
  - Sorption
  - Microbial degradation
  - Chemical transformation

Field Experiments

Industry Collaborators

Precure Nursery - Oklahoma City, OK ✦ Zelenka Farms - Hulbert, OK ★



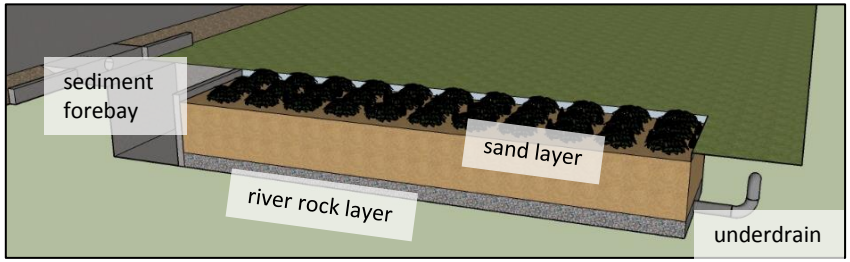
Precure Nursery

Zelenka Farms

Map source: Oklahoma Department of Transportation

Overview of Projects

- Precure Nursery
  - Retail nursery – 16 acres
  - Subsurface flow constructed wetland



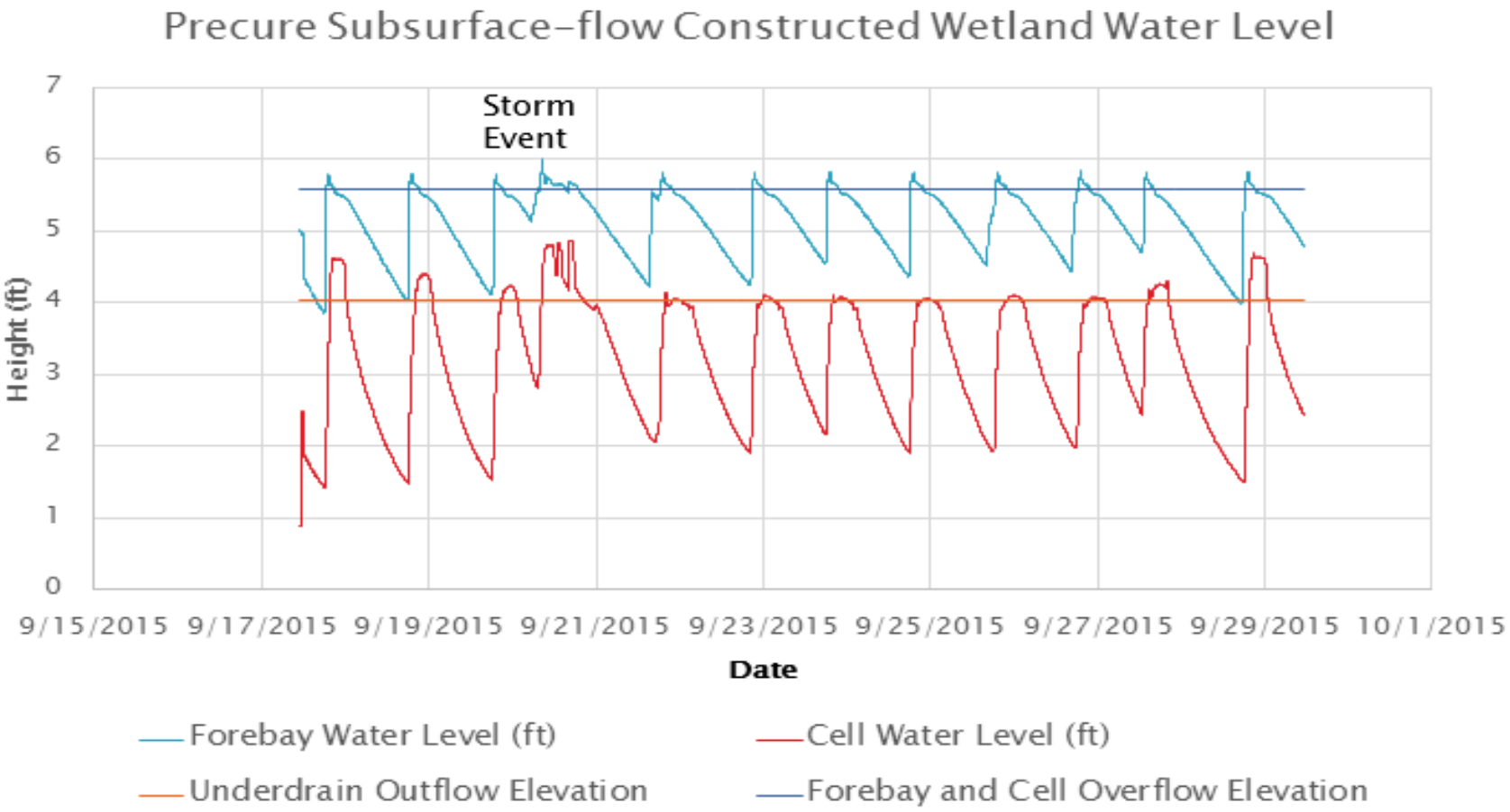
- Zelenka Farms
  - Wholesale nursery – 450 acres
  - Free surface constructed wetland

“Typical” Irrigation Event






Typical System Hydrology



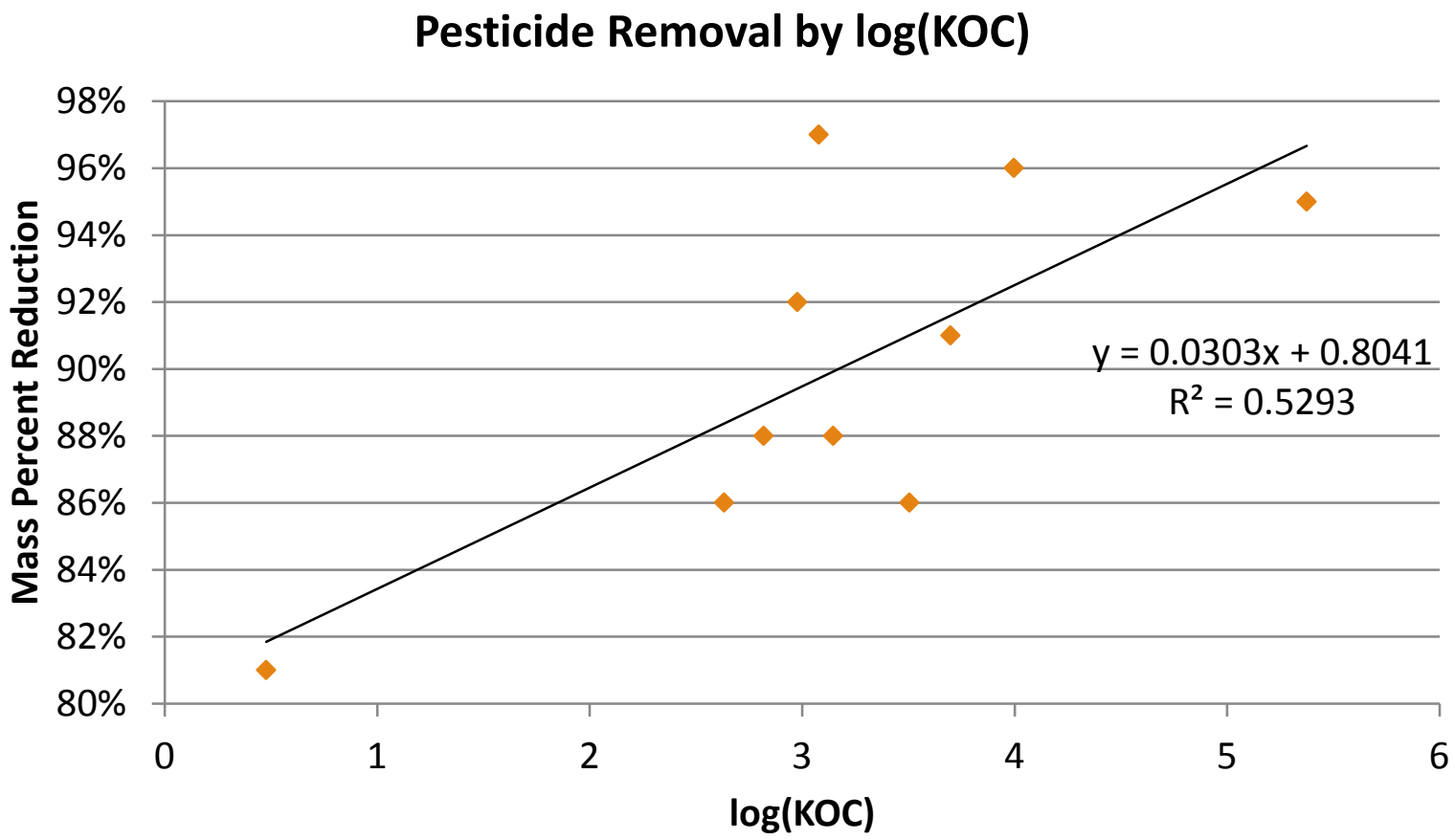
Water Quality Preliminary Results

Constituent	Average Mass Removal	# of Events
Volume	78%	16
NO_3^- (Nitrate)	86%	16
PO_4^{3-} (Phosphate)	79%	16
Total Nitrogen	85%	14
Total Phosphorus	78%	14
Total Suspended Solids	89%	9

Water Quality Preliminary Results (cont.)

Constituent	K_{OC}	Pesticide Type	Average Mass Removal	# of Events Analyzed	# of Events Detected
Bifenthrin	237,000	Insecticide	95%	8	8
Chlorpyrifos	9,930	Insecticide	96%	8	4
Chlorothalonil	5,000	Fungicide	91%	8	8
Oxadiazon	3,200	Herbicide	86%	8	8
The State of California considers K_{OC} < 1,900 "mobile compounds"					
Isoxaben	1,400	Herbicide	88%	8	7
Dimethanamid	1,200	Herbicide	97%	8	6
Myclobutanil	950	Fungicide	92%	8	8
Propiconazole	660	Fungicide	88%	8	8
Indaziflam	430	Herbicide	86%	8	5
Acephate	3	Insecticide	81%	8	3

Water Quality Preliminary Results (cont.)



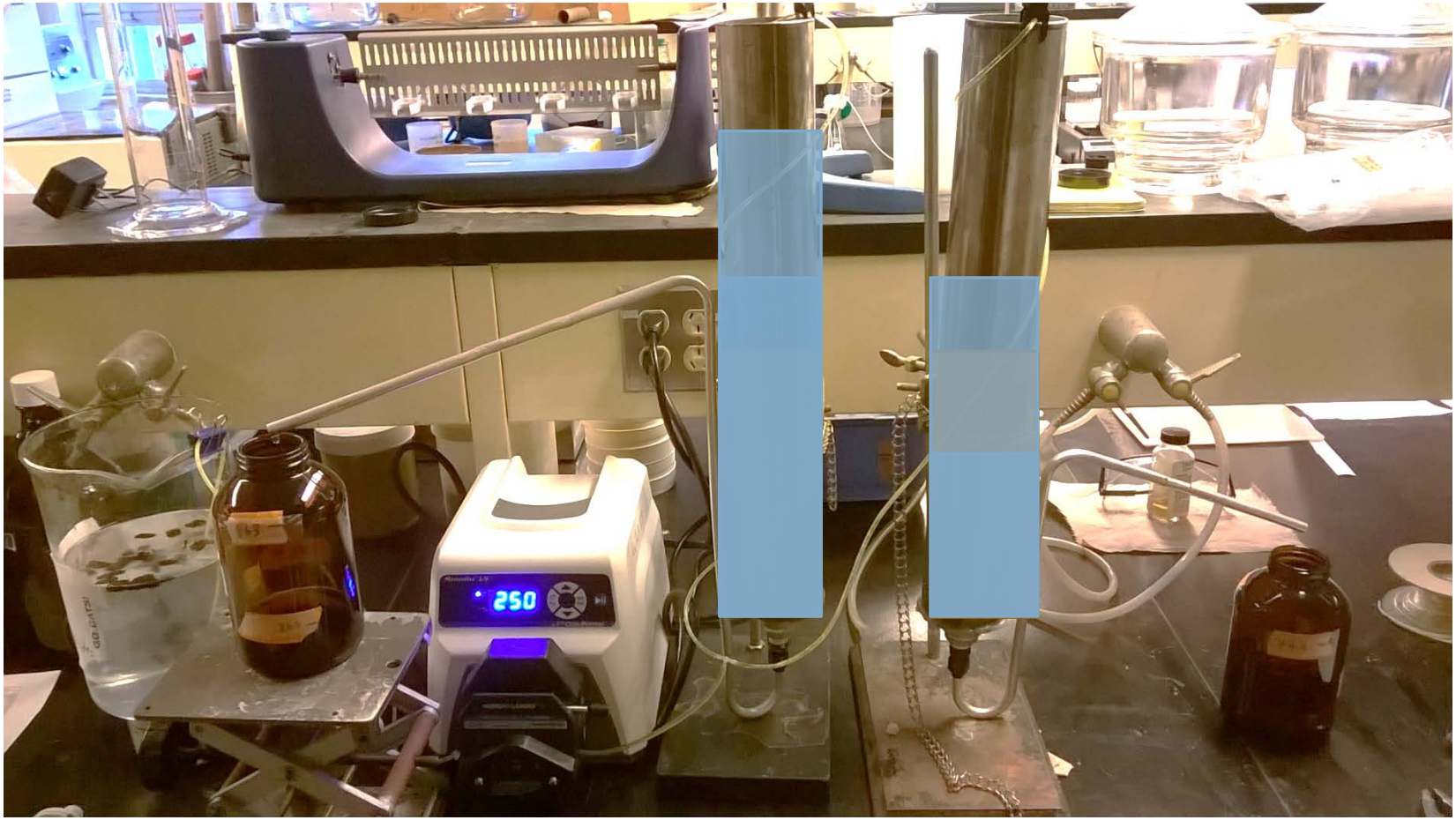
Highlights

- Out of 16 analyzed pesticides
  - 14 were reported at least once
  - 10 were reported in over half of the analyzed inflow samples
- High capacity to infiltrate runoff – 82% volume reduction for 102 irrigation events
- Effective reduction of immobile and mobile compounds

Further Questions

- How do saturation conditions affect pesticide removal?
  - Comparison of subsurface-flow and free surface constructed wetlands
- How does event frequency affect pesticide removal?

Column Experiments



Conclusions and Future Work

- Nursery runoff has high potential for negative environmental impact
- Constructed wetlands show potential to be an effective runoff management tool
- Are constructed wetlands effective long-term?

- How do saturation conditions affect pesticide removal?
- How does event frequency affect pesticide removal?

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