USING GREEN INFRASTRUCTURE TO REDUCE PESTICIDES AND NUTRIENTS IN RUNOFF FROM A COMMERCIAL GREENHOUSE

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Problem Background

In the U.S., the nursery and greenhouse industry has a significant economic impact, employing over 260,000 individuals in 2006. To reduce economic losses due to weed contamination, insect pressure, and fungal disease, the use of pesticide is commonplace at nurseries throughout Oklahoma and the U.S. Pesticides are often present in leachate from nursery pots. Nitrogen and phosphorus are often present in pot leachate from application of fertilizer. Irrigation and stormwater runoff from production nurseries can be a vector for pesticide and nutrient transport to rivers and lakes. The presence of pesticides in aquatic environments poses a threat to biological communities. Field runoff simulations found bifenthrin concentrations in pot leachate exceeded the LC_{50} for H. azteca by more than 100-fold[1]. Pesticide and nutrient loading in nursery runoff prevents existing nursery practices from being sustainable.

Project Results

- Opportunity for demonstration
- Tangible performance results
  - Peak flow reduction
  - Water volume reduction
  - Nutrient mass reduction
  - Pesticide mass reduction

Site Characteristics

- The subsurface-flow constructed wetland (SFCW) is located at Precure Nursery in Oklahoma City, OK.
- The SFCW was retrofit into an existing in-ground concrete cell.
- Irrigation runoff events occur daily during spring, summer, and fall months as needed.
- The nursery does not heavily apply pesticides on-site, but pot leachate contains pesticides.
- Drainage area is 1.5 acres and includes greenhouses and unprotected plants.
- Soils have a high infiltration rate.

Constructed Wetland Design and Maintenance

- SFCW was retrofit into an existing concrete walled cell with dimensions of 34 ft. in length, 5 ft. in width, and 4 ft. in depth. The cell did not have a concrete bottom.
- Forebay (Figure 1) intercepts sediment forcing inflow to slow down and sediment to settle out.
- Sediment can be removed from forebay using a small backhoe.
- Treatment cell is made up of a 1.5 ft. gravel layer and 4 ft. sand layer. The two layers are separated by a layer of geotextile fabric. Water ponds to 0.5 ft. above the sand layer before overflowing.
- Hydraulic conductivity of treatment cell can be maintained by raking cell surface to remove fine particles and reduce clogging.
- Two underdrain pipes, installed in parallel for redundancy, in the gravel layer connect to the storm sewer.
- Upturned elbow prevents underdrain flow until water level is 0.5 ft. below media surface.

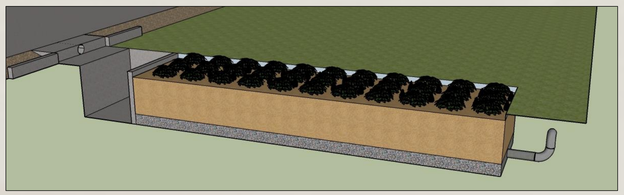

Figure 1 – Conceptual drawing showing forebay at left, media layers, and underdrain.

Field Monitoring Methods

- Hydrologic monitoring and sample collection Spring 2016 – Fall 2016.
- Inflow is measured using a 0.5 ft. H-flume and ISCO 720 flow probe. (Figure 2)
- Overflow is measured using a 0.4 ft. HS-flume and ISCO 720 flow probe (Figure 3).
- Underdrain flow is measured using a 0.25 ft. Palmer-Bowlus flume and ISCO 720 flow probe (Figure 4).
- All samples are collected using ISCO Avalanche autosamplers with Teflon-lined tubing and glass sample containers to minimize sorption of pesticides.
- Cell is surrounded by a wooden barrier to ensure that all inflow is quantified through the 0.5 ft. H-flume (Figure 5).
- Water level in forebay and underdrain is measured using HOBO level loggers.
- Rainfall is measured using an ISCO 0.01 inch tipping bucket rain gauge.

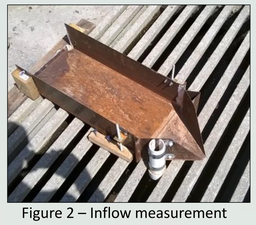

Figure 2 – Inflow measurement

Figure 3 – Overflow measurement

Figure 4 – Underdrain flow measurement

Figure 5 – Project site, sampler set up for inflow, wooden barrier surrounding cell.

Sample Analysis Methods

- All samples are collected within 24 hours of the sampling event.
- Samples are separated into aliquots to be analyzed for nitrate, ortho-phosphate, total nitrogen, total phosphorus, pesticides, and total suspended solids.
- Nitrate and ortho-phosphate samples are filtered using a 0.45 µm syringe filter and refrigerated until analysis by the Soil, Water, and Forage Analytical Laboratory (SWAFL) at Oklahoma State University.
- Pesticide samples are extracted onto Agilent Technologies 50 mg C8 solid-phase extraction cartridges and then frozen until analysis.
- Pesticide samples are analyzed using an Agilent 6850 Gas Chromatograph coupled with a 5975C Mass Spectrometer.

References

1-Graves GM, Vogel JR, Belden JB, Rebek EJ, Simpson AM. Investigation of insecticide leaching from potted nursery stock and aquatic health benefits of bioretention cells receiving nursery runoff. Environ Sci Pollut Res Int. 2014 Jul;21(14) 8801-8811.

Acknowledgements

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Outreach

- Extension workshop September, 2016.
- Thirty-one individuals participated. Participants were from municipalities, state environmental agencies, and academic institutions and included practitioners, scientists, regulators, and
- Morning lecture topics included best management practices, water management, regulation, pesticide and contaminant transport.
- A tour of the field site was given in the afternoon.

Preliminary Hydraulic Results

Irrigation events (Spring and Summer 2016)

- Average inflow = 400 gallons
- Max inflow = 600 gallons
- Average outflow = 90 gallons
- Average capture = 80%

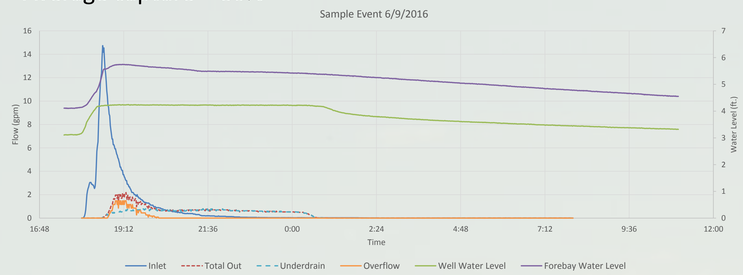

Figure 6 – Irrigation event from 6/9/2016. This event had 591 gal of inflow, 63 gal of overflow, and 220 gal of underdrain flow. Approximately 52% of inflow was captured for this event.

Preliminary Nutrient Results

Event	Event Type	Runoff Reduction	Nitrate Mass Reduction	Ortho Phosphate Mass Reduction
5/17/2016	Storm	67%	55%	16%
6/9/2016	Irrigation	52%	43%	54%
6/23/2016	Irrigation	97%	98%	97%
7/1/2016	Irrigation	82%	43%	35%
7/7/2016	Irrigation	90%	62%	56%

Table 1 – Nutrient reduction performance for five events in May 2016 – July 2016

Preliminary Pesticide Results

Event	Event Type	Runoff Reduction	Chlorothalonil	Pendimethalin	Oxadiazon	Carbaryl	Propiconazole
5/17/2016	Storm	67%	52%	28%	8%	63%	15%
6/9/2016	Irrigation	52%	81%	70%	79%	86%	81%
6/23/2016	Irrigation	97%	98%	98%	97%	100%	97%

Table 2 – Pesticide reduction performance for three events in May 2016 – June 2016

Discussion

- Positive nutrient reduction for five analyzed events (Table 1).
- Pesticide removal varies among pesticide type (Table 2).
- Nutrient mass reduction correlated with volume reduction.
- Pesticide mass reduction greater than volume reduction indicates system is capturing or transforming pesticide.

Conclusions

- High capacity to capture and infiltrate runoff.
- Effective at reducing runoff volume, pesticide mass, and nutrient mass during irrigation events.
- Effective at reducing runoff volume and nutrient mass during storm events but less effective at reducing some pesticides.
- More events will be sampled and analyzed to determine statistical significance of pesticide and nutrient mass reduction.
- Preliminary results indicate that SFCWs are a viable tool for nursery runoff management.