FY2017-2018 DWRC Interns and Their Research Projects

Undergraduate Internships

Samuel Furio (Economics), Advisor: Dr. Kent Messer (Applied Economics & Statistics), Understanding the Social Behavior within a Competitive Environment: An Experimental Investigation of Agri- Environmental Policies.

Lauren Glinko (Geography), Advisor: Dr. Tracy Deliberty (Geography), Linking Causes of Irrigation to Available Water Capacity.

Reid Williams (Environmental Engineering), Advisor: Dr. Paul Imhoff (Civil and Environmental Engineering), Effectiveness of Bio-Char to Reduce Nitrate Concentration in Storm Water Runoff.

Margaret Krauthauser (Geology), Advisor: Dr. James Pizzuto (Geological Sciences), Quantifying Floodplain Sediment Storage Rates and Identifying Rate-Changing Characteristics in the White Clay Creek Watershed, Pennsylvania.

Jack Protokowicz (Biochemistry), Advisor: Dr. Shreeram Inamdar (Plant and Soil Sciences), Nuclear Magnetic Resonance Analysis of Particulate Organic Matter from Forested Watershed.

Nicholas Tobia (Geology), Advisor: Dr. James Pizzuto (Geological Sciences), Quantifying the Rate of Bank Migration in the White Clay Creek Watershed, Pennsylvania.

Christina Valenti (Environmental Engineering), Advisor: Dr. Anastasia Chirnside (Entomology and Wildlife Ecology), Assessment of the Leaching Potential of Fibrous Plastic Inert Support Material from a Fungal Biocell Reactor.

Michael Rechsteiner (Environmental Engineering), Advisor: Dr. Paul Imhoff (Civil & Environmental Eng'g.), Reducing Stormwater Runoff & Pollutant Loading with Biochar Addition to Highway Greenways.

Graduate Research Assistantships

Jillian Young (M.S. Water Science and Policy), Advisor: Gerald Kauffman (Public Policy and Administration), Water Quality Assessment of Noxontown Pond in the Appoquinimink River Watershed.

Jordan Martin (M.S. Water Resources Engineering), Advisor: Gerald Kauffman (Public Policy and Administration), Water Quality Trends in the Brandywine Christina Watershed in Delaware.

Understanding Social Behavior: An Experimental Economic Investigation of Agri-Environmental Policies

Sam Furio, University of Delaware

Under the direction of Dr. Kent Messer, Dr. Olesya Savchenko, and Sean Ellis

Motivation:

- Consumers are stigmatized towards recycled water, especially in food production.
- Understanding consumer stigmatization toward recycled water is crucial for agri-environmental policy on growing water scarcity.
- We need to test de-stigmatization methods such as: social comparison messaging in the form of celebrity endorsements, social comparison messaging in the form of a peer consumption statement, and exposure to a variety of distances from the stigma.

Research Questions:

- How do consumers respond to a stigmatizing food attribute as they move through different trophic levels?
- What is the effect on consumer willingness-to-pay from different types of priming?

Methods:

- Participants shown three versions of five products: lamb, cheese, spinach, hot chocolate powder, and bottled water. Each version produced with one of three types of water: ground, recycled, or ground from and aquifer recharged with recycled.

- Participants are asked a series of dichotomous choice, real purchasing options at a randomized price.

Do you want to purchase approximately 8 ounces of spinach irrigated with **recycled water** for $3.52?
○ Yes
○ No

Experimental Design:

- This study was run with a 2x2 design consisting of a control(A), a celebrity endorsement video treatment(B), a statement about peers' willingness to drink recycled water treatment(C), and a combination of the video and statement(D).

Experimental Matrix	Short Informational Video	Celebrity Endorsement Video
No Statement	A	B
Social Comparison Message	C	D

- We employ an incentive compatible economic experiment in order to compare the true willingness- to- pay between treatments.

Short Informational Video

Celebrity Endorsement Video

In previous studies, 95% of people were willing to pay for food produced with recycled irrigation water.

Social Comparison Messaging

Initial Results:

- No effect from celebrity endorsement and social comparison messaging treatments on stigma.
- When those two terms interact however in treatment D, the amount of stigma is reduced.
- Consumers are more likely to purchase foods produced with recycled and recharged water.
- People in treatment D are more likely to purchase recycled lamb than people outside of treatment D. Significantly different than the control.

CEAE Team at New Castle Farmer's Market

Future Work:

- Further analyze data and create visual representations
- Continue to explore different types of social comparisons
- Expand data analysis skillset

Acknowledgments:

This research was made possible by CONSERVE. I would like to thank the DWRC, CBEAR, the USDA, the University of Delaware, the College of Ag and Natural Resources, the Department of Applied Economics and Statistics, and the Center for Experimental and Applied Economics

I would like to personally thank my mentors, Dr. Kent Messer, Sean Ellis, Dr. Olesya Savchenko as well as Maddi Valinski, James Geisler, Carlos Estrada, Kaitlynn Ritchie, Melissa Langer, Philipo Lukumay, Rubait Rahman and Chriss Davis.

Causes of Change of Irrigation in The Eastern United States

Lauren Glinko, Dr. Tracy Deliberty, Dr. Afton Clarke-Sather
Department of Geography University of Delaware, Newark, DE 19716
Delaware Water Resource Center

Overview

Agricultural practices in the Eastern United States historically have not involved extensive irrigation, but recently irrigation practices have been expanding. Irrigation is widely assumed to be primarily directed towards cultivating corn, however, to date no research has investigated the drivers of using irrigation. By understanding the irrigation practices, the water supply can be quantified and conservation measures initiated.

Objectives

This research combines the National Agricultural Statistics Service Cropscape data set for the years of 7 years (2002, 2008, 2012, 2013, 2014, 2016 and 2017) and irrigation center pivots for the state of Delaware created by James Atkins(2010) to discover:

1. If corn is solely being cultivated under irrigation
2. Identify if climate trends are influencing crop cultivation
3. If there is a trend of increase in irrigated corn and irrigation
4. If soil conditions have influenced where irrigation is occurring

Methods

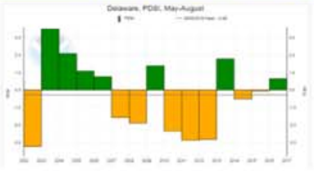
STEP 1: Create non-irrigated shapefiles using James Atkins central pivots

Delaware State Boundary
Irrigation Pivots
Erase
Non-irrigated Area

STEP 2: Create available water supply shapefiles and SSURGO soil textures

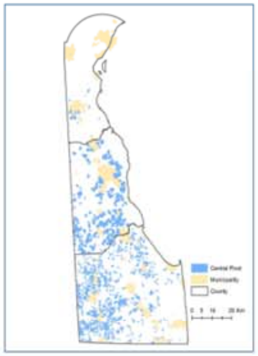
New Castle County Soils
Kent County Soils
Sussex County Soils
Available Water Supply Shapefile
Soil Texture Shapefile

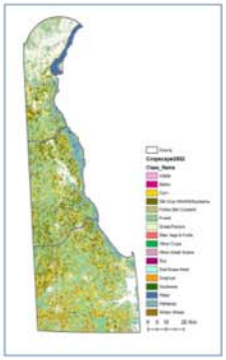
Palmer Drought Index Climate Data 2002-2017

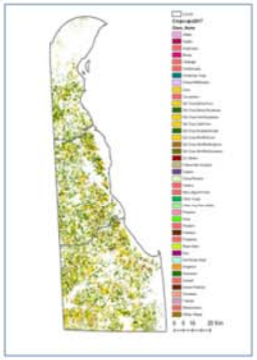


NOAA National Centers for Environmental information, Climate at a Glance: Statewide Time Series, published April 2018, retrieved on April 24, 2018 from http://www.ncdc.noaa.gov/cag/

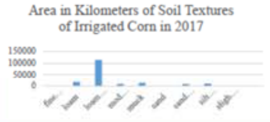
Irrigation Pivots and Cropscape Data



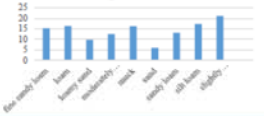




Soil Data Charts from 2017



Area in Kilometers of Soil Textures of Irrigated Corn in 2017



AWS of Irrigated Corn in 2017

Results

- Over the years the area of cultivation has decreased, yet the quantity of crop types has increased significantly.
  - Total corn cultivation has increased over the years from 22% in 2002 to 43% in 2017.
  - Soybeans are consistently more widely cultivated on non-irrigated land as compared to.
- Presence of irrigation in agriculture has increased from 15% to 21% over 15 years.
  - Total percent of irrigated corn increased from 45% to 58%.
- Available water supply and soil texture do not reflect any trends in irrigation or cultivation for corn.
  - Primary soil texture of irrigated corn is loamy sand.

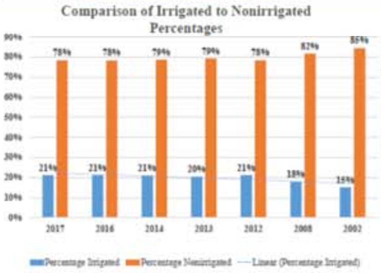
Conclusions

Over the past 15 years corn has undergone an extensive increase in cultivation. This cultivation trend is reflected across all cropland, with corn cultivate doubling from 22% to 43%.

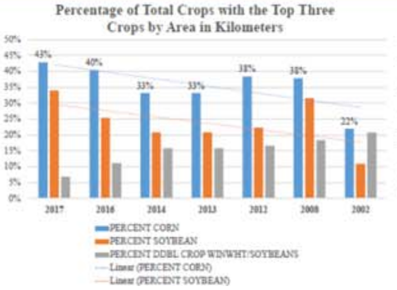
Irrigation has increased in Delaware over the past 15 years. The percentage of irrigation area increased from 15% to 21%, with corn representing the majority of the irrigated crops under cultivated. The percentage of irrigated corn started at 45% in 2002 and increased to 58% in 2017.

One of the possible causes of the increase of irrigation is reflected by the climate data from NOAA. The graph of climate data depicts the Palmer Drought Severity Index which utilizes temperature and precipitation data to estimate relative dryness. From this graph, the years of 2013 and 2016 were considered wet years, and the rest of the years were drought years. Comparing the "wet years" to the "dry years", the decreases in irrigated cultivation correlate to more precipitation. The relationship between irrigation and precipitation, as depicted by the graphs, is an inverse correlation. The increase of irrigation and cultivation of corn correlate, proving that corn is a water intensive crop and one of the driving factors in the trend of increase of irrigation in Delaware, and possibly the eastern United States.

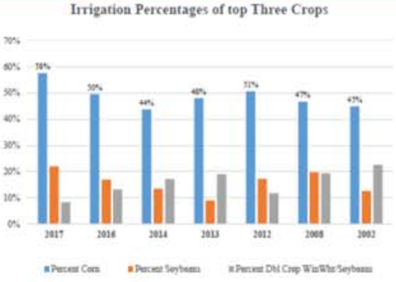
Charts and Tables



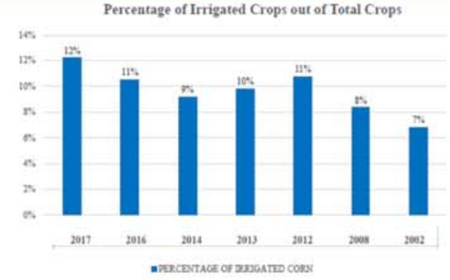
Comparison of Irrigated to Nonirrigated Percentages



Percentage of Total Crops with the Top Three Crops by Area in Kilometers



Irrigation Percentages of top Three Crops



Percentage of Irrigated Crops out of Total Crops

The Effect of Varying Properties of Biochar and its Impact on Soil Hydraulic Conductivity

Reid Williams[1], Paul Imhoff[1], Ali Nahkli[1], Yudi Yang[1]
[1]Department of Civil and Environmental Engineering, University of Delaware

Background

Biochar is a charcoal product that, due to its high porosity and surface area, has the potential to change the properties of soil. Biochar is known to be able to increase or decrease the hydraulic conductivity of the soil, however it is a complex process dependent on many variables. In this experiment, soil column experiments were taken place to understand exactly how biochar affects Ksat. The following variables that were inspected are:

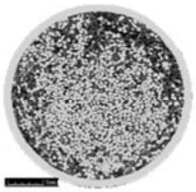

Biochar Particles

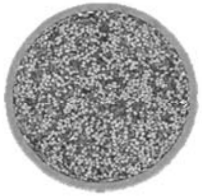
- **Biochar Particle Size:** The larger the Biochar particles are, the larger the porosity of the soil will be, thus having an affect on the flow of water through the medium.
- **Biochar Elongation:** Testing the effect of the shape of the Biochar on the Ksat. Longer particles may have different properties than more spherical particles.
- **Biochar Segregation:** Generally, in the field the biochar tends to clump together and segregate. How much does this affect the Ksat of the soil?

Objectives

- Quantify how the size of the added biochar particles affects the difference in hydraulic conductivity of the soil
- Quantify how the shape, or elongation, of the added biochar particles affects the difference in hydraulic conductivity of the soil
- Quantify how the segregation of the added biochar particles and the soil particles affects the difference in hydraulic conductivity of the soil

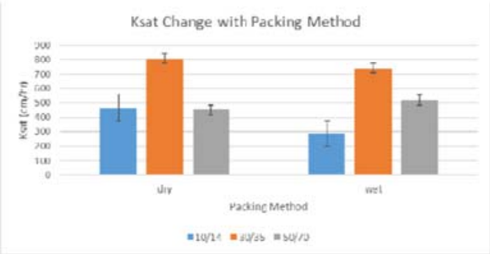
Segregation Images – Using X-ray Tomography

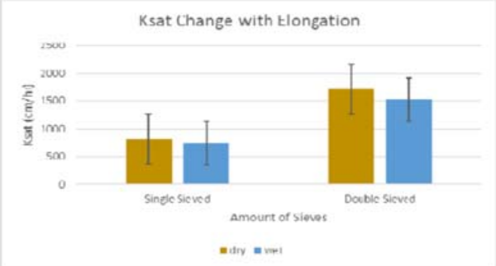

Microstructural Images for Dry Packed Biochar-Soil Mixture by Kalehiwot Nega Manahiloh

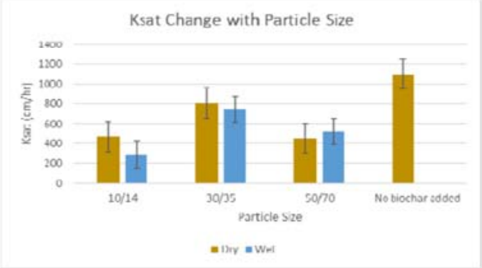

Microstructural Images for Wet Packed Biochar-Soil Mixture by Kalehiwot Nega Manahiloh

RESULTS

Type	Pure Sand (30/35)	Sand with Large Biochar (10/14)	Sand with Medium Biochar (30/35)	Sand with Small Biochar (50/70)	Sand with Double Sieved Medium Biochar
Sand Size (mm)	0.0197 -0.0234	0.0197 - 0.0234	0.0197 -0.0234	0.0197 - 0.0234	0.0197 - 0.0234
Biochar Size (mm)	-	0.0555 - 0.0787	0.0197 -0.0234	0.0083 - 0.1170	0.0197 - 0.0234
Bulk Density (g/cm3)	1.646	1.250	1.210	1.330	1.085
Total Porosity	0.378	0.504	0.520	0.473	0.570
Inter Porosity	0.378	0.449	0.467	0.414	0.522

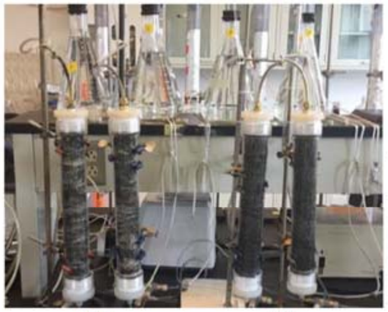






Note: All Results in the graphs above are the mean value from triplicate data, and all error bars represent standard error.

Methods


Dry packing
Wet Packing

Sieving

- Unsieved biochar is placed in a three-sieve configuration. A standard shaker time of 8 minutes was used.
- Elongated particles were sieved once, then collected on the 30 sieve in a over a smaller 1 minute run.

Column Packing

- Wet: To prevent soil segregation, water is added before the mixture is put into the columns. The mixing with water creates a virtually unsegregated mixture.
- Dry: To mimic the real world, no water is added in the mixing stage. The particles are still put together and mixed, however they do not stick together, and the particles tend to stay next to their own type. So, the soil is mostly segregated.

Measuring Ksat

- To reliably measure the Ksat of the columns, water was pumped through the columns to achieve full saturated, meaning all voids are filled with water.
- To measure the Ksat, the volumetric flow of water out of the column was measured and then Darcy's law was used to find the Ksat. Containers filled with water are suspended at a know height h2, the h1 is the height where the water drips out of the column, L is vertical length of the column, and A is the cross-sectional area of the column.

Conclusion

- The total porosity of the medium size biochar is the largest, due to the properties of biochar
- The larger porosity of the medium biochar causes it to have the highest Ksat compared to small and large.
- The particle Elongation had the greatest effect out of any variable, nearly doubling the Ksat compared to single sieved.
- The elongated particles were the only biochar particles to increase Ksat
- The fully segregated particles only slightly decreased the Ksat, with the Ksat of the smaller particles actually increasing.

References and Acknowledgments

Li, Liqing, and Allen P. Davis. "Urban Stormwater Runoff Nitrogen Composition and Fate in Bioretention Systems." *Environmental Science & Technology*, vol. 48, no. 6, 2014, pp. 3403–3410., doi:10.1021/es4055302.

Olson, Nicholas C., et al. "Remediation to Improve Infiltration into Compact Soils." *Journal of Environmental Management*, vol. 117, 2013, pp. 85–95., doi:10.1016/j.jenvman.2012.10.057.

Yan, Yudi. "PREDICTING IMPACT OF BIOCHAR ON SATURATED HYDRAULIC CONDUCTIVITY OF NATURAL AND ENGINEERED MEDIA." *University of Delaware*, 2017.

I would like to thanks Professor Imhoff for this opportunity to do this research, and for the guidance and teaching he provided throughout the process. I would like to thank Yudi Yan (Conrad) and Tian Jing for providing a helping hand as well. And finally, I would like to give my fullest gratitude to Seyyedalireza Nakhli (Ali) for everything he did to make this process as smooth as possible, I feel very lucky that I got to work with him.

Using ArcGIS as a Tool to Map Areas of Deposition and Erosion Along the Powder River, Wyoming Between 1973 and 1991

Presented by Margaret Krauthauser

1. Introduction

ArcGIS is a platform used to create, manage, share and analyze spatial data in a variety of different fields. In this project, ArcGIS was used to:

- Outline areas of overlap between the river reaches during 1973 and 1991
- Identify whether such areas were erosional or depositional during the time frame
- Find the value of the area in square meters of erosional or depositional polygons

3.Methods

- A hillshade of the region, a single polygon showing the river reach from 1973 and a single polygon showing the river reach in 1991 were provided in advance
- Three main ArcGIS tools were used: **Erase**, **Merge**, and **Explode**
- **Erase** was used to subtract the 1973 river reach from the 1991 river reach, thus showing all of the areas of overlap (i.e. all potential areas where deposition and erosion could have occurred)
- **Merge** was used to combine the areas of river overlap with any ground that may have been developed within the 20 year time span
- Finally, **Explode** was used to fully separate all the different polygons that had been outlined
  - Up until **Explode** was used, the program considered the whole layer to be one unit, as opposed to several different units; this tool was necessary in order to establish the individual areas
- Once the areas were separated, ArcGIS used the hillshade datum to establish area of the selected regions in meters
- Once the areas were established within the attributes table, the table was then transferred to Excel, where individual areas were classified as being Erosional or Depositional based on where they were in relation to the river reaches

Example of **Merge**; Why was it necessary?

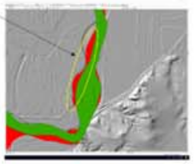
- The green shows the river reach in 1973
- The red shows the river reach in 1991
- The yellow shows the expanse of land that the river traveled over between 1973 and 1991; it could for instance represent a flood plain in that area
- This area would not have been accounted for if only the **Erase** tool had been used; it essentially combined both the area of the river as well as the flood plain making it one single polygon
- **Merge** was not used often, but it was necessary in some parts of the reach

2. Study Area

- The Powder River was chosen as a study site due to the fact that it is a well defined area of research, with multiple studies going on
  - There are decades of almost annual cross section survey data
  - It is a major river with little to no anthropologic disturbances (for instance, no dams)
  - It is the site of various other research including channel migration, terrace aggradation and floodplain development
- It was the site of a geomorphic tree analysis study that was also being run by Dr. Jim Pizzuto
- The area that was focused on using ArcGIS covered roughly a 50 kilometer section of the pictured study area

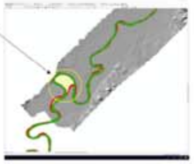
3.2 Erosional Example

In this image, the river reach of 1991 goes past the banks of the reach in 1973; this indicates erosion of the banks in this section



3.3 Depositional Example

In this image, the river has jumped from it's position in 1973 to the bank position in 1991; in this case it is indicative of deposition, possibly a flood plain

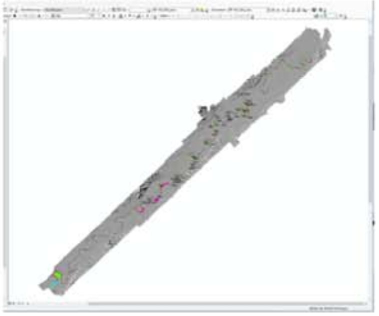


🟩 River Reach 1973 🟥 River Reach 1991 ▨ Region covered during deposition between 1973 and 1991

4. Results

- In total, there were 124 polygons classified as being depositional, and 115 polygons classified as erosional
- In image 4.1, the depositional polygons are shown in pink, and the erosional polygons are shown in green
- The total area of deposition was calculated to be roughly 2,555 square kilometers
- The total area of erosion was calculated to be roughly 1,722 square kilometers
- Based on these numbers, it appears that the river, at least in this section, is depositing more sediment then it is eroding

4.1: Erosional and Depositional Polygons



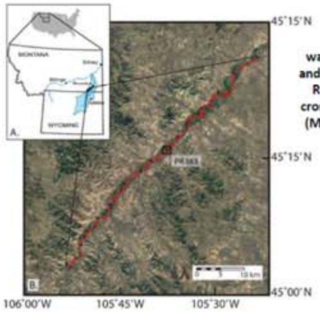
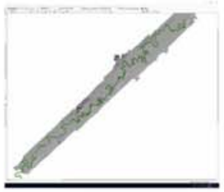
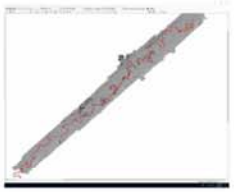


Figure 2.1: A. Powder River watershed location map. B. Moody and Meade study reach of the Powder River outlining annually surveyed cross sections with PR163 highlighted (Moody and Meade, 1990 and 2018; Moody et al., 2002).

2.2 Study area of Powder River: 1973



2.3 Study Area of Powder River: 1991



Acknowledgements

- Dr. Jim Pizzuto for his patience
- Tara Metzger for help figuring out how to differentiate between erosional and depositional polygons

Identifying the Differences in Soils from Various Land Uses by Fluorescence Spectroscopy

Jack Protokowicz[1]
Advisor: Shreeram Inamdar, UD Department of Plant and Soil Sciences
[1]Biochemistry Major

Purpose

Sediment from sources known to contribute to local waterways was collected and separated by land use and particle size in order to identify and examine key chemical differences in organic carbon released from these sources.

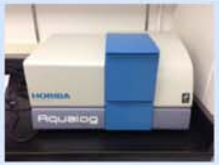
Introduction

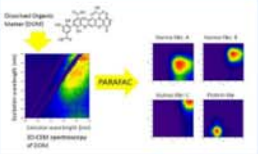
The increase in both the magnitude and occurrence of storm events locally and globally poses a great threat to water quality and natural ecosystems. These storms have a great potential to mobilize sediment sources and carry sediment-associated molecules large distances, which could lead to disastrous environmental impacts. The chemical character of these particles is significantly influenced by their local environment, i.e. land use, and understanding the chemistry behind these molecules is key to identifying their sources as well as mitigating the molecules' consequences to the natural environment.

(Left) taken from the Fair Hill NRMA site, and (right) the Chesapeake Bay, demonstrate the possibility of large sediment influxes over long distances due to large storm events.

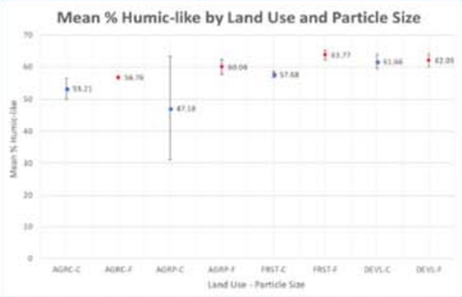
Methods

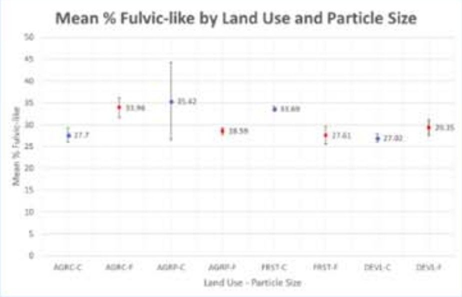
1. Sediments were collected from 4 land uses: agriculture cropland (AGRC), agriculture pasture (AGRP), developed land (DEVL), and forested land (FRST)
2. Sediments were dried and sieved into two particle class sizes: coarse (C, > 1mm diameter) and fine (F, < 1mm diameter)
3. 40mL extracts were made with 0.5g of each sediment
4. Dissolved carbon in the filtrate was analyzed using fluorescence spectroscopy
5. EEM data were normalized with a PARAFAC model, calibrated to local area

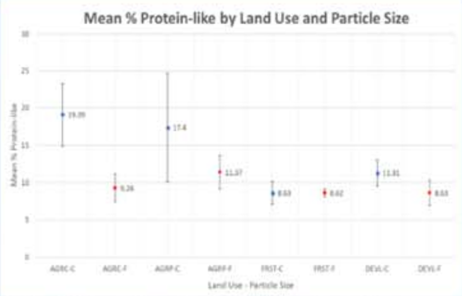




Results







Note: Axes arranged to best demonstrate the differences between land use and particle sizes. The plots are not scaled the same.

Discussion

A z-test assessment of the data at the 95% confidence level showed significant differences ($p < 0.05$) in the mean % for each component, based on their land use and particle class size. These differences are listed below, and the sources they compare move from left to right on each respective plot.

For the mean % humic-like component, it was determined that AGRC-C was significantly different from AGRP-F, FRST-C, FRST-F, DEVL-C, and DEVL-F. Furthermore, AGRC-F was significantly different from AGRP-F, FRST-C, FRST-F, DEVL-C, and DEVL-F. FRST-C was significantly different from FRST-F, DEVL-C, and DEVL-F.

It was also found that the mean % fulvic-like component also had significant differences between land uses and particle class sizes. AGRC-C was significantly different from AGRC-F and FRST-C. AGRC-F was significantly different from AGRP-F, FRST-F, DEVL-C, and DEVL-F. Finally, FRST-C was significantly different than FRST-F, DEVL-C, and DEVL-F.

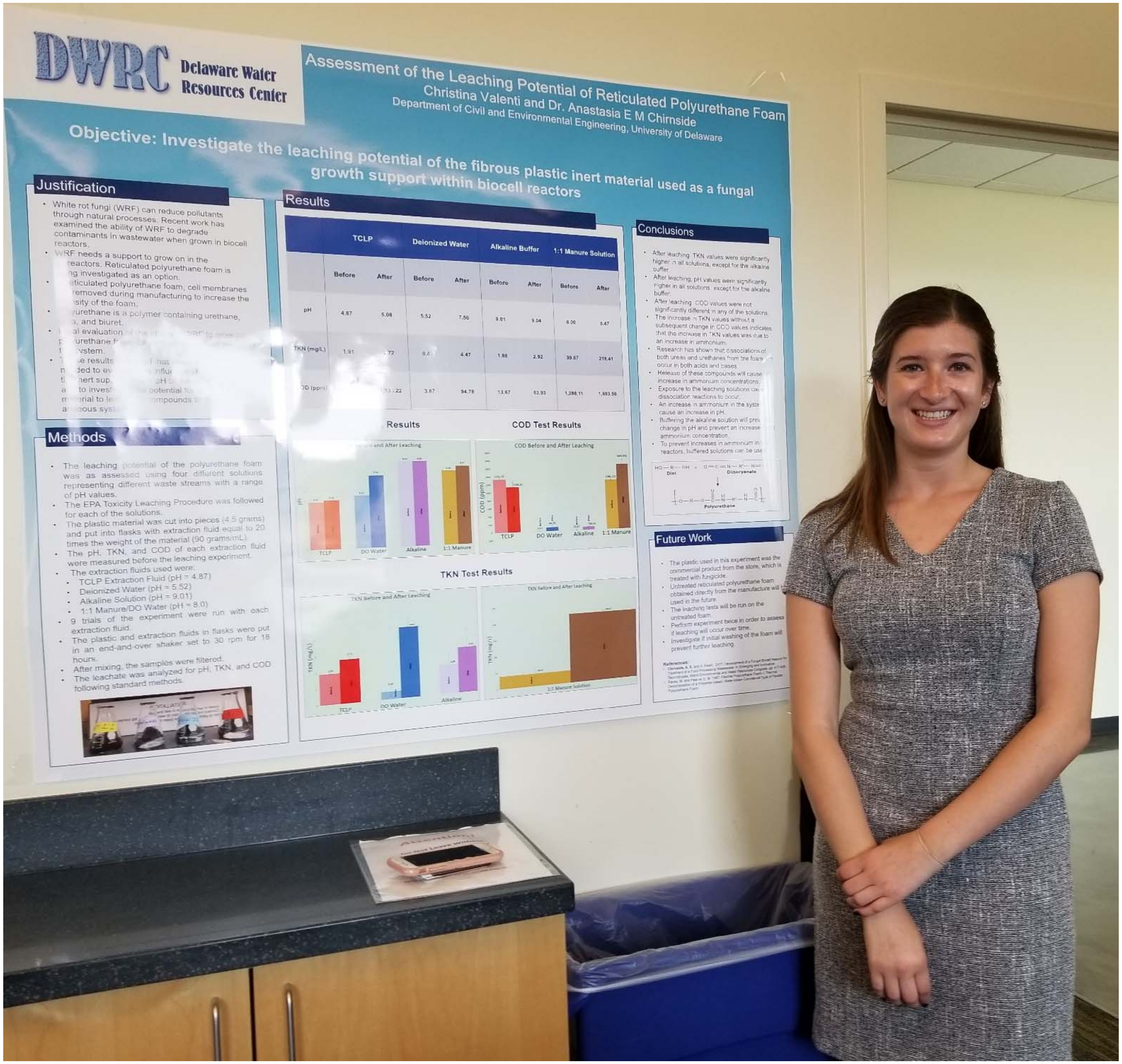
The mean % protein-like component showed the least amount of significant differences between the land uses and particle sizes. AGRC-C was significantly different than AGRC-F, AGRP-F, FRST-C, FRST-F, DEVL-C, and DEVL-F. Also, the mean for FRST-F was significantly different than DEVL-C.

Conclusion

The significant chemical differences between the land uses and particle class sizes will help to identify the main contributors to watershed chemistry. Resolving models for better accuracy in predicting the contributing factors to a watershed's chemistry will lead to more precise prevention and mitigation strategies for dealing with the repercussions of anthropogenically-modified lands. Assisting to reinforce the natural environment's resilience to anthropogenic sources would benefit the ecology itself as well as the ecosystem services the environment provides us.

Acknowledgements

I would like to thank the DWRC for offering me an internship position that supported this project. I'd also like to thank my advisor, Shree, for his guidance and oversight on this project and others during my time at the University of Delaware.



DWRC Delaware Water Resources Center

Assessment of the Leaching Potential of Reticulated Polyurethane Foam

Christina Valenti and Dr. Anastasia E M Chirnside
Department of Civil and Environmental Engineering, University of Delaware

Objective: Investigate the leaching potential of the fibrous plastic inert material used as a fungal growth support within biocell reactors

Justification

- White rot fungi (WRF) can reduce pollutants through natural processes. Recent work has examined the ability of WRF to degrade contaminants in wastewater when grown in biocell reactors.
- WRF needs a support to grow on in the [illegible]reactors. Reticulated polyurethane foam is [illegible]ng investigated as an option.
- [illegible]eticulated polyurethane foam, cell membranes [illegible] removed during manufacturing to increase the [illegible]sity of the foam.
- [illegible]yurethane is a polymer containing urethane, [illegible], and biuret.
- [illegible]al evaluation [illegible] urethane [illegible] system.
- [illegible]e results [illegible] has [illegible]ded to ev[illegible] influ[illegible] [illegible]nert sup[illegible] pH [illegible] to invest[illegible] potential [illegible]rial to le[illegible] compounds [illegible] [illegible]eous sys[illegible]

Methods

- The leaching potential of the polyurethane foam was as assessed using four different solutions representing different waste streams with a range of pH values.
- The EPA Toxicity Leaching Procedure was followed for each of the solutions.
- The plastic material was cut into pieces (4.5 grams) and put into flasks with extraction fluid equal to 20 times the weight of the material (90 grams/mL)
- The pH, TKN, and COD of each extraction fluid were measured before the leaching experiment.
- The extraction fluids used were:
  - TCLP Extraction Fluid (pH = 4.87)
  - Deionized Water (pH = 5.52)
  - Alkaline Solution (pH = 9.01)
  - 1:1 Manure/DO Water (pH = 8.0)
- 9 trials of the experiment were run with each extraction fluid.
- The plastic and extraction fluids in flasks were put in an end-and-over shaker set to 30 rpm for 18 hours.
- After mixing, the samples were filtered.
- The leachate was analyzed for pH, TKN, and COD following standard methods.

Results

	TCLP		Deionized Water		Alkaline Buffer		1:1 Manure Solution	
	Before	After	Before	After	Before	After	Before	After
pH	4.87	5.08	5.52	7.56	9.01	9.04	8.00	8.47
TKN (mg/L)	1.91	[illegible]	[illegible]	4.47	1.88	2.92	39.67	218.41
[illegible]OD (ppm)	[illegible]	[illegible]	3.67	94.78	13.67	53.93	1,288.11	1,693.56

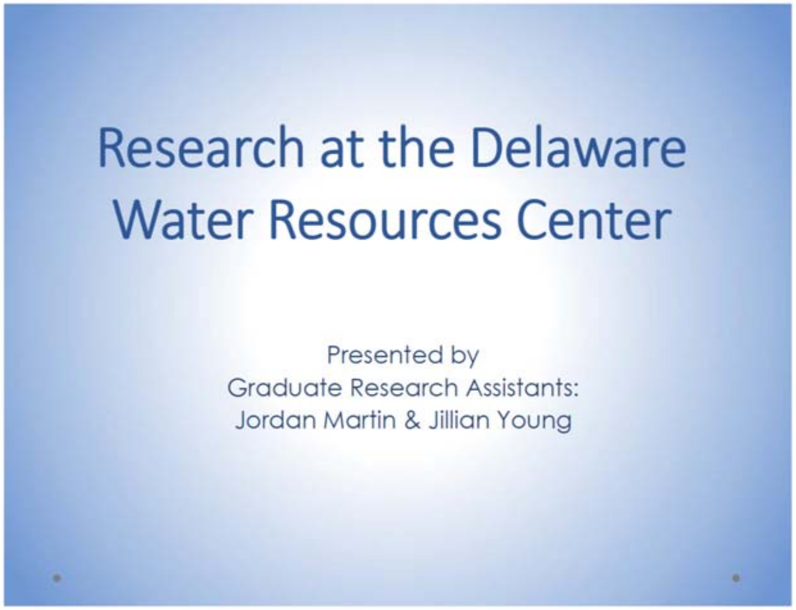
Conclusions

- After leaching TKN values were significantly higher in all solutions, except for the alkaline buffer.
- After leaching, pH values were significantly higher in all solutions except for the alkaline buffer.
- After leaching COD values were not significantly different in any of the solutions.
- The increase in TKN values without a subsequent change in COD values indicates that the increase in TKN values was due to an increase in ammonium.
- Research has shown that dissociations of both ureas and urethanes from the foam [illegible] occur in both acids and bases.
- Release of these compounds will cause [illegible] increase in ammonium concentrations.
- Exposure to the leaching solutions ca[illegible] dissociation reactions to occur.
- An increase in ammonium in the syst[illegible] cause an increase in pH.
- Buffering the alkaline solution will prev[illegible] change in pH and prevent an increase [illegible] ammonium concentration.
- To prevent increases in ammonium in [illegible] reactors, buffered solutions can be use[illegible]

Future Work

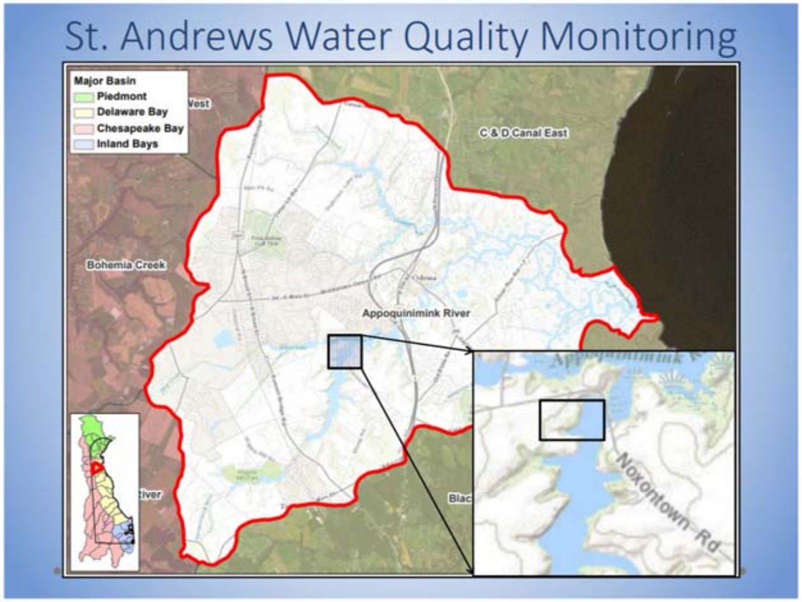
- The plastic used in this experiment was the commercial product from the store, which is treated with fungicide.
- Untreated reticulated polyurethane foam obtained directly from the manufacture will [illegible] used in the future.
- The leaching tests will be run on the untreated foam.
- Perform experiment twice in order to assess if leaching will occur over time.
- Investigate if initial washing of the foam will prevent further leaching.

References:

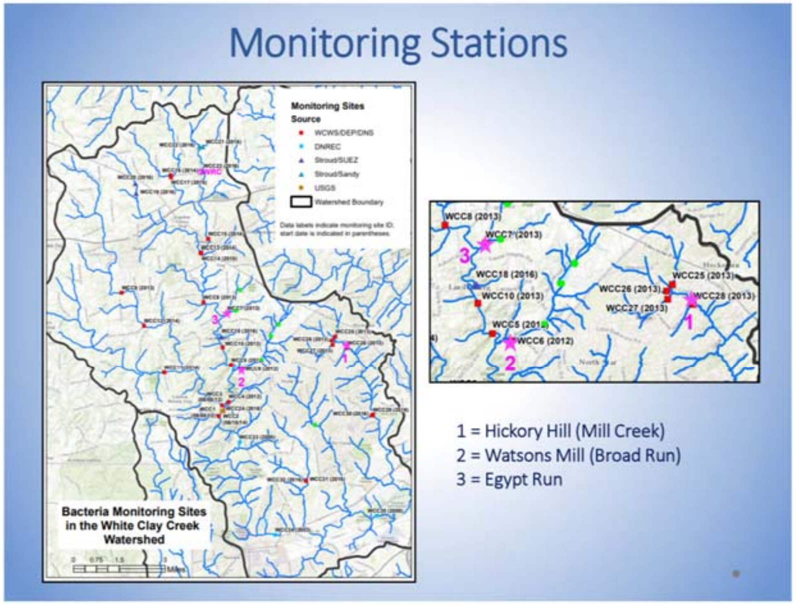


Research at the Delaware Water Resources Center

Presented by
Graduate Research Assistants:
Jordan Martin & Jillian Young

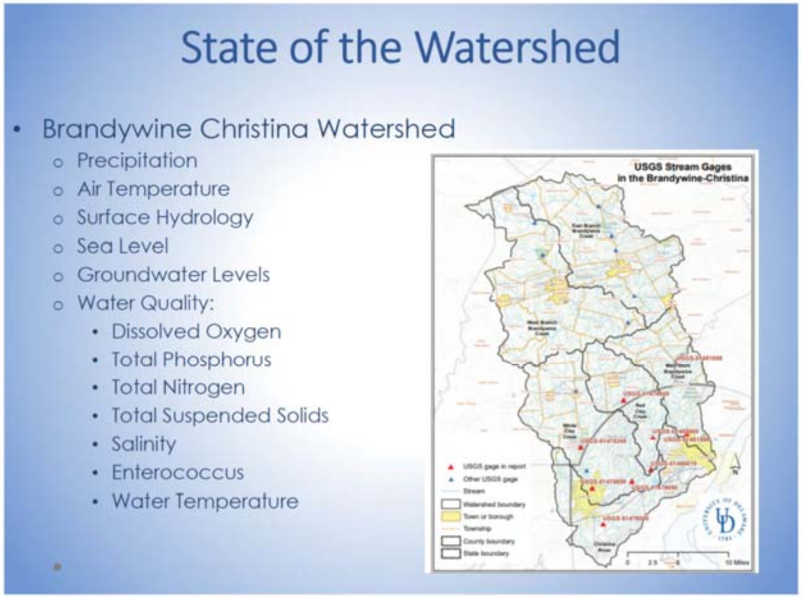


St. Andrews Water Quality Monitoring



Monitoring Stations

1 = Hickory Hill (Mill Creek)
2 = Watsons Mill (Broad Run)
3 = Egypt Run



State of the Watershed

- Brandywine Christina Watershed
  - Precipitation
  - Air Temperature
  - Surface Hydrology
  - Sea Level
  - Groundwater Levels
  - Water Quality:
    - Dissolved Oxygen
    - Total Phosphorus
    - Total Nitrogen
    - Total Suspended Solids
    - Salinity
    - Enterococcus
    - Water Temperature