Fall 2011

Researching Sustainable Ideas for a Brighter Future

Lafayette College

Environmental Poster Presentation

December 1, 2011

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Event Summary

The 2011 Environmental Poster Presentation was the culmination of a semester long assignment in which students researched environmental topics of their choice. Student teams (two - three students) from Dr. Arthur Kney's Environmental Science and Engineering course (CE321) and Dr. Steven Mylon's Environmental Chemistry course (Chem 252) came together to collaborate on numerous Environmental topics.

Students had the opportunity to gain valuable knowledge through their research as well as through hands on experimentation. A number of groups that did hands' on research worked with upper classmen, whom acted as mentors. Each group then had the opportunity to present their findings at the Environmental Poster Presentation held on Thursday, December 1, 2011 in the Marlo Room of the Farinon Student Center from 7:00 to 9:00 pm. This year the poster session showcased twenty-eight posters.

Throughout the semester, the student teams gathered data and organized their research and other background information to create posters representing their topics. Over the course of this project, various drafts were submitted for critique to enable the groups to revise their work and produce their final poster.

The judges selected for this event were a collection of professionals from the Lehigh Valley along with students who previously took one of the courses. Judges were placed in groups of two or three to evaluate six or seven posters based on specific criteria including presentation, professionalism, and aesthetics of the poster as well as the grammar and organization. Each category is judged on a scale of one to five with one being poor and five being excellent. Each year, prizes are awarded to the top five posters in each respective class.

If you would like more information about the Environmental Poster Presentation or these specific courses, please feel free to contact either Dr. Arthur Kney at kneya@lafayette.edu or Dr. Steven Mylon at mylons@lafayette.edu.

The Top Five Posters for Environmental Science and Engineering (CE 321)

First Place: Engineering Education For Grades K-12
Rebecca Citrin and Laura Spadaccini

Second Place: Soil Property Change Under Japanese Barberry
Hua He and Rebecca Folk

Third Place: "Phate of Aquatic Life"
Michelle Echenique and Lauren Hartnett

Fourth Place: 'Pard Pedals
Kathy Delsener, Joelle Neilson, and Jen White

Fifth Place: The Power of Pervious Pavement
Eric Himmelwright, Stephen Berkin, and Matt Muller

The Top Five Posters for Environmental Chemistry (Chem 252)

First Place: Methane Hydrates: Energy Solution or Environmental Hazard?
Rich Albertini and Ashley Kaminski

Second Place: "Phate of Aquatic Life"
Michelle Echenique and Lauren Hartnett

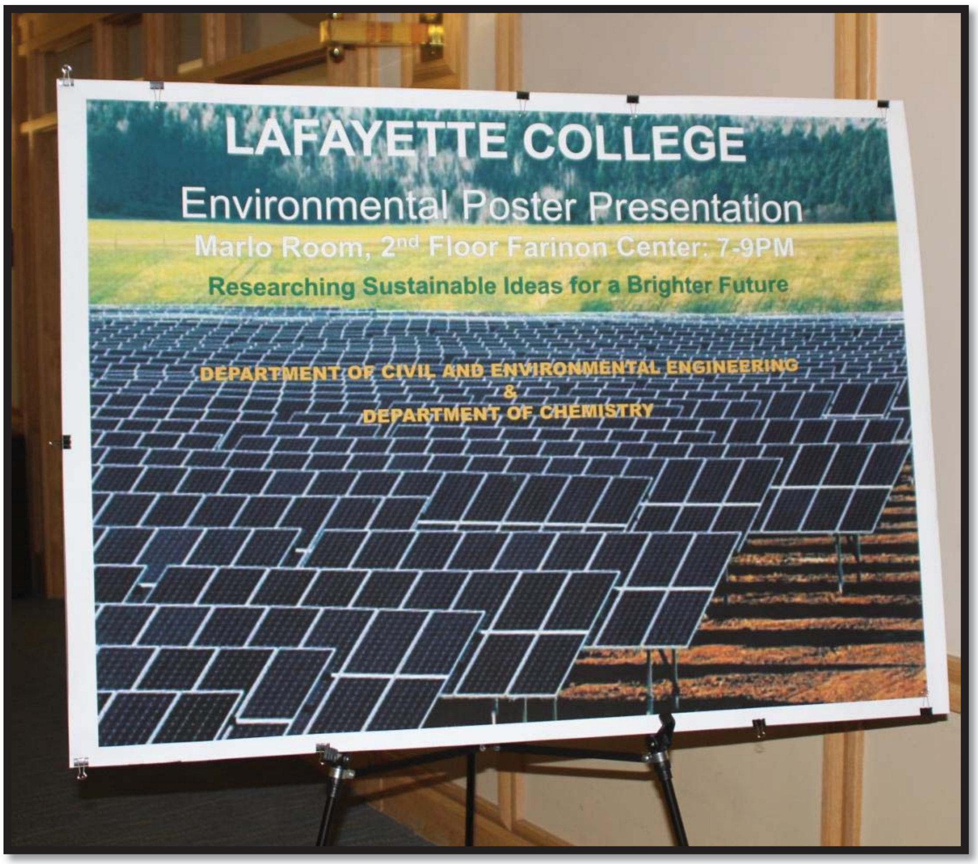
Third Place: Wind Power: The Good, the Bad, and the Sustainability
Steven Saunders, Ciara O'Sullivan, and Kevin Janssen

Fourth Place: Greening Urban Spaces
Taimoor Sohail and Olivia Lewis

Fifth Place: Peril in Pakistan: Exploring Flooding in the Indus River Valley
Asad Akram and Tom Benjamin

Congratulations to Everyone for a Job Well Done!

Poster Summaries



CE 321: Environmental Science and Engineering Poster Research Topics

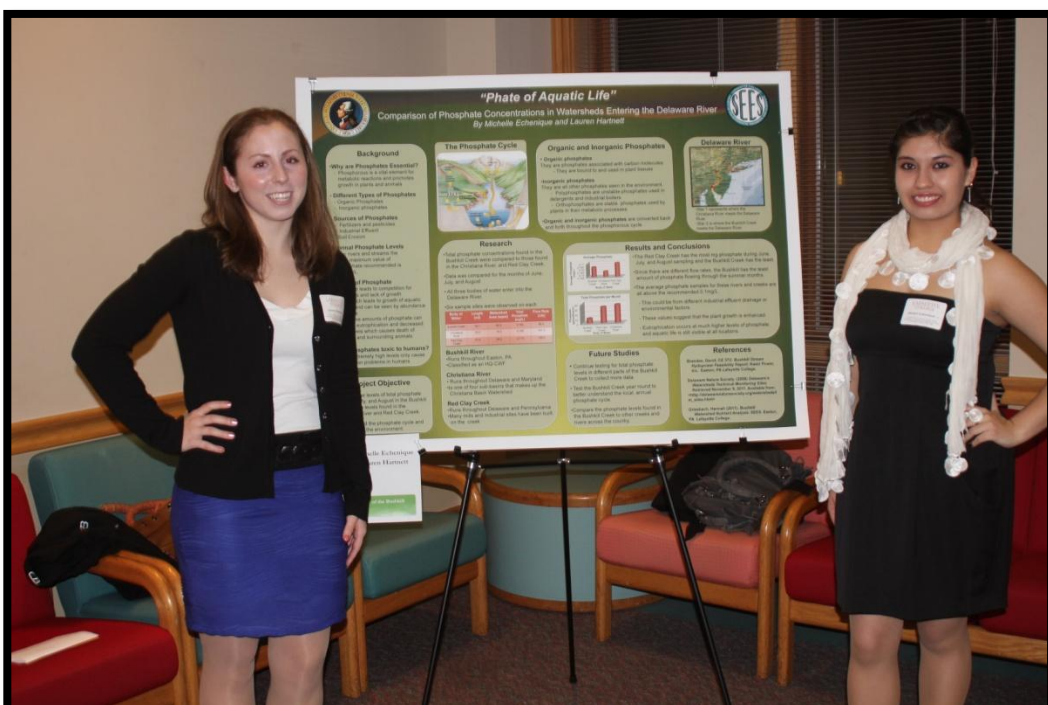
1. "Phate of Aquatic Life"
2. Our Compost Brings All the Food to the Garden: Mass Balance of Nitrogen in Compost
3. Low-Head Dam Impact on Dissolved Oxygen and Temperature
4. Green Roofs: Raising the Roof on Urban Sustainability
5. Engineering Education For Grades K – 12
6. Don't Metal With Our Water
7. The Power of Pervious Pavement
8. Heavy Metal Removal Using a Constructed Wetland
9. Walking on Clean Coals
10. Soil Property Change Under Japanese Barberry
11. Conventional Soil vs. Organic Soil
12. Denitrifying Bacteria: A Natural Water Purifier in Your Backyard
13. Greening Urban Spaces
14. Eat My Trash
15. 'Pard Pedals
16. The Use of Permeable Pavement in Subsurface Detention Basins
17. Best Management Practices for Homeowners
18. Peril in Pakistan: Exploring Flooding in the Indus River Valley
19. The Warmth Of Mother Earth
20. If You Wouldn't Eat It, It Shouldn't Go Into the Water
21. Analyzing the Efficiency of Solar Energy
22. Methane Hydrates: Energy Solution or Environmental Hazard?
23. "Hey Marcellus"… "Yes Frack"… "Shale we drill?"
24. Nutrient Pollution in the Chesapeake Bay
25. Nitrogen and Wetlands: An Evaluation
26. Methanol: The Best Alternative Fuel
27. Wind Power: The Good, the Bad, and the Sustainability
28. Economic Benefits of Solar Hot Water on Lafayette Campus

Poster #1

“Phate of Aquatic Life”

Michelle Echenique ’14 and Lauren Hartnett ‘13

Total phosphate levels from the Bushkill Creek, Red Clay Creek, and Christiana River were analyzed and compared to one another for the months of June, July, and August. Phosphate was the focus of this research project because it is an important compound in metabolic processes. While phosphate is typically the limiting nutrient for a natural environment, it can have harmful effects, such as eutrophication, when in excess. Multiple annual watershed reports were read to compile data for samples taken at six different sites on the same day of each month during the summer. The levels of phosphate were used to calculate the average phosphate per month per acre for each specific watershed. Presenting the data in this way helps eliminate differences, such as flow rate, between each of the bodies of water that would skew the comparison. The Christiana River has the highest level of phosphate per month per acre, while the Bushkill Creek has the lowest levels. All bodies of water have phosphate levels above the recommended EPA value of 0.1mg/L, which suggests that eutrophication should be occurring in all of them. These high levels could be one of the contributing factors of phosphate rich fertilizer erosion from farms in Delaware and Pennsylvania. Even though eutrophication is not occurring in the Christiana River and Bushkill Creek, it is happening in parts of the Red Clay Creek. Other factors, such as nitrogen levels, need to be compared to the phosphate levels found in this project to understand why eutrophication is happening in some areas, but not others.



"Phate of Aquatic Life"

Comparison of Phosphate Concentrations in Watersheds Entering the Delaware River

By Michelle Echenique and Lauren Hartnett

Background

•Why are Phosphates Essential?
- Phosphorous is a vital element for metabolic reactions and promotes growth in plants and animals

• Different Types of Phosphates
- Organic Phosphates
- Inorganic phosphates

• Sources of Phosphates
- Fertilizers and pesticides
- Industrial Effluent
- Soil Erosion

•Normal Phosphate Levels
- For rivers and streams the EPA maximum value of phosphate recommended is 0.1mg/L.

•Effects of Phosphate
- Too little leads to competition for nutrients and lack of growth
- Too much leads to growth of aquatic plants and can be seen by abundance of algae
- Extreme amounts of phosphate can cause eutrophication and decreased O_2 levels which causes death of plants and surrounding animals

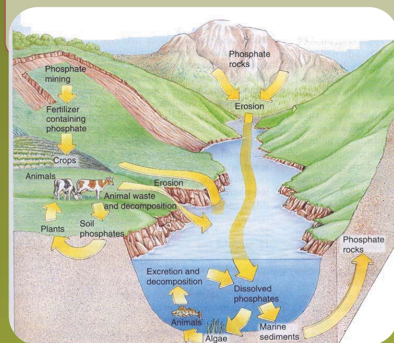
•Are phosphates toxic to humans?
- No, extremely high levels only cause digestion problems in humans

Project Objective

- Compare the levels of total phosphate for June, July, and August in the Bushkill Creek to the levels found in the Christiana River and Red Clay Creek.

-To understand the phosphate cycle and its effects on the environment.

The Phosphate Cycle



Research

•Total phosphate concentrations found in the Bushkill Creek were compared to those found in the Christiana River, and Red Clay Creek.

•Data was compared for the months of June, July, and August

• All three bodies of water enter into the Delaware River.

•Six sample sites were observed on each

Body of Water	Length (mi)	Watershed Area (sqmi)	Total Phosphate (mg/L)	Flow Rate (cfs)
Bushkill Creek	30.1	80.0	0.163	86.0
Christiana River	35.0	78.0	0.155	331.0
Red Clay Creek	27.6	54.0	0.170	185.0

Bushkill River
•Runs throughout Easton, PA
•Classified as an HQ-CWF

Christiana River
• Runs throughout Delaware and Maryland
•Is one of four sub-basins that makes up the Christiana Basin Watershed

Red Clay Creek
•Runs throughout Delaware and Pennsylvania
•Many mills and industrial sites have been built on the creek

Organic and Inorganic Phosphates

• Organic phosphates
They are phosphates associated with carbon molecules.
- They are bound to and used in plant tissues

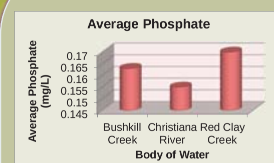
•Inorganic phosphates
They are all other phosphates seen in the environment.
- Polyphosphates are unstable phosphates used in detergents and industrial boilers.
- Orthophosphates are stable phosphates used by plants in their metabolic processes.

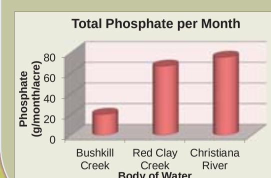
•Organic and inorganic phosphates are converted back and forth throughout the phosphorous cycle.

Delaware River

•Star 1 represents where the Christiana River meets the Delaware River.
•Star 2 is where the Bushkill Creek meets the Delaware River.

Results and Conclusions





•The Red Clay Creek has the most mg phosphate during June, July, and August sampling and the Bushkill Creek has the least.

•Since there are different flow rates, the Bushkill has the least amount of phosphate flowing through the summer months.

•The average phosphate samples for these rivers and creeks are all above the recommended 0.1mg/L.

- This could be from different industrial effluent drainage or environmental factors.
- These values suggest that the plant growth is enhanced.
- Eutrophication occurs at much higher levels of phosphate, and aquatic life is still visible at all locations.

Future Studies

• Continue testing for total phosphate levels in different parts of the Bushkill Creek to collect more data.

• Test the Bushkill Creek year round to better understand the local, annual phosphate cycle.

•Compare the phosphate levels found in the Bushkill Creek to other creeks and rivers across the country.

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Delaware Nature Society. (2008) *Delaware's Watersheds Technical Monitoring Sites.* Retrieved November 9, 2011. Available from: <http://delawarenaturesociety.org/watersheds/tm_sites.html>

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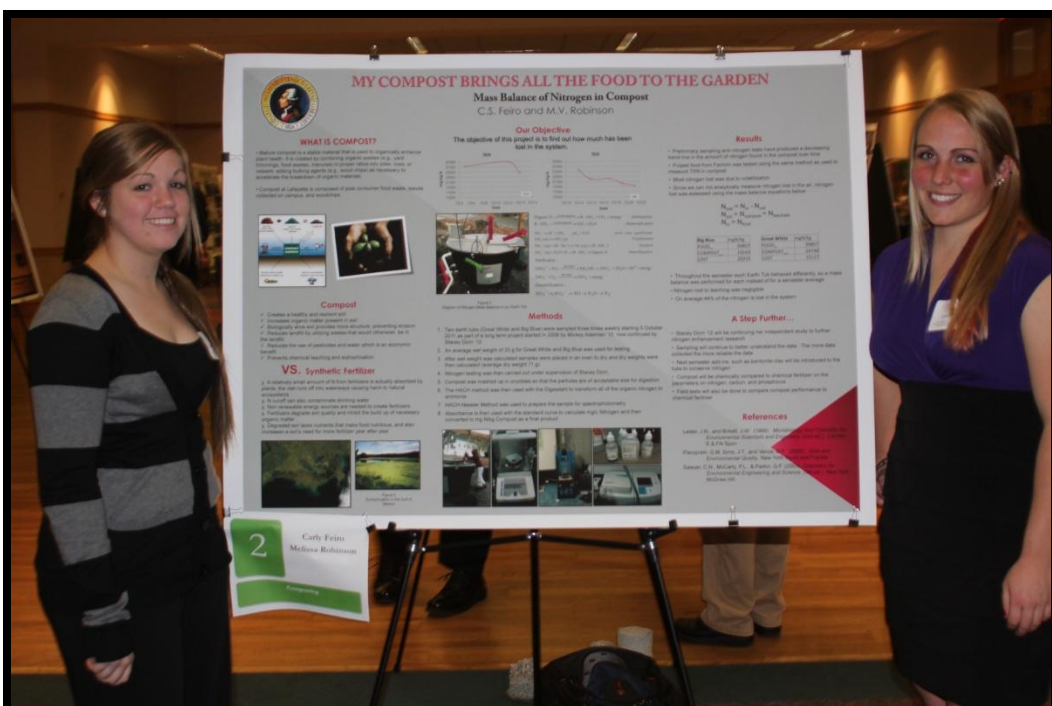
Poster #2

Our Compost Brings All the Food to the Garden: Mass Balance of Nitrogen in Compost

Carly Feiro '12 and Melissa Robinson '14

We worked with compost and the nitrogen cycle that takes place within the compost process. Compost is created by combining organic wastes, such as yard trimmings, food wastes and manures, in proper ratios into piles, rows, or vessels. The additions of bulking agents are necessary to accelerate the breakdown of organic materials. The ultimate goal of our project was to find out how much nitrogen is lost throughout the composting process. We tested various nitrogen levels by sampling the compost in our two earth tubs three days a week and also by sampling the leachate. With these compost samples, we then digested them in the digesdahl. After that we used the HACH-Nessler method to get the compost ready for the spectrophotometer. The HACH spectrophotometer renders an absorbance which we then compared to a standard curve to produce the nitrogen level of that sample. We used mass balance equations to compare these samples with each other to see the differences in the levels of nitrogen and to see how much nitrogen was lost. We wanted to find how much nitrogen was lost in order to better understand how to keep as much nitrogen in the compost as possible.



MY COMPOST BRINGS ALL THE FOOD TO THE GARDEN

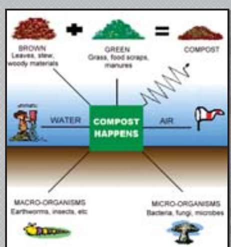
Mass Balance of Nitrogen in Compost

C.S. Feiro and M.V. Robinson

WHAT IS COMPOST?

• Mature compost is a stable material that is used to organically enhance plant health. It is created by combining organic wastes (e.g., yard trimmings, food wastes, manures) in proper ratios into piles, rows, or vessels; adding bulking agents (e.g., wood chips) as necessary to accelerate the breakdown of organic materials.

• Compost at Lafayette is composed of post consumer food waste, leaves collected on campus, and woodchips.



Compost

- ✓ Creates a healthy and resilient soil
- ✓ Increases organic matter present in soil
- ✓ Biologically alive soil provides more structure, preventing erosion
- ✓ Reduces landfill by utilizing wastes that would otherwise be in the landfill.
- ✓ Reduces the use of pesticides and water which is an economic benefit
- ✓ Prevents chemical leaching and eutrophication

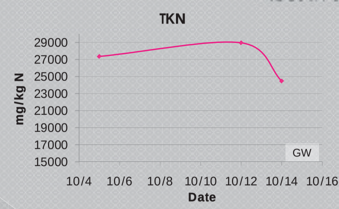
VS. Synthetic Fertilizer

- χ A relatively small amount of N from fertilizers is actually absorbed by plants, the rest runs off into waterways causing harm to natural ecosystems
- χ N runoff can also contaminate drinking water
- χ Non renewable energy sources are needed to create fertilizers
- χ Fertilizers degrade soil quality and inhibit the build up of necessary organic matter
- χ Degraded soil lacks nutrients that make food nutritious, and also increases a soil's need for more fertilizer year after year

Figure 2
Eutrophication in the Gulf of Mexico

Our Objective

The objective of this project is to find out how much has been lost in the system.



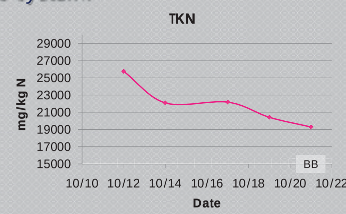


Figure 3
Diagram of Nitrogen Mass Balance in our Earth Tub

$$\text{Organic N} \xrightarrow{\text{Aerobic/anaerobic}} R\text{-}NH_2 + CO_2 + \text{energy} \qquad \textit{Amination}$$

$$R\text{-}NH_2 \xrightarrow{\text{Aerobic/anaerobic}} NH_3 + H_2O \qquad \textit{Ammonification}$$

$$NH_4^+ \leftrightarrow H^+ + NH_3 \qquad pK_a = 9.23 \qquad \textit{Acid-base equilibrium}$$

$$NH_3(aq) \leftrightarrow NH_3(g) \qquad \textit{Volatilization}$$

$$NH_4^+(aq) + (R\text{-}Na^+) \leftrightarrow Na^+(aq) + (R\text{-}NH_4^+) \qquad \textit{Sorption}$$

$$NH_4^+(aq) + H_2O + R \rightarrow R\text{-}NH_2 \rightarrow \text{Organic N} \qquad \textit{Immobilization}$$

Nitrification:

$$2NH_4^+ + 3O_2 \xrightarrow{\text{Aerobic}} NH_2OH \rightarrow 2NO_2^- + 2H_2O + 4H^+ + \text{energy}$$

$$2NO_2^- + O_2 \xrightarrow{\text{Aerobic}} 2NO_3^- + \text{energy}$$

Denitrification:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Methods

1. Two earth tubs (Great White and Big Blue) were sampled three times weekly starting 5 October 2011 as part of a long term project started in 2008 by Mickey Adelman '10 now continued by Stacey Dorn '12.
2. An average wet weight of 33 g for Great White and Big Blue was used for testing.
3. After wet weight was calculated samples were placed in an oven to dry and dry weights were then calculated (average dry weight 11 g)
4. Nitrogen testing was then carried out under supervision of Stacey Dorn.
5. Compost was mashed up in crucibles so that the particles are of acceptable size for digestion
6. The HACH method was then used with the Digesdahl to transform all of the organic nitrogen to ammonia.
7. HACH-Nessler Method was used to prepare the sample for spectrophotometry.
8. Absorbance is then used with the standard curve to calculate mg/L Nitrogen and then converted to mg N/kg Compost as a final product.

Results

- Preliminary sampling and nitrogen tests have produced a decreasing trend-line in the amount of nitrogen found in the compost over time
- Pulped food from Farinon was tested using the same method as used to measure TKN in compost
- Most nitrogen lost was due to volatilization
- Since we can not analytically measure nitrogen lost in the air, nitrogen lost was assessed using the mass balance equations below:

$$N_{lost} = N_{in} - N_{out}$$
$$N_{out} = N_{compost} + N_{leachate}$$
$$N_{in} = N_{food}$$

Big Blue	mgN/kg
$FOOD_{in}$	39857
$COMPOST_{out}$	19543
LOST	20315

Great White	mgN/kg
$FOOD_{in}$	39857
$COMPOST_{out}$	24740
LOST	15117

- Throughout the semester each Earth Tub behaved differently, so a mass balance was performed for each instead of for a semester average
- Nitrogen lost to leaching was negligible
- On average 44% of the nitrogen is lost in the system

A Step Further…

- Stacey Dorn '12 will be continuing her independent study to further nitrogen enhancement research
- Sampling will continue to better understand the data. The more data collected the more reliable the data
- Next semester add-ins, such as bentonite clay will be introduced to the tubs to conserve nitrogen
- Compost will be chemically compared to chemical fertilizer on the parameters on nitrogen, carbon, and phosphorus
- Field tests will also be done to compare compost performance to chemical fertilizer

References

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Poster #3

Low-Head Dam Impact on Dissolved Oxygen and Temperature

Gabrela Lachapel '12, Sarah Rogal '12, and Briana Skalski '12

In the 1700 and 1800's low-head dams were placed along the Bushkill Creek, a local coldwater fishery. These dams are no longer in operation and represent no economic value. During low or intermediate flows, the dams create pools of water, which allow for easy collection or for recreational purposes. The disadvantages of these pools however, are that they have altered the water and river chemistry, in addition to the biota. Using a Quanta Probe, we tested levels of dissolved oxygen and temperatures, which are characteristics of a healthy stream for plants and animals. Higher levels of dissolved oxygen and colder temperatures are positive attributes because they are generally associated with higher species richness. Our data was inconclusive due to unforeseen weather patterns this fall. Because of the weather, we were not able to illustrate the correlation between DO and decreasing temperature that has been proven in previous literature. In the future, we hope to see data collection continue along the dams of the Bushkill.

Low-Head Dam Impact on Dissolved Oxygen and Temperature

Gabriela Lachapel, Sarah Rogal & Briana Skalski
Faculty Advisor: Professor David Brandes, Civil & Environmental Engineering

Background

What is a Low-Head Dam?

A low-head dam is a small overflow dam typically 3 to 15 feet in height that extends along the body of water.

How does dissolved oxygen help determine stream quality?

Dissolved Oxygen is exactly what it sounds like; oxygen gas dissolved in water. This is an essential part of stream life since it is required by both plants and animals for survival. Dependent on weather and temperature, high levels of DO can help support diverse species populations.

What role does temperature play?

Certain streams call for different temperatures to provide for the wildlife that is present. In our case, the Bushkill Creek is designated as a cold water fishery. This type of environment normally has temperatures under 20° Celsius, which is crucial for the biota and dissolved oxygen levels. Research has proven that colder temperatures have been correlated with higher species richness.

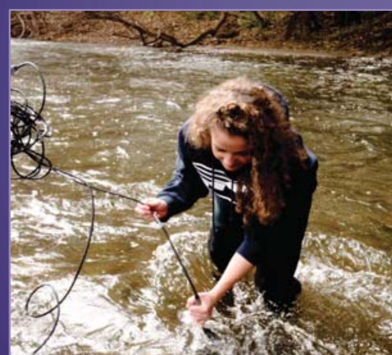
How does a Low-Head Dam impact the water quality over time?

The dams disrupt the natural flow, movement of sediment, and migratory patterns of fish native to this watershed. Normally, the water would flow at a much faster rate along shallow depths. However, once the dam is in place, the streambed deepens as sediment and water build up. Pools form behind the dams because the velocity of the water begins to decrease as it approaches the dam. The sediment buildup increases suspended solids that disrupt the flow of oxygen in the water. Fish cannot migrate upstream with the dam blocking their journey.

The Bushkill Creek

In the 18th and 19th centuries low-head dams were placed all along the Bushkill to power a number of sawmills that resided in the area. The Bushkill had high levels of biodiversity, as well as a significantly smaller number of inhabitants and development along the creek. Even though these dams served as a source of power and other uses for other industries in the past, they have now become obsolete.

Despite the fact that the creek has changed over the past one hundred years, these low-head dams are still intact serving no economic value. Today, the location of these damns is justified by nature of flows along the Bushkill. During low or intermediate flows, the dams create pools of water, which allow for easy collection or for recreation purposes. The disadvantage of these pools however, are that they have altered the water and river chemistry, in addition to the biota.



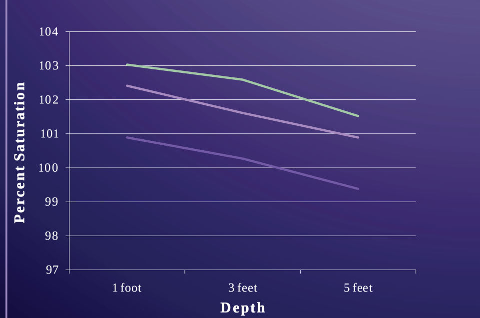
Methods

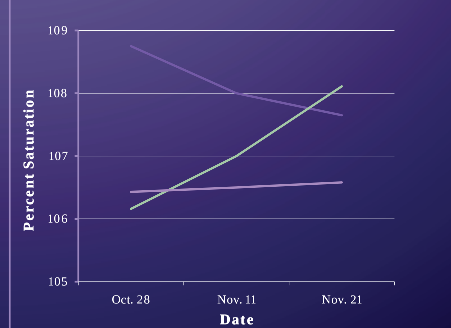
We collected our samples in the pools and riffles located behind the last dam before the Bushkill meets the Delaware in downtown Easton. The red circles on the map to the right are approximate locations where we gathered data at various depths using a Quanta Probe.

This probe measures dissolved oxygen and temperature, which are the two most important variables to stream quality. In the pools, we gathered measurements of DO and temperature at three depths of 5, 3, and 1 foot. In the riffles we were only able to get a depth of about 1 foot at each location due to the shallow waters.

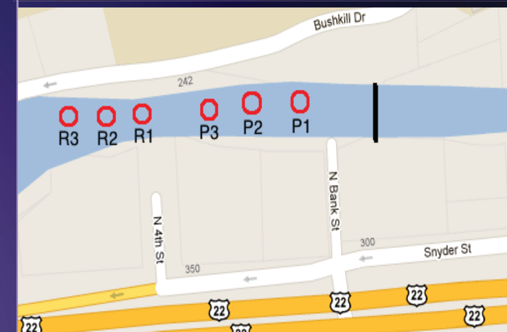
The pool, located right behind the dam, had slower velocities as well as lower levels of DO and higher temperatures, according to theory. Since the riffles are much more shallow, they move faster, which is conducive to higher DO and colder temperatures.

Oxygen Saturation





Sampling Locations



Results & Recommendations

Our data was inconclusive due to unforeseen weather patterns this fall. However, we were able to find that the DO was higher in the riffles than in the pools, as predicted. In addition, as the depth of the pools increased, DO decreased. Because of the weather, we weren't able to illustrate the correlation between DO and decreasing temperature that has been proven in previous literature. Ultimately, we would have liked to see DO increase over time as we head into the winter months. In the future we'd hope to see data collection continue throughout these months and into the spring and after the dams along the Bushkill have been removed to observe its effects.

A number of possibilities may arise as the result of the dam removal. One of these is the release of previously immobile sediment, which could be detrimental to the health of the river. It is also possible to see restoration of vegetation along the riparian buffer zones. The increased number of trees and shrubbery creates shade for the stream. This protective cover helps to keep the water temperatures down and dissolved oxygen up. The leaves that fall from these trees are also a source of the food for the variety of organisms that live in the Bushkill waters. Without the dams, fish native to the watershed are able to swim up and downstream further but this too could be altered by the change in sediment transport.

As a result of the removal of these man-made structures, we hope to see the natural functions of the stream be restored.

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Poster #4

Green Roofs: Raising the Roof on Urban Sustainability

Addison Wechter '14, Mazi Chiles '14, and Patrick Crosby '14

Our research primarily focused on the sustainability and practicality of green roof technology in an urban environment, while also analyzing the benefits and obstacles that this initiative could face. There are many benefits to green roofs, ranging from lowering the urban heat island, to creating an environment for species untouched by people. However, the biggest benefit to green roofs is the reduction in storm water runoff from the buildings in a city. When the runoff from storms reaches its ending point, in a lake or river, it is equivalent to untreated wastewater being dumped in that body of water. We chose to focus on Philadelphia as an example of this, where they have implemented a project to reduce storm water runoff and save the city money from repairing the sewer system. In order for green roofs to become a more prominent feature in an urban setting, awareness about the benefits and more initiatives like Philadelphia's are needed. The long term benefits of implementing green roof technology in a city far outweigh the initial cost, while also providing an important environmental service.

LAFAYETTE COLLEGE

Green Roofs: Raisin' the Roof on Urban Sustainability

By: Addison Wechter, Mazi Chiles, and Patrick Crosby

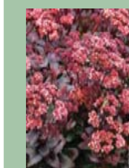
Background

As our world becomes increasingly industrialized and space becomes more and more of a commodity, engineers will need to come up with sustainable alternatives to help with the environmental issues we will surely face. One of these issues will be replacing the green space lost to impervious material in urban areas. Green roofs are a type of sustainable solution that should become more common in the years to come. The presence of vegetation on rooftops is both economically and ecologically beneficial. Not only does it reduce storm water runoff and reduce the "urban heat island" effect but it increases the longevity of the roof and the building efficiency. Many cities around the world have begun to incorporate green roofs into their infrastructure. Nearby, the city of Philadelphia has 18.98 acres of green roofs either installed or in the process of being installed.

Plant Selection

•Aesthetic appeal, environmental conditions, and necessary substrate depth are all factors that need to be considered

•Succulent plants are common on extensive green roofs due to their ability to store excess water



The genus Sedum is a very common selection for extensive green roofs due to its high drought tolerance, low maintenance, and ground coverage

Downfalls

•Increased Initial cost
  •Have potential to cost twice as much as non-green roofs
•Possible structural concern to the building
  •Intensive designs will put more stress on the building structure

Green Philly

•Called the GreenWorks Plan
•Goal is to make Philly the "greenest city in America"
•Green roofs are the main focus of the program and are designed to address the city's stormwater issues
•Three main incentives to build green roofs
  •Stormwater regulations for development
  •Stormwater impervious cover parcel-based billing
  •Business privilege tax credits
•Diverse use of green roofs
•Projected to share the top ranking of most square footage of green roofs installed by any city in 2015

Green Roofs By Geographical Area In Philadelphia

Neighborhood	Built		Planned or Constructed		Total	
	Count	Area (sq ft)	Count	Area (sq ft)	Count	Area (sq ft)
Center City	9	127,862	7	148,524	16	276,386
University City	6	55,471	1	21,890	7	77,361
Northern Liberties	11	78,030	5	109,448	16	187,478
West Philly	2	19,394	2	46,671	4	66,065
North Philly	3	56,031	3	33,319	6	89,350
Northwest Philly	3	14,219	3	17,198	6	31,147
South Philly	4	2,330	3	41,403	7	43,733
Northest Philly	0	-	2	55,134	2	55,134
Total	38	53,337	26	473,587	64	826,924

Design

•There are two categories of green roofs, extensive and intensive
  •Intensive-need intense maintenance and designed for human interaction, substrate > 15.2 cm
  •Extensive-need minimal maintenance and are generally not accessible to the public, substrate < 15.2 cm
•Extensive green roofs are the more sustainable and practical of the two
•Construction components of both intensive and extensive include a growing medium, water retention fabric, filter fabric, drainage layer and root barrier under the vegetation

•Environmental conditions of the region and design constraints always need to be taken into account

Benefits

•Reduced volume of stormwater runoff
  •Greatest benefit to the environment
  •Can reduce runoff by 60% to 100%
•Delayed stormwater runoff
  •Can reduce water flow rates by 57% to 87%
•Increase the lifespan of roofing membrane
  •Protect membrane from solar exposure and ultraviolet radiation
  •Can extend membrane 2 to 3 times
•Energy conservation and reduction in urban heat island
  •Can reduce solar energy gain by 90%
  •0.12% to 0.2% heating reduction
  •6.2% to 6.4% cooling reduction

•Increased biodiversity and habitat
•Reduction of air pollution
  •If 20% of green roof ready buildings in Washington D.C. built green roofs, it would be equivalent to planting 17,000 trees.
•Leadership in energy and environmental design (LEED) standards
  •Could earn up to 15 LEED credits

Future Advancement

•Although we have a long way to go, green roofs are becoming more popular and practical throughout America.
•Increased education on installation and benefits
  •Green Roofs for Healthy Cities (GRHC) is a nonprofit that has increased the public awareness by offering classes
•Government incentives
  •Atlanta offers discounts on monthly stormwater bill to owners of green roofs
  •Earth Pledge offices in New York built green roof to grow food for employees

Sources

•Crockett, Christopher, Jeremy Chadwick, and Joanne Dahme. "Green Philly." *Living Architecture Monitor* Spring (2010): 12-15. Print.
•Getter, Kristin L., and Bradley D. Rowe. "The Role of Extensive Green Roofs in Sustainable Development." HortScience (2006). Print.

Poster #5

Engineering Education for Grades K – 12

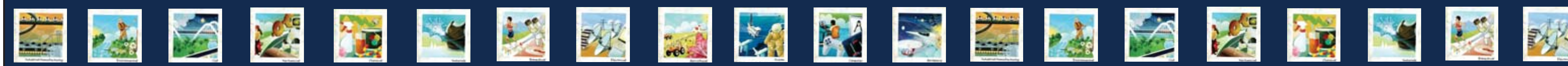
Rebecca Citrin ’14 and Laura Spadaccini ’14

The demand for research in Engineering Education for students from grades K – 12 has grown rapidly since the 1990’s. New developments have been made in this field which have allowed for the implementation of engineering strategies in primary and secondary schools. Through an in depth analysis of the current status of engineering curriculum throughout the Unites States, we were able to gain insight into this area of research. As the world around us is changing and an increased importance is being placed on engineering, it is important that students are exposed to this discipline at an early age. In order to put into practice what we researched, we organized the first Lafayette College Engineering Brain Bowl. Approximately 35 students from Northampton County attended the event where they were exposed to various engineering disciplines. Lafayette faculty presented information to the students based on their respective area of expertise and the students then participated in interactive hands on activities. At the conclusion of the event an evaluative survey was distributed to assess what knowledge the students had gained as well as to validate our research. The event was successful in the fact that we were able to bring exposure to the importance of studying engineering in primary and secondary schools through educational activities. Through our findings we were able to identify the importance of implementing engineering based programs for students from grades K – 12, who will not only benefit academically from this early exposure to engineering, but will also gain valuable life skills.

Engineering Education for Grades K – 12

An In Depth Analysis of the Status of Engineering Curriculum Throughout the United States.

By: Rebecca Citrin and Laura Spadaccini
CE 321 Introduction to Environmental Engineering



Introduction

Defining Engineering
The National Academy of Engineering defines engineering as design under constraints, with the most fundamental of these constraints being the laws of nature.

Engineers design solutions to particular problem and must take into account how objects behave in motion. Engineers design with the goal of meeting human needs and wants.

History of Engineering Education
The first official K–12 engineering curriculum program was introduced during the 1990's.

The acronym STEM, or Science, Technology, Engineering and Mathematics was coined in 2001 by the National Science Foundation as a program that aims to educate all students in these disciplines, as opposed to previously developed programs which only focused on advanced students.

While science, mathematics and technology education all have well established roots in elementary and secondary schools, engineering education still lacks a defined set of curriculum, standards and assessments.

The Committee on K–12 Engineering Education was established in 2006 by the National Academy of Engineering to institute standards for engineering education for future generations.

Objectives of Research

Significance of Engineering Education

The world around us is changing – increasing in complexity, interconnectivity, competitiveness, and technology dependence – which poses new challenges for individuals and for nations that cannot be met by continuing education as usual.

– National Academy of Engineering

Positive outcomes which can result from engineering education for students in grades K–12 include:

- Enhanced Knowledge of Science and Mathematic Concepts
- Critical Thinking and Design Skills
- Improved Technological Capabilities
- Increased School Attendance and Retention of Students
- Increased Cognizance of Engineering and What Engineers Do
- Interest in Pursuing an Engineering Career

Standards for Engineering Education

Content Standards	• Includes comprehension and aptitude of learning outcomes students are presumed to acquire.
Teaching Standards	• Includes responsibility of teachers to provide educational learning opportunities focusing on the STEM disciplines.
Teacher Professional Development Standards	• Includes comprehension and aptitude of teachers to obtain knowledge through professional development experiences.
Program Standards	• United States government standards for education programs
Assessment Standards	• Implementation of standardized tests and other practices to gage student accomplishment.
Performance Standards	• Includes the convention and capacity to demonstrate the achievements of students

Techniques for Implementation

Methods

Engineering Concepts
- Systems
- Optimization

Engineering Skills
- Drawing and Representing
- Experimenting and Testing

Teaching Strategies
- Allowance of an appropriate amount of class time for students to fully engage in the development of designs and revisions.
- Formatting material presented to students so that it builds upon itself, where a simple understanding of a topic precedes a more difficult concept.

Figure #1

Figures #1 and #2: Students constructing and testing balloon powered racers as part of Mechanical Engineering activity.

Evaluative Techniques

Lessons Learned
- Assess Knowledge Gained
- Student Input to Evaluate Effectiveness of Activity

Figure #3: Students constructing gum drop bridge as part of Civil Engineering activity.

Figure #4: Students constructing water filtration system as part of Environmental Engineering activity.

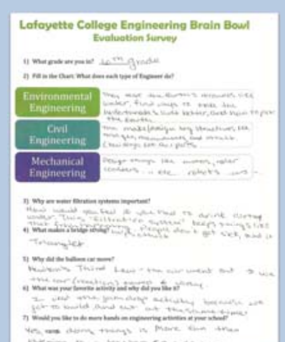


Figure #5: Survey distributed to students at conclusion of Brain Bowl.

Implementation

Lafayette College Engineering Brain Bowl:
There's No Planet B

Figure #6: Entrance poster.

Figure #7: Students testing gum drop bridges.

Figure #8: Professor Kney teaching students about the benefits of recycling.

Figure #9: The winning team posing with their model balloon powered racer.

Results and Conclusion

"I came here," said Reilly, "because I wanted to learn about engineering. I wanted to learn about building bridges and buildings."

Figure #10: Media coverage from event printed in the Allentown Morning Call.

Figure #11: Media coverage from event printed in the Lehigh Valley Express Times.

References

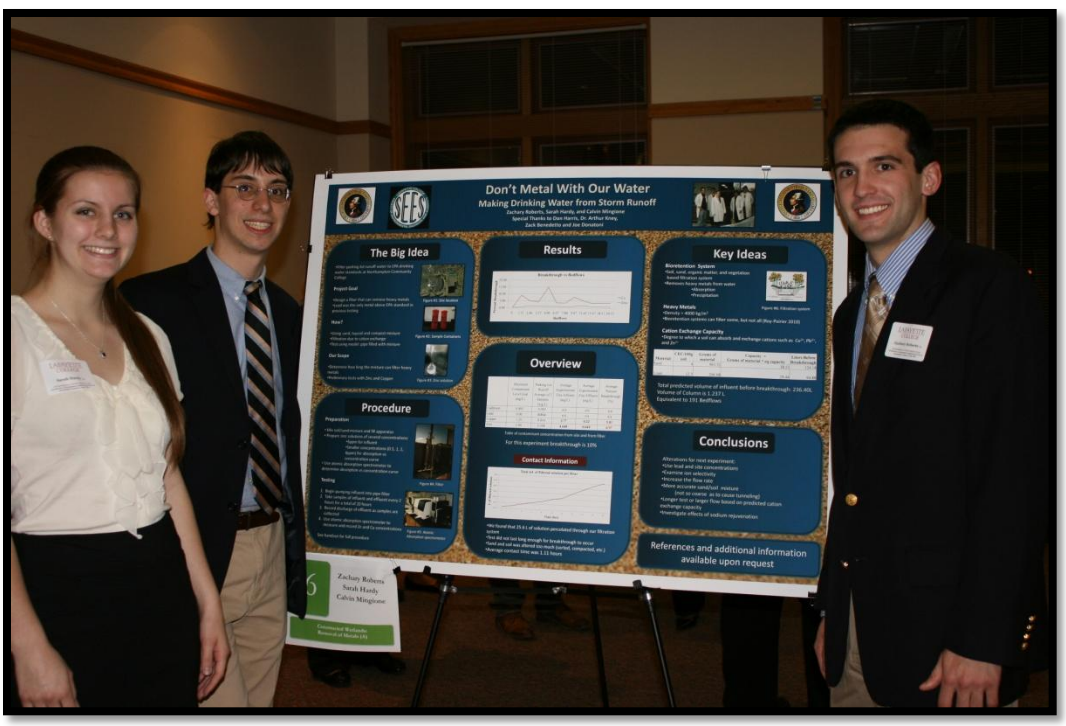
Committee on Standards for K – 12 Engineering Education, National Academy of Engineering. (2010). *Standards for K-12 Engineering Education?* Washington, D.C.: The National Academies Press.
Katehi, L., Pearson, G., & Feder, M. A. (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prospects.* Washington, D.C.: National Academies Press.
National Academy of Engineering. "K-12 Engineering Education." *The Bridge: Linking Engineering and Society* (2009): 5-37.
National Research Council. (1996). *National Science Education Standards: Observe, Interact, Change, Learn.* Washington, D.C.: National Academy.

Poster #6

Don't Metal With Our Water

Zachary Roberts '11, Sarah Hardy '14, and Calvin Mingione '14

The purpose of our research was to determine how long the bioretention system at Northampton Community College could remain an effective filter for heavy metals before needing replacement. We used EPA standards to determine which pollutants were found in excess of the legal limit at the site. Modeling the filter with a glass pipe filled with a sand and soil mixture, we ran solutions of zinc and copper through it for a twenty-hour test. Concentrations were measured using the Atopic Absorption Spectrometer, and the results showed that breakthrough was not achieved. We then used the properties associated with cation exchange and previous experimental results to predict how long the model could be left active before breakthrough would occur. Recommendations for future research included a longer test time and finding accurate correlation factors between our model and the Northampton Community College's site.



Don't Metal With Our Water

Making Drinking Water from Storm Runoff

Zachary Roberts, Sarah Hardy, and Calvin Mingione
Special Thanks to Don Harris, Dr. Arthur Kney,
Zack Benedetto and Joe Donatoni

The Big Idea

•Filter parking lot runoff water to EPA drinking water standards at Northampton Community College

Project Goal

•Design a filter that can remove heavy metals
•Lead was the only metal above EPA standard in previous testing

How?

•Using sand, topsoil and compost mixture
•Filtration due to cation exchange
•Test using model: pipe filled with mixture

Our Scope

•Determine how long the mixture can filter heavy metals
•Preliminary tests with Zinc and Copper

Figure #1: Site location

Figure #2: Sample Containers

Figure #3: Zinc solution

Procedure

Preparation

- Mix soil/sand mixture and fill apparatus
- Prepare zinc solutions of several concentrations:
  - •5ppm for influent
  - •Smaller concentrations (0.5, 1, 2, 4ppm) for absorption vs concentration curve
- Use atomic absorption spectrometer to determine absorption vs concentration curve

Figure #4: Filter

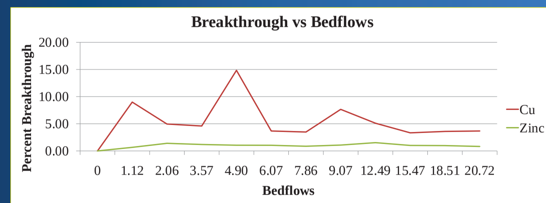
Testing

1. Begin pumping influent into pipe filter
2. Take samples of influent and effluent every 2 hours for a total of 20 hours
3. Record discharge of effluent as samples are collected
4. Use atomic absorption spectrometer to measure and record Zn and Cu concentrations

See handout for full procedure

Figure #5: Atomic Absorption spectrometer

Results



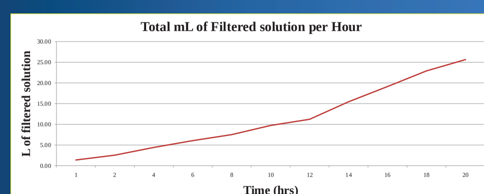
Overview

	Maximum Contaminant Level Goal (mg/L)	Parking Lot Runoff Average of 2 Samples (mg/L)	Average Experimental Zinc Influent (mg/L)	Average Experimental Zinc Effluent (mg/L)	Average Percent Breakthrough (%)
Cadmium	0.005	0.002	n/a	n/a	n/a
Lead	0.00	**0.014**	n/a	n/a	n/a
Copper	1.30	0.044	**3.77**	**0.22**	**5.81**
Zinc	5.00	0.308	**4.648**	**0.049**	**0.97**

Table of contaminant concentration from site and from filter

For this experiment breakthrough is 10%

Contact Information



•We found that 25.6 L of solution percolated through our filtration system
•Test did not last long enough for breakthrough to occur
•Sand and soil was altered too much (sorted, compacted, etc.)
•Average contact time was 1.11 hours

Key Ideas

Bioretention System

•Soil, sand, organic matter, and vegetation based filtration system
•Removes heavy metals from water
•Absorption
•Precipitation

Figure #6: Filtration system

Heavy Metals

•Density > 4000 kg/m^3
•Bioretention systems can filter some, but not all (Roy-Poirier 2010)

Cation Exchange Capacity

•Degree to which a soil can absorb and exchange cations such as Cu^{2+}, Pb^{2+}, and Zn^{2+}

Material	CEC/100g soil	Grams of material	Capacity = Grams of material * eq capacity	Liters Before Breakthrough
Sand	4	963.32	38.53	124.18
Loam	12.5	206.68	29.44	94.88

Total predicted volume of influent before breakthrough: 236.40L
Volume of Column is 1.237 L
Equivalent to 191 Bedflows

Conclusions

Alterations for next experiment:
•Use lead and site concentrations
•Examine ion selectivity
•Increase the flow rate
•More accurate sand/soil mixture (not so coarse as to cause tunneling)
•Longer test or larger flow based on predicted cation exchange capacity
•Investigate effects of sodium rejuvenation

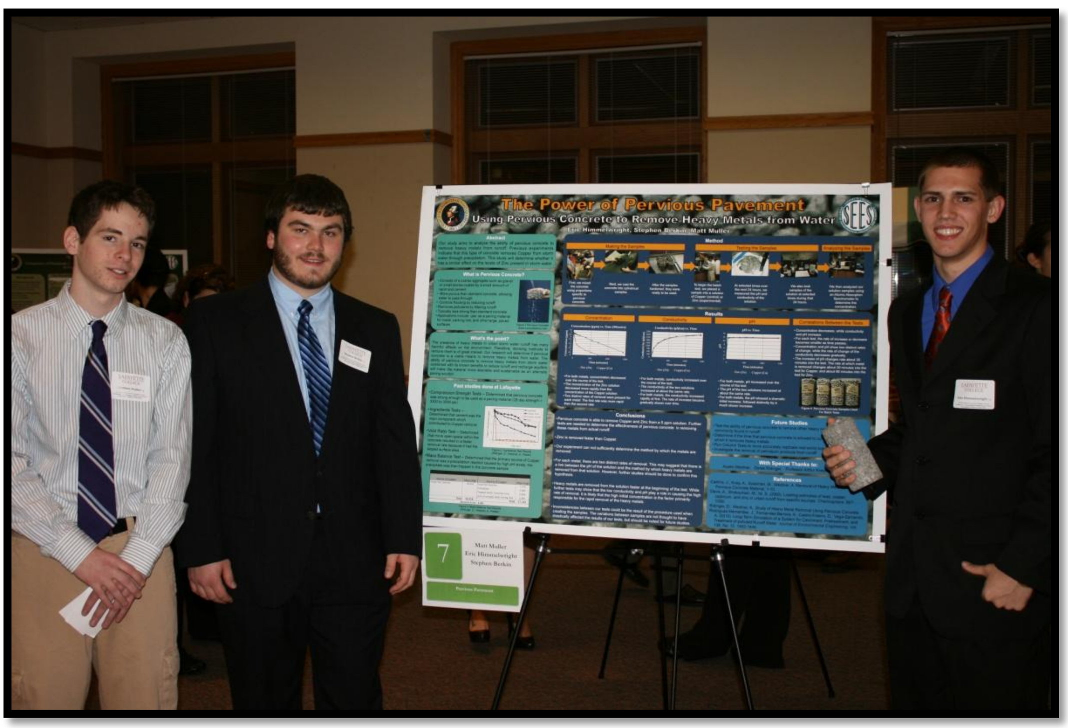
References and additional information available upon request

Poster #7

The Power of Pervious Pavement

Eric Himmelwright '14, Stephen Berkin '14, and Matt Muller '14

Pervious concrete has less fine aggregate than standard concrete. This makes it a highly porous material that allows water to pass through it. As a result, it can be used as a paving material in order to reduce and filter runoff. Several years ago, Lafayette students determined that pervious concrete could remove Copper from water. For our project, we wanted to determine if it could also remove Zinc. To do this, we placed a sample of pervious concrete in a solution of Zinc. At specified times for the next 24 hours, we took samples of the solution and measured pH and conductivity. We later determined the concentrations of the samples using an Atomic Absorption Spectrometer. The results of our tests showed that Zinc was in fact removed from the solution.



The Power of Pervious Pavement

Using Pervious Concrete to Remove Heavy Metals from Water

Eric Himmelwright, Stephen Berkin, Matt Muller

Abstract

Our study aims to analyze the ability of pervious concrete to remove heavy metals from runoff. Previous experiments indicate that this type of concrete removes Copper from storm water through precipitation. This study will determine whether it has a similar effect on the levels of Zinc present in storm water.

What is Pervious Concrete?

- Consists of a coarse aggregate such as gravel or small stones coated by a small amount of sand and cement
- More porous than standard concrete, allowing water to pass through
- Controls flooding by reducing runoff
- Removes pollutants by filtering runoff
- Typically less strong than standard concrete
- Applications include use as a paving material for roads, parking lots, and other large, paved surfaces

Figure 1:Pervious Concrete (www.concretedecor.net)

What's the point?

The presence of heavy metals in urban storm water runoff has many harmful effects on the environment. Therefore, devising methods to remove them is of great interest. Our research will determine if pervious concrete is a viable means to remove heavy metals from water. The ability of pervious concrete to remove heavy metals from storm water combined with its known benefits to reduce runoff and recharge aquifers will make the material more desirable and sustainable as an alternate paving solution.

Past studies done at Lafayette

- Compression Strength Tests – Determined that pervious concrete was strong enough to be used as a paving material (28 day strength = 3300 to 3500 psi)
- Ingredients Tests – Determined that cement was the main component which contributed to Copper removal
- Void Ratio Test – Determined that more open space within the concrete resulted in a faster removal rate because it had the largest surface area

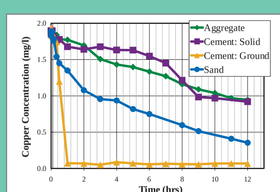


Figure 2: Ingredients Test Results (Ridinger, D., Weidner, A.; Poster)

- Mass Balance Test – Determined that the primary source of Copper removal was a precipitation reaction caused by high pH levels; the precipitate was then trapped in the concrete sample

Mass At Test's Start		Mass at Test's End	
Source of Copper	Mass (mg)	Source of Copper	Mass (mg)
Initial Test Solution	18.018	Final Test Solution	7.513
		Precipitate	5.404
		Trapped within Concrete Core	3.836
		Sum of samples taken during Test	0.390
Total	18.018	Total	17.143
Percent Error: 4.9%			

Figure 3: Mass Balance Test Results (Ridinger, D., Weidner, A.; Poster)

Method

Making the Samples

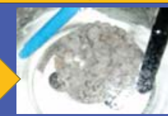
First, we mixed the concrete using proportions specific to pervious concrete.

Next, we cast the concrete into cylindrical samples.

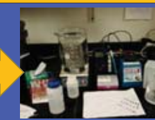
After the samples hardened, they were ready to be used.

Testing the Samples

To begin the batch test, we placed a sample into a solution of Copper (control) or Zinc (experimental).



At selected times over the next 24 hours, we measured the pH and conductivity of the solution.



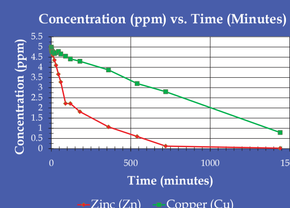
We also took samples of the solution at selected times during that 24 hours.

Analyzing the Samples

We then analyzed our solution samples using an Atomic Absorption Spectrometer to determine the concentration.

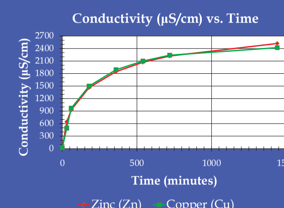
Results

Concentration



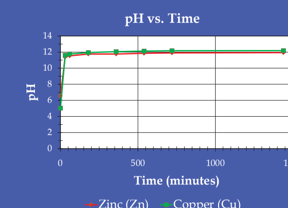
- For both metals, concentration decreased over the course of the test.
- The concentration of the Zinc solution decreased more rapidly than the concentration of the Copper solution.
- Two distinct rates of removal were present for each metal. The first rate was more rapid than the second rate.

Conductivity



- For both metals, conductivity increased over the course of the test.
- The conductivity of the two solutions increased at about the same rate.
- For both metals, the conductivity increased rapidly at first. The rate of increase became gradually slower over time.

pH



- For both metals, pH increased over the course of the test.
- The pH of the two solutions increased at about the same rate.
- For both metals, the pH showed a dramatic initial increase, followed distinctly by a much slower increase.

Correlations Between the Tests

- Concentration decreases, while conductivity and pH increase.
- For each test, the rate of increase or decrease becomes smaller as time passes.
- Concentration and pH show two distinct rates of change, while the rate of change of the conductivity decreases gradually.
- The increase of pH changes rate about 30 minutes into the test. The rate at which metal is removed changes about 30 minutes into the test for Copper, and about 90 minutes into the test for Zinc.

Figure 4: Pervious Concrete Samples Used For Batch Tests

Conclusions

- Pervious concrete is able to remove Copper and Zinc from a 5 ppm solution. Further tests are needed to determine the effectiveness of pervious concrete in removing these metals from actual runoff.
- Zinc is removed faster than Copper.
- Our experiment can not sufficiently determine the method by which the metals are removed.
- For each metal, there are two distinct rates of removal. This may suggest that there is a link between the pH of the solution and the method by which heavy metals are removed from that solution. However, further studies should be done to confirm this hypothesis.
- Heavy metals are removed from the solution faster at the beginning of the test. While further tests may show that the low conductivity and pH play a role in causing the high rate of removal, it is likely that the high initial concentration is the factor primarily responsible for the rapid removal of the heavy metals.
- Inconsistencies between our tests could be the result of the procedure used when creating the samples. The variations between samples are not thought to have drastically affected the results of our tests, but should be noted for future studies.

Future Studies

- Test the ability of pervious concrete to remove other heavy metals that are commonly found in runoff
- Determine if the time that pervious concrete is allowed to cure affects the rate at which it removes heavy metals
- Run Column Tests to more accurately replicate real-world scenarios
- Investigate the removal of petroleum products from runoff

With Special Thanks to:

Austin Weidner, Derek Ridinger, Professor Arthur Kney, Antonio Alves

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Poster #8

Heavy Metal Removal Using a Constructed Wetland

Zachary Benedetto '14 and Joseph Donatoni '14

We researched and conducted experiments concerning a constructed wetland at Northampton Community College. The college wants to use storm water runoff to water a community garden that will produce food for the students. However, the water needs to be brought down to EPA drinking water standards for concentrations of heavy metals. This can be accomplished by having the storm water flow through the wetland, where the metals will be removed from the water by the process of ion exchange. Our ultimate goal was to find an approximate lifetime that the wetland could effectively remove the metals before becoming saturated, thus allowing the contaminants to break through. We tested a sample of the same sand and soil mixture in place at the site of the wetland. By pumping water through a column containing the mixture, we attempted to mimic the process on a smaller scale. Our results did not give a time until breakthrough due to our low flow rate. Regardless, we gained more knowledge about the process of ion exchange and we know what needs to be adjusted for future testing.

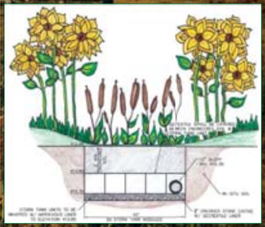
Heavy Metal Removal Using a Constructed Wetland

Zachary Benedetto and Joseph Donatoni

I. Background

Northhampton Community College

- Joint project between Northhampton Community College and Lafayette College.
- The Southern Detention Basin at NCC is being converted into a constructed wetland. It will be used to remove heavy metals in storm water runoff from the parking lot.
- Once that water is brought to drinking water standards, it can be used to water a community garden. The produce from the garden will supply food for the college cafeteria.



Objective

- Through testing, determine how long the wetland can effectively remove heavy metals from the water before its substrate needs to be replaced or have the metals flushed out.

II. Heavy Metal Removal with Wetlands

Constructed Wetlands

- Constructed wetlands have been known to have efficient abilities in treating wastewater at low costs.
- One study used two wetlands consisting of coke and gravel substrates. Both were effective in removing 95-99% of Lead concentration.
- In UAE, tests were done that showed that using column filtration, the removal rate of Lead was 86,000mg Pb/kg Sand.
- Heavy metals cannot be destroyed nor degraded.

Heavy Metals

- Heavy metals ingested from drinking water can have detrimental effects on the body.
- Heavy metals can be removed from water and be captured in the wetland through the process of ion exchange.

Effects of Long Term Lead Exposure

- IQ reduction
- Increased blood pressure
- Behavioral and developmental effects
- Neurological damage

III. Ion Exchange

Ion Exchange

- Heavy metals in water exist as cations. Soil particles have other cations attached to them. The heavy metal cations have a higher affinity for electrons so they take the place of the existing cations attached to the soil.

Lead vs. Copper/Zinc

- As seen in the table, Lead is the only contaminant that is not at EPA drinking standards.
- Lead is difficult to analyze using the equipment available at Lafayette College.
- Copper and Zinc have the same charge as Lead and act similarly during ion exchange.

Sand-Soil Mixture

- Actual Site
  - -50% sand (permeability)
  - -20% organic soil (heavy metals)
  - -30% compost (remove oils)
- Our testing
  - -75% sand (permeability)
  - -25% organic soil (heavy metals)

Table 3: Contaminants & their Maximum Contaminant Level Goal

Contaminant	Maximum Contaminant Level Goal (mg/L)	Levels from Benchmark Report	
		Parking Lot Runoff Bottle 1	Parking Lot Runoff Bottle 2
Cadmium	0.005	0.002	0.002
Copper	1.30	0.05	0.037
Lead	0.00	0.016	0.011
Zinc	5.00	0.325	0.291

IV. Procedure

Predictions

- -Total Influent ($Cu^{+2}+Zn^{+2}$)
  - .31 meq/L
- -Cation Exchange Capacity
  - 193.5 meq
- -Liters until capacity
  - 626.2 L
- -Bed volumes until capacity
  - 509.1 BV

Testing Procedure

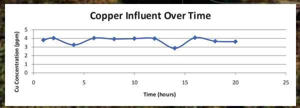
- Set up
  - -Glass column (2ft, 2in diameter)
  - -Sump pump
    - i. Inflow pressure valve
  - Outflow valve
  - -Influent bucket
    - i. 5ppm Copper/Zinc solution
  - -Effluent bucket
- Testing (column pre-saturated)
  - -20 hour running test
  - -influent pumped through column
  - -every 2 hours:
    - i. sample of influent and effluent
    - ii. measure flow rate

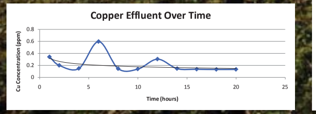
V. Results

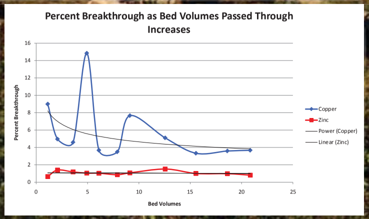
Observations and Analysis of Results

-Average flow rate:
32mL/sec
-Contact time:
65 minutes

- Influent lower than expected
  - -Could have been accidentally diluted too much
  - -Could have precipitated in the bucket
- Effluent not zero, but approaching zero
  - -Normal for initial breakthrough before steadying out to zero
  - -Extend test time/Increase flow rate







VI. Conclusions

The Big Picture

- If we had extended the test or increased the flow rate we could have found an actual number for bed volumes to pass through before breakthrough. We could then scale that up to the size of the actual site and then precipitation data could be used to predict when the bed has reached its capacity.
- However, the actual site has a different influent. Our tests were to see how the system of ion exchange works compared to our predictions. With that knowledge we could then compare to predictions for the actual influent to get an idea of when actual capacity would be reached. Testing with actual influent could also be done.
- Relate back to Lead

References and Acknowledgements

- Dr. Kney and Mr. DeFazio for use of the Environmental and SEES labs
- Don Harris for guidance throughout the project and for information from his co-written "Wetlands Project" Final Report

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Poster #9

Walking on Clean Coals

Sam Brinton '14 and Chris Luna '14

We researched topics involving clean coal technology, discussed the benefits and shortcomings of implementation of these technologies, and analyzed the current national policies of two leading coal using countries. Coal is one of the largest sources of energy in the world, which magnifies the negative effects it has on the environment. Within the energy industry, the potential remains to reduce pollution and also to eventually move towards other energy sources. Specifically, we investigated carbon capture and sequestration, low-sulfur coal, and coal blending. While alternative energies are being researched and developed, the current infrastructure greatly favors continued coal consumption in the immediate future. Clean coal technologies can significantly diminish society's ecological footprint, but it remains only a temporary solution to growing global energy demands.

Walking on Clean Coals

An Investigation of the Clean Coal Industry and Its Role in the Future of Energy

By Sam Brinton and Chris Luna

LAFAYETTE COLLEGE

Background

What is Clean Coal?

A generic term that describes all technologies used to reduce emissions of CO_2, sulfur, and heavy metals that negatively affect the environment.

What's Happening Now?

- At least 40% of the world's electricity comes from coal
- World population (2011): over 6.8 billion
- Global average coal efficiency is currently 28%

Why Is it a Problem?

- Greenhouse gas and heavy metal emissions
- Acid rain
- Contamination of land and waterways from mining operations
- Air quality

Arguments

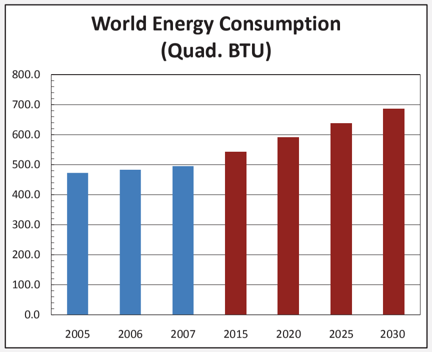
Pro-Clean Coal

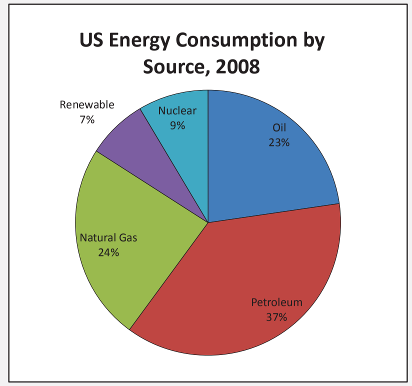
- Coal is a plentiful, domestic resource
- Industry infrastructure already exists
- Improving plant efficiency cheaper than developing alternative energy

Anti-Clean Coal

- Coal pollution is rampant and unhealthy for the planet
- Alternatives to coal and carbon-based energy are becoming viable
- "Big Coal" can control legislation limiting the industry
- Mining still an environmental threat

Energy Crisis





Implementation

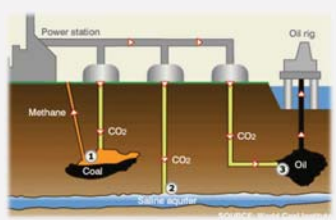
Improving Efficiency

- By updating CO_2 capture technologies in existing power plants, the net pollution rate can be decreased immensely
- Advanced heavy metal controls (particularly Mercury)

New Clean Coal Technologies

- Carbon Capture and Sequestration
- Coal Blending
- Low-Sulfur Coal

Advances in technology



Carbon Capture and Storage

Current Policies

Leading Nations

- United States and China account for ~50% of coal consumption worldwide
- Distinct differences in approaches

United States

- Economic downturn prompting industry reluctance to invest in clean coal technology
- Attempts at subsidizing clean coal met with resistance from alternative energy supporters and traditional coal producers

China

- State-led implementation, championing blending process
- Substantial reductions in pollution have gained supporters
- critics raise concerns on sustainability of current practices
- focus on short-term solutions seems to be motivated by profits

Advantages

- Helps meet future energy needs
- Limits damage to atmosphere
- Better air quality
- Less air pollution to land and waterways
- Infrastructure for implementation already exists ("Renovate not create")
- Economic stimulus & job creation potential
- Domestic source of energy; leads to a less energy-dependent America

Disadvantages

- Continued environmental cost of mining
  - Heavy metal pollution
  - Irreversibly damaging ecosystems
- New technologies can be prohibitively expensive
  - Raises energy prices
  - Economically unfeasible from the perspective of many coal companies
- Short term solutions distract policy from long term solutions

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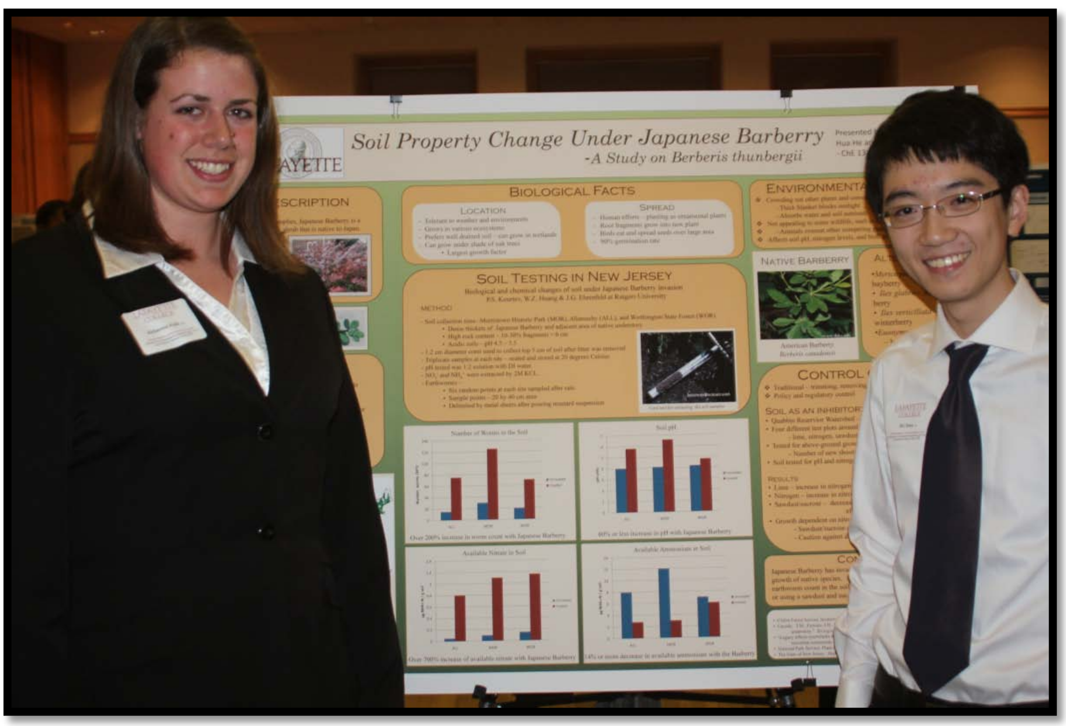
Poster #10

Soil Property Change Under Japanese Barberry

Hua He '13 and Rebecca Folk '13

Japanese Barberry is small shrub native to Japan. It entered the United States in the 1800's and has become an invasive species in twenty states. Most of the Barberry invasion has occurred in the Northeastern United States with a temperate climate, although the plant grows in many conditions. Originally, the plant was better for dyes and jams then its native counterpart. Now, it's found as an ornamental plant in many nurseries. The plant is spread through animals and leaving root fragments in the soil. With a germination rate of 90%, Japanese Barberry multiplies easily. One study by Rutgers University tested the soils in New Jersey. Comparing control plots with those invaded by Japanese Barberry, the soil surrounding the barberry had up to a 200% increase in earthworms, up to a 60% increase in pH, up to a 700% increase in available nitrate, and more than a 14% decrease in ammonium than the control. Control options include trimming, removing the plant, policy, and chemical. Another study in Massachusetts found that applying a sawdust/sucrose solution around the plant absorbs nutrients and decreases the growth of the plant. Japanese Barberry affects the makeup of the surrounding soil, and native alternatives should be used.

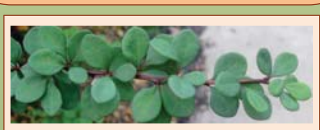


Soil Property Change Under Japanese Barberry
-A Study on Berberis thunbergii

Presented by:
Hua He and Rebecca Folk
- ChE 13’

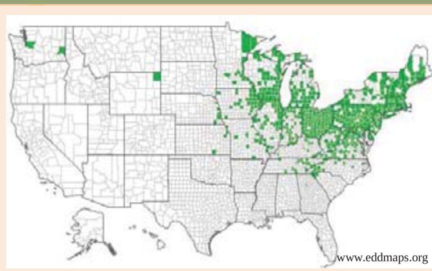
Description

As the name implies, Japanese Barberry is a compact, spiny shrub that is native to Japan. The plant ranges from 2-8 feet in height with small green leaves and red berries.



Origins

- ❖ 1875 – Russia to Boston Massachusetts
  - Ornamental plant in landscaping and home use
- ❖ 1896 – New York Botanic Garden receive shoots from the original seeds in Boston
- ❖ Substitute for the native barberry
  - Dyes and jams
  - Host to black stem grain rust
- ❖ Today – sold in home improvement stores and greenhouses



Spread of the Japanese Barberry across the United States

Invasive Species

- ❖ Map displays the most threatened areas – Northeastern and Mid-Atlantic area of the United States
- ❖ Labeled as an invasive species in twenty states plus the District of Columbia

Biological Facts

Location

- Tolerant to weather and environments
- Grows in various ecosystems
- Prefers well drained soil – can grow in wetlands
- Can grow under shade of oak trees
  - Largest growth factor

Spread

- Human efforts – planting as ornamental plants
- Root fragments grow into new plant
- Birds eat and spread seeds over large area
- 90% germination rate

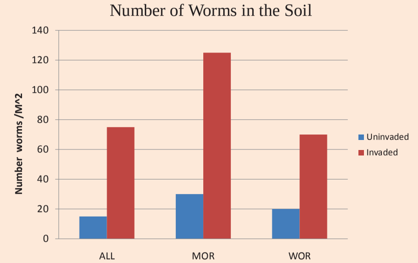
Soil Testing in New Jersey

Biological and chemical changes of soil under Japanese Barberry invasion
P.S. Kourtev, W.Z. Huang & J.G. Ehrenfeld at Rutgers University

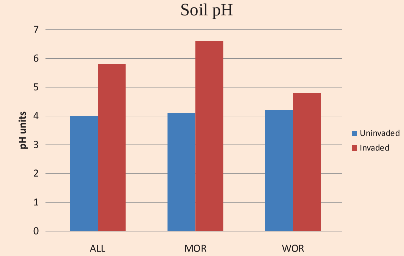
Method

- Soil collection sites– Morristown Historic Park (MOR), Allamuchy (ALL), and Worthington State Forest (WOR)
  - Dense thickets of Japanese Barberry and adjacent area of native understory
  - High rock content – 10-30% fragments > 6 cm
  - Acidic soils – pH 4.5 – 5.5
- 1.2 cm diameter corer used to collect top 5 cm of soil after litter was removed
- Triplicate samples at each site – sealed and stored at 20 degrees Celsius
- pH tested was 1:2 solution with DI water.
- NO_3^- and NH_4^+ were extracted by 2M KCL.
- Earthworms –
  - Six random points at each site sampled after rain
  - Sample points – 20 by 40 cm area
  - Delimited by metal sheets after pouring mustard suspension

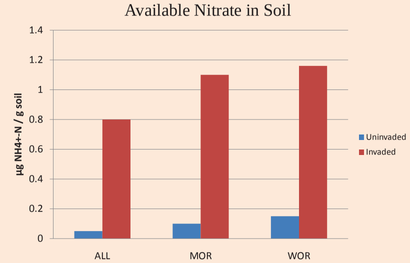
Core tool for extracting the soil samples



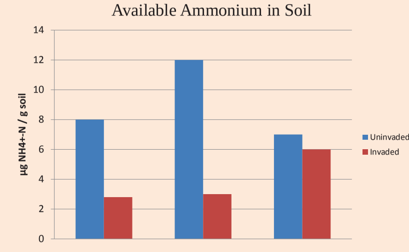
Over 200% increase in worm count with Japanese Barberry



60% or less increase in pH with Japanese Barberry



Over 700% increase of available nitrate with Japanese Barberry



14% or more decrease in available ammonium with the Barberry

Environmental Impacts

- ❖ Crowding out other plants and common varieties
  - Thick blanket blocks sunlight
  - Absorbs water and soil nutrients
- ❖ Not appealing to some wildlife, such as deer
- ❖ - Animals overeat other competing plants
- ❖ Affects soil pH, nitrogen levels, and biological activity

Native Barberry

American Barberry
Berberis canadensis

Alternatives

- *Myrica pensylvanica* – bayberry
- *Ilex glabra* – ink-berry
- *Ilex verticillata* – winterberry
- *Euonymus americana* – hearts-a-bustin

Control Options

- ❖ Traditional – trimming, removing plant and roots, chemicals
- ❖ Policy and regulatory control

Soil as an Inhibitor:

- Quabbin Reservior Watershed – west-central Massachusetts
- Four different test plots around the base of a Japanese Barberry
  - lime, nitrogen, sawdust/sucrose mixture, and control
- Tested for above-ground growth
  - Number of new shoots, leaf to twig ratio
- Soil tested for pH and nitrogen content

Results

- Lime – increase in nitrogen and pH by 0.2 – 0.3 units
- Nitrogen – increase in nitrogen and no effect on pH
- Sawdust/sucrose – decreased nitrogen and ammonium with no effect on pH
- Growth dependent on nitrogen but not pH change
  - Sawdust/sucrose can inhibit and control growth
  - Caution against damaging soil for other species

Conclusion

Japanese Barberry has invaded the United States and compromised the growth of native species. The plant increases the pH, nitrate, and earthworm count in the soil. This plant can be controlled by trimming or using a sawdust and sucrose mixture in the soil.

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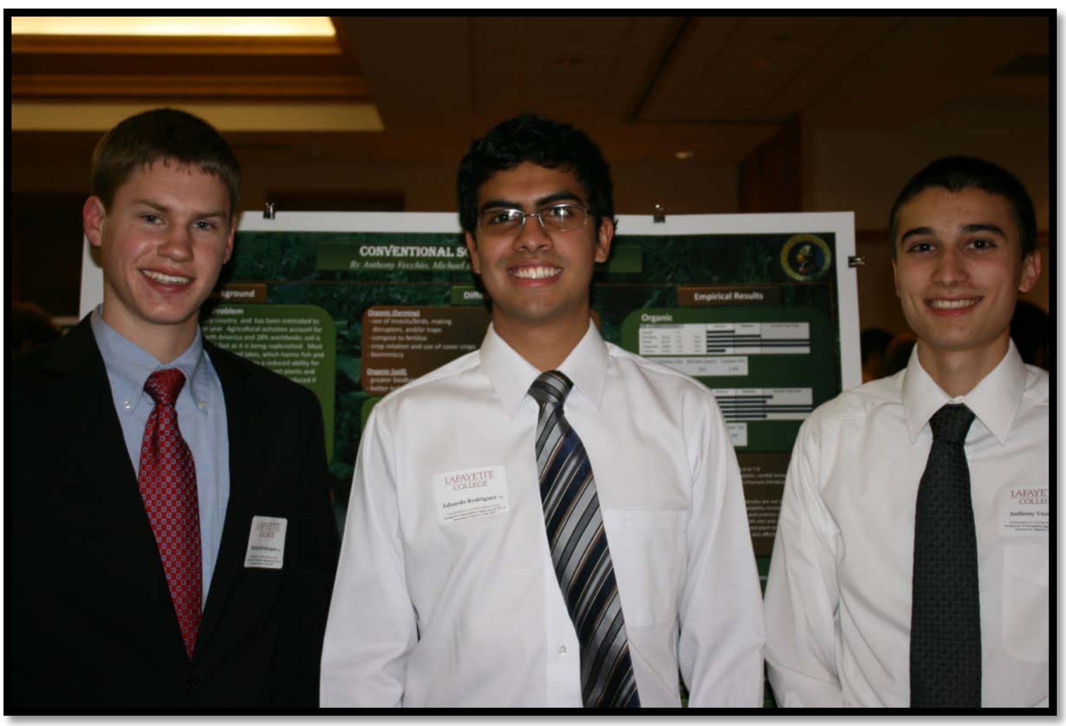
Poster #11

Conventional Soil vs. Organic Soil

Anthony Vecchio '14, Michael Bevilacqua '14, and Eduardo Rodriguez '14

Our research looked at the differences between conventional soil and organic soil, meaning the different soils that result from organic verse conventional farming practices. In order to do this, we had to figure out what determines the quality of a soil. The reason for focusing on soil is that soil is the foundation for crop health and yield. Soil provides nutrients, stores and drains water, and augments plants' immune system. In addition, the type of soil structure effects the how easily the soil degrades or erodes. This is important because soil degradation has been estimated to cause the United States billions of dollars a year. Organic soil, unlike conventional soil, has a higher water and nutrient holding capacity, greater biodiversity and ability to suppress insect pests and weeds, higher organic matter, and no pesticides or chemical fertilizers. For these reasons, organic soil is the more sustainable and reliable option for farmers and mankind.



CONVENTIONAL SOIL VS. ORGANIC SOIL

By Anthony Vecchio, Michael Bevilacqua, and Eduardo Rodriguez

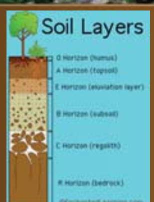
Background

Problem

- Soil erosion has affected every country and has been estimated to cost the U.S. $37.6 billion per year. Agricultural activities account for 66% of soil degradation in North America and 28% worldwide; soil is being depleted 10 to 40 times as fast as it is being replenished. Most eroded soil ends up in rivers, streams, and lakes, which harms fish and pollutes our drinking water. And less soil means a reduced ability for remaining soil to store water and nutrients, and support plants and soil organisms. Agriculture's effect on soil erosion can be reduced if farmers use certain practices and avoid others. Practices that contribute to erosion include the use of chemical pesticides and herbicides as well as synthetic fertilizers.

*Note: topsoil is practically irreplaceable.

- Another issue is that the chemicals used in conventional farming runoff into streams, creating dead zones (e.g. the Gulf of Mexico) and contaminating our water resources. In fact, there are an estimated 1 million cases of pesticide poisoning each year.
- Energy inputs are inherently greater in conventional systems because fertilizers are often fossil fuel-based.



http://www.enchantedlearning.com/geology/soil/ http://www.globalchange.umich.edu/globalchange2/current/lectures/land_deg/land_deg.html

Importance of Soil in Agriculture

1. Water-Holding Capacity
2. Water Infiltration and Drainage
3. Nutrient Content, Retention, and Cycling
4. Susceptibility to Erosion by water
5. Resistance to Pests (i.e. insects, nematodes, fungi)
6. Emission and Absorption of gases and dust

Ways to Maintain Soil Structure and Fertility:

1. Recycle and compost crop wastes and animal manures
2. Crop rotation
3. Plant green manures (cover crops) such as legumes (e.g. beans, lentils, peas)
4. Mulching on the soil surface

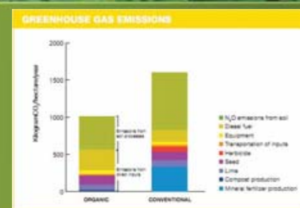
Differences

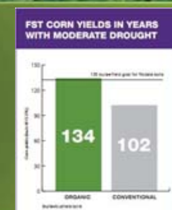
Organic (farming)
- use of insects/birds, mating disruptors, and/or traps
- compost to fertilize
- crop rotation and use of cover crops
- biomimicry

Conventional(farming)
- use of pesticides, herbicides
- chemical fertilizers
- monoculture (1 crop)
- technology-based

Organic (soil)
- greater biodiversity
- better nutrient uptake & retention

Conventional (soil)
- fewer earthworms and microbes
- weaker structure/stability





Rodale Institute

Effects of Organic vs. Conventional Methods

	Organically Managed	Conventionally Managed
Soil Organic Carbon	Higher	Lower
Soil Nitrogen	Higher	Lower
Soil Microbial Biomass Carbon	Higher	Lower
Soil Microbial Biomass Nitrogen	Higher	Lower

Organic plots contain microorganisms that require less energy to maintain their biomass, which may be a result of the more diverse and interrelated communities they contain.
A herbicide called Herbogil resulted in inhibited growth of a variety of soil bacteria (decreased microbial biomass).

Organic Matter Effects

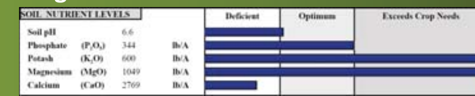
Most of the fresh residues of soil organic matter decay to CO_2, H_2O, and minerals that provide energy for soil microbes and mineral nutrients. The well decomposed residue is very resistant to decay and is commonly referred to as humus which is typically about 70% of the total SOM in agricultural soils. The importance of humus is that it enhances soil nutrient (especially cation) holding water and holding capacities, soil structure and tilth and general fertility.

Terminology:

-Biodiversity – the quantity and variety of different organisms
-Biomimicry – imitating or drawing inspiration from the designs and processes of nature to solve human problems
-Green Manure - a type of cover crop grown primarily to add nutrients and organic matter to the soil
-Microbes – microorganisms – microscopic organisms
-Organic Matter – substances that contain carbon
-Soil Quality – a soil's ability to support biological processes and promote environmental, plant, and animal health
-Till – to plow
-Tilth – physical condition of soil

Empirical Results

Organic



Organic Matter (%)	Nitrate (ppm)	Carbon (%)
2.3	9.6	1.49

Conventional

Organic Matter (%)	Nitrate (ppm)	Carbon (%)
2.8	8.3	1.64

pH Overview and Implications:

- a healthy pH for most agronomic crops is from 6.0 to 7.0
- soil acidity depends on soil composition, native plants, rainfall amounts, as well as chemical fertilizer and manure application; fertilizer/manure introduces NH_4^+ and increase acidity (decrease pH)
- lime ($CaCO_3$) should be added if pH is low
- if pH<6, herbicides are not as active; if pH>7, herbicides are not as effective
- when pH<5.5, aluminum (Al^{3+}) and manganese availability increase and may reach toxic levels; Al^{3+} interferes with root growth and function, and restricts uptake of nutrients
- acidic soils cause P to form insoluble compounds with iron and aluminum, and micronutrient concentrations to reach levels that exceed plant needs
- nitrogen-fixing and nitrifying bacteria in the soil are also affected, resulting in less nitrate production

Evenness:

Definition – a measure of the relative abundance of species.
Metric – Shannon's Index
Experiment: examined whether differences in natural enemy evenness affected population growth of pests (potato beetles), plant growth, and potato beetle mortality.
Natural Enemies – 4 families of potato beetle predators and 3 pathogens. Organic potato fields had substantially more natural enemy evenness than conventional ones; one natural enemy species accounted for as much as 80% of individuals in conventional fields, whereas the most abundant species in organic fields comprised only 38%. Predator evenness and pathogen evenness both corresponded to increased plant biomass, crop yield, and potato beetle mortality.
Statistics: 18% lower pest densities and 35% larger plants on organic plots than conventional plots.

Sources:

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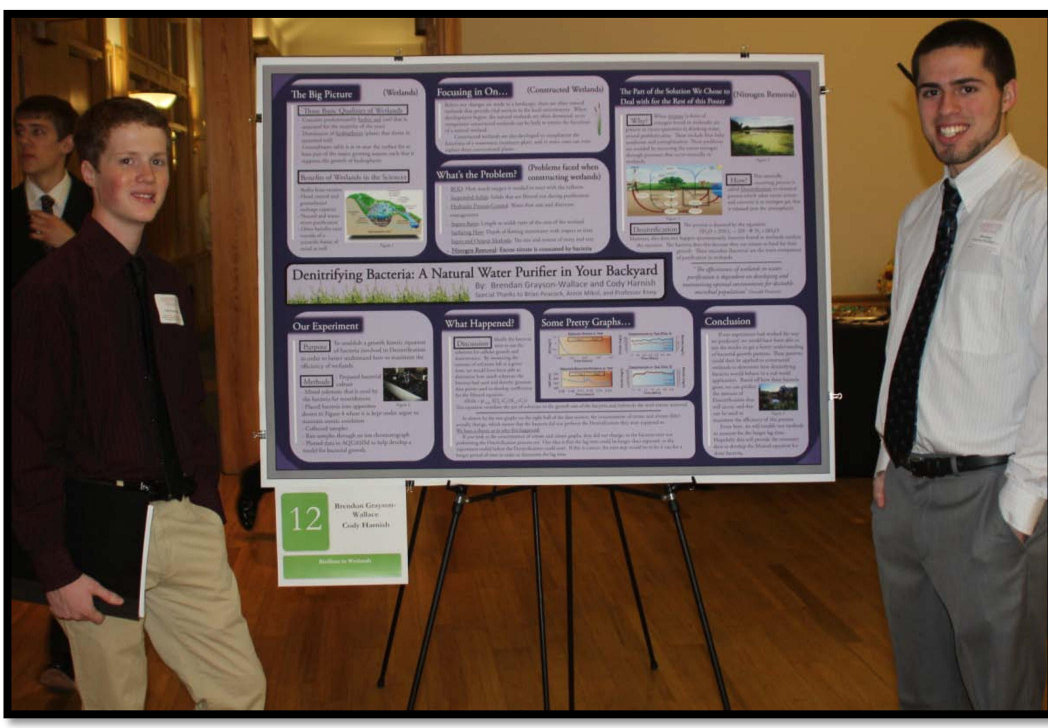
Poster #12

Denitrifying Bacteria: A Natural Water Purifier in Your Backyard

Brendan Grayson-Wallace'14 and Cody Harnish '14

The first part of our project consisted of researching constructed wetlands and the factors that must be considered in order to best utilize them in the removal of pollutants. From here we decided to focus in on one of these factors: the removal of nitrate by the bacteria present in the wetland. What we found was that there is a significant lack of data on these bacteria, and our goal became to fill this gap in knowledge. The second part of our project took place in the lab. There we conducted research on denitrifying bacteria in order to develop a growth kinetic model for how they would ideally react in the environment. In the experiment, certain parameters were held within the necessary ranges in order to ensure that denitrification would occur. Throughout the experiment, samples were taken while two other probes collected data continuously. However, the data we collected did not yield the desired results, though from this we were able to determine the flaw in our experiment and adjust it according. Because of the time restraints of this project, we were not able to put these adjustments into effect. What we were able to do was set up the correct ramifications to complete the experiment and gain the desired data.



Denitrifying Bacteria: A Natural Water Purifier in Your Backyard

By: Brendan Grayson-Wallace and Cody Harnish
Special Thanks to Brian Peacock, Annie Mikol, and Professor Kney

The Big Picture (Wetlands)

Three Basic Qualities of Wetlands

- Contains predominantly hydric soil (soil that is saturated for the majority of the year)
- Dominance of hydrophytes (plants that thrive in saturated soil)
- Groundwater table is at or near the surface for at least part of the major growing seasons such that it supports the growth of hydrophytes

Benefits of Wetlands in the Sciences

- Buffer from erosion
- Flood control and groundwater recharge capacity
- Natural and waste-water purification
- Other benefits exist outside of a scientific frame of mind as well

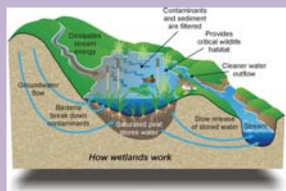


Figure 1

Focusing in On… (Constructed Wetlands)

Before any changes are made to a landscape, there are often natural wetlands that provide vital services to the local environment. When development begins, the natural wetlands are often destroyed, so to compensate constructed wetlands can be built to mimic the functions of a natural wetland.

Constructed wetlands are also developed to compliment the functions of a wastewater treatment plant, and in some cases can even replace these conventional plants.

What's the Problem? (Problems faced when constructing wetlands)

- BOD: How much oxygen is needed to react with the influent
- Suspended Solids: Solids that are filtered out during purification
- Hydraulic Process Control: Water flow rate and direction management
- Aspect Ratio: Length to width ratio of the area of the wetland
- Surfacing Flow: Depth of flowing wastewater with respect to time
- Input and Output Methods: The size and system of entry and exit
- **Nitrogen Removal: Excess nitrate is consumed by bacteria**

The Part of the Solution We Chose to Deal with for the Rest of this Poster (Nitrogen Removal)

Why? When nitrates (a form of nitrogen found in wetlands) are present in excess quantities in drinking water, several problems arise. These include blue baby syndrome and eutrophication. These problems are avoided by removing the excess nitrogen through processes that occur naturally in wetlands.

Figure 2

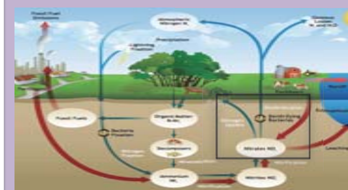


Figure 3

How? This naturally occurring process is called Denitrification (a chemical process which takes excess nitrate and converts it to nitrogen gas that is released into the atmosphere).

Denitrification The process is denoted by the equation:

$$5H_2O + 2NO_3^- + 2H^+ \rightarrow N_2 + 6H_2O$$

However, this does not happen spontaneously, bacteria found in wetlands catalyze the reaction. The bacteria does this because they use nitrate as food for their growth. These microbes (bacteria) are the main component of purification in wetlands.

"The effectiveness of wetlands in water purification is dependent on developing and maintaining optimal environments for desirable microbial populations" -Donald Hammer

Our Experiment

Purpose To establish a growth kinetic equation of bacteria involved in Denitrification in order to better understand how to maximize the efficiency of wetlands.

Methods
- Prepared bacterial culture
- Mixed substrate that is used by the bacteria for nourishment
- Placed bacteria into apparatus shown in Figure 4 where it is kept under argon to maintain anoxic condition
- Collected samples
- Ran samples through an ion chromatograph
- Plotted data in AQUASIM to help develop a model for bacterial growth.

Figure 4

What Happened?

Discussion Ideally the bacteria were to use the substrate for cellular growth and maintenance. By measuring the amount of substrate left at a given time, we would have been able to determine how much substrate the bacteria had used and thereby generate data points used to develop coefficients for the Monod equation.

$$\partial X/\partial t = \mu_{max} X \prod_I (C_I/(K_{s,I}+C_I))$$

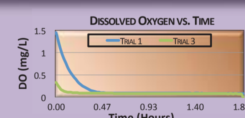
This equation correlates the use of substrate to the growth rate of the bacteria and indirectly the total nitrate removed.

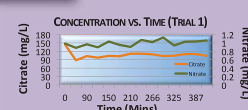
As shown by the two graphs on the right half of the data section, the concentration of citrate and nitrate didn't actually change, which means that the bacteria did not perform the Denitrification they were supposed to.

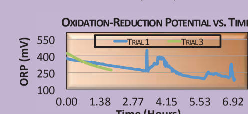
We have a theory as to why this happened:

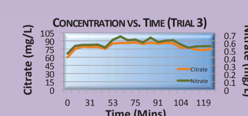
If you look at the concentration of nitrate and citrate graphs, they did not change, so the bacteria were not performing the Denitrification process yet. Our idea is that the lag time could be longer than expected, so the experiment ended before the Denitrification could start. If this is correct, the next step would be to let it run for a longer period of time in order to determine the lag time.

Some Pretty Graphs…









Conclusion

If our experiment had worked the way we predicted, we would have been able to use the results to get a better understanding of bacterial growth patterns. These patterns could then be applied to constructed wetlands to determine how denitrifying bacteria would behave in a real world application. Based off how these bacteria grow, we can predict the amount of Denitrification that will occur, and this can be used to maximize the efficiency of this process.

From here, we will modify our methods to account for the longer lag time. Hopefully this will provide the necessary data to develop the Monod equation for these bacteria.

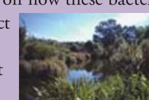


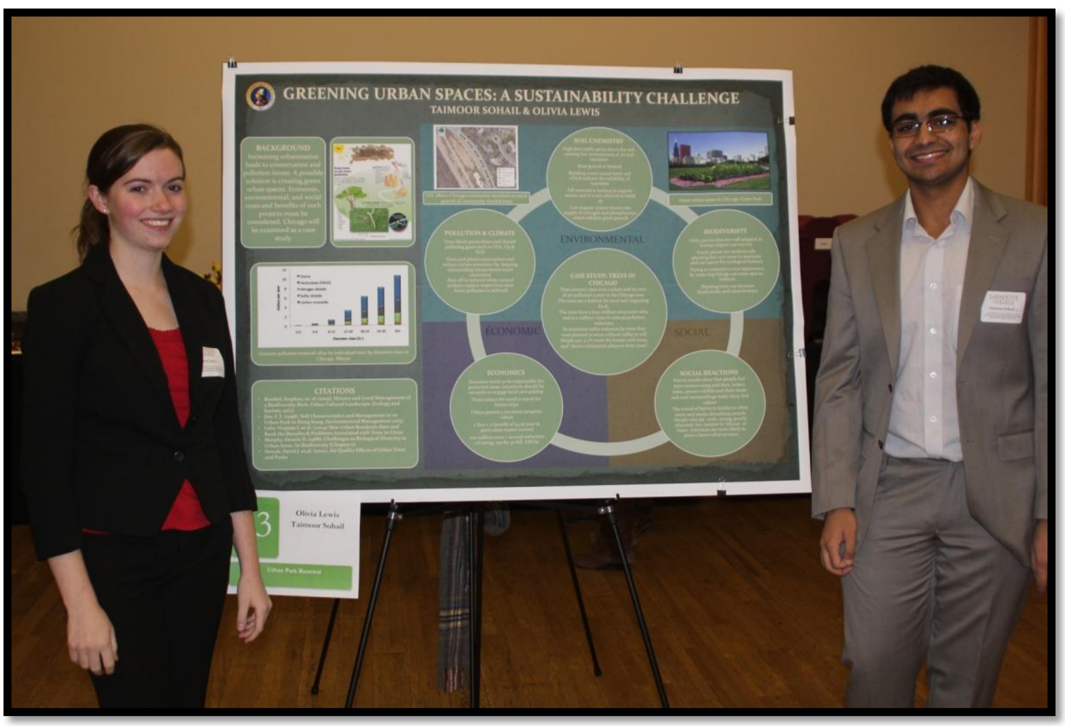
Figure 5

Poster #13

Greening Urban Spaces

Taimoor Sohail '14 and Olivia Lewis '14

Our presentation focused on greening urban spaces and the challenges faced when implementing greenery in urban areas. We looked at the costs and benefits of having green spaces from a sustainability perspective. So, our main focus was on the social, environmental and economic aspects of urban parks and spaces, and we looked particularly at soil chemistry, pollution and climate, the social reactions, the economics and the biodiversity brought about by trees in cities and large metropolitan areas. Finally, we tied all these ideas together by looking at Chicago as a case study, looking at specific examples gathered from research in that city pertaining to economics, social aspects and environmental costs and benefits.

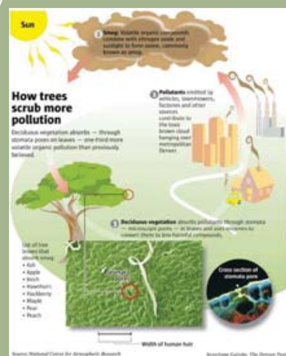


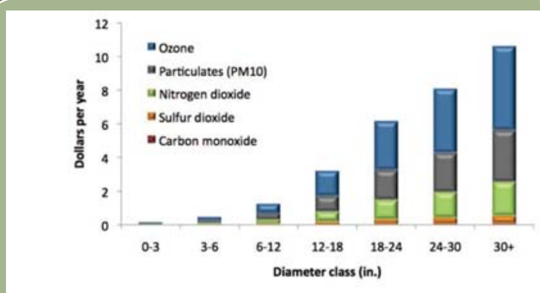
GREENING URBAN SPACES: A SUSTAINABILITY CHALLENGE

TAIMOOR SOHAIL & OLIVIA LEWIS

BACKGROUND

Increasing urbanization leads to conservation and pollution issues. A possible solution is creating green urban spaces. Economic, environmental, and social costs and benefits of such projects must be considered. Chicago will be examined as a case study.





Estimate pollution removal value by individual trees by diameter class in Chicago, Illinois

GIS allows Chicago community members to track growth of community-funded trees

Green urban space in Chicago: Grant Park

ENVIRONMENTAL

SOIL CHEMISTRY

High foot traffic packs down the soil, causing low transmission of air and moisture

Root growth is limited

Building waste causes basic soil which reduces the solubility of nutrients

Fill material is lacking in organic matter and it is not allowed to build up

Low organic matter lessens the supply of nitrogen and phosphorous, which inhibits plant growth

POLLUTION & CLIMATE

Trees block particulates and absorb polluting gases such as CO_2, O_3 & NO_2

Trees and plants store carbon and reduce carbon emissions by keeping surrounding temperatures more consistent

Run-off is reduced when natural surfaces replace impervious ones

Noise pollution is reduced

BIODIVERSITY

Only species that are well adapted to human impact can survive

Exotic plants are aesthetically pleasing but cost more to maintain and can upset the ecological balance

Trying to maintain a neat appearance by removing foliage can erase species' habitats

Planting trees can increase biodiversity and attractiveness

CASE STUDY: TREES IN CHICAGO

Trees remove 1,600 tons carbon and 64 tons of air pollution a year in the Chicago area

The trees are a habitat for local and migrating birds

The trees have a $192 million structural value and $1.5 million value in annual pollution reduction

To minimize sulfur emission by trees they were planted in areas without sulfur in soil

People pay 3-7% more for homes with trees, and "derive substantial pleasure from trees"

ECONOMIC

ECONOMICS

Someone needs to be responsible for protected areas; incentives should be set aside to engage local stewardship

Trees reduce the need to travel for leisure trips

Urban greenery increases property values

1 Tree = a benefit of $4.16/year in particulate matter control

100 million trees = annual reduction of energy use by 30 bill. kW/hr

SOCIAL

SOCIAL REACTIONS

Survey results show that people feel trees remove smog and dust, reduce noise, attract wildlife and their shade and cool surroundings make them feel calmer

The sound of leaves is similar to white noise and masks disturbing sounds

People who are male, young, poorly educated, low income or African- or Asian- American are more likely to place a lower value on trees

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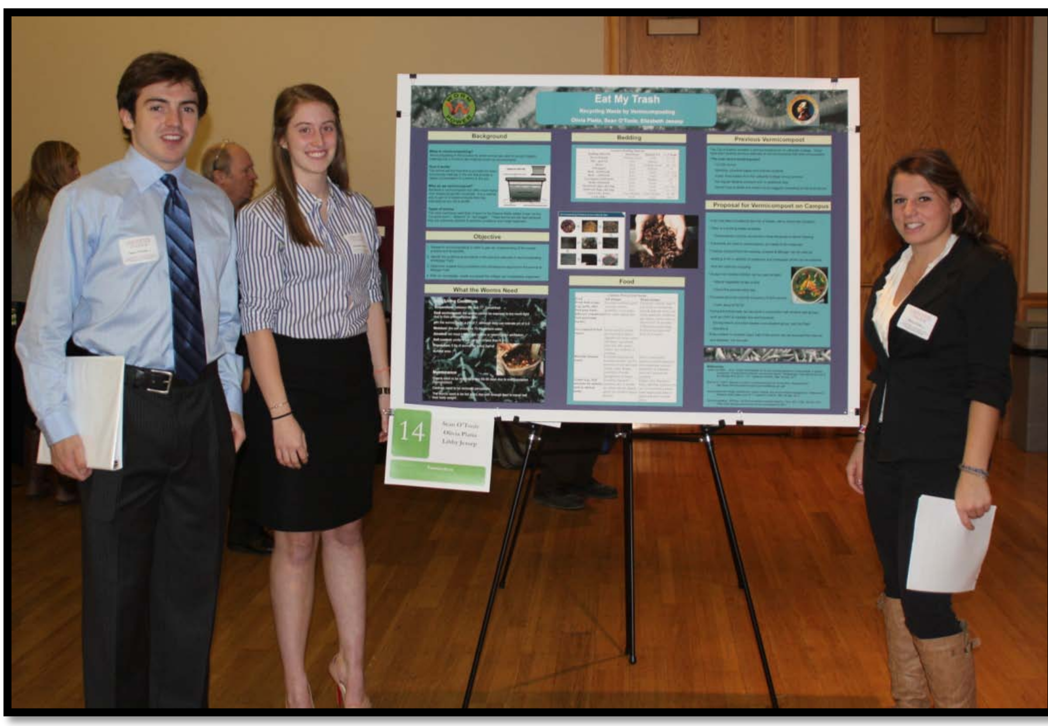
Poster #14

Eat My Trash

Olivia Platia '14, Sean O'Toole '14, and Elizabeth Jessep '14

We wanted to use this project as a vehicle to propose how to make Lafayette greener. Because we already have an organic garden and compost facility at Metzgar Fields we thought it would be beneficial, as well as realistic, to find a way to improve the practices already in place here. We came up with the idea of having a vermicompost, composting with worms, on campus, in order to dispose of more of the college's waste and provide a higher quality soil for the organic garden. We developed a proposal that would be ready for the school to implement if they choose to do so. Cost and practicality were both factors in our decision-making as far as materials and labor, as well as making the living conditions as ideal as possible for the worms. In an attempt to make our proposal as well-developed as possible we worked with Jennifer Bell, a former student and member of LEAP, and would just like to add a special thanks to her for the time she spent working with us.



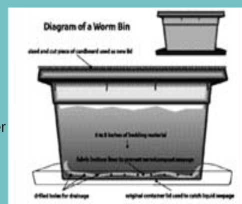
Eat My Trash

Recycling Waste by Vermicomposting

Olivia Platia, Sean O'Toole, Elizabeth Jessep

Background

What is vermicomposting?
Vermicomposting is the process by which worms are used to convert organic materials into a hummus like material known as vermicompost.



How it works
The worms eat the food that is provided for them And excrete castings in the soil that provide a Higher concentration of nutrients in the soil.

Why do we vermicompost?
Nutrients in vermicomposts are often much higher than traditional garden composts. It is a natural way to get rid of waste products that may otherwise be put into a landfill.

Types of worms
The most commonly used type of worm is the Eisenia fetida, better known as the "compost worm", "redworm" or "red wiggler." These worms are the best because they are extremely resilient to adverse conditions and rough treatment.

Objective

1. Research vermicomposting in order to gain an understanding of the overall practice and its benefits
2. Identify the problems encountered in the previous attempts in vermicomposting at Metzgar Field
3. Determine suitable living conditions and maintenance required for the worms at Metzgar Field
4. With our knowledge, create a proposal the college can immediately implement

What the Worms Need

Ideal Living Conditions

- **Temperature:** between 55° and 77° Fahrenheit
- **Dark environment:** the worms cannot be exposed to too much light due to their photosensitive skin
- **pH:** the worms prefer a pH of 7, although they can tolerate pH of 5-9
- **Moisture:** the soil should be 70-90 percent water
- **Aeration:** bin must have small cracks or openings for ventilation
- **Salt content:** prefer a salt content of less than 0.5%
- **Population:** 5 kg of worms for every 2m² of surface area

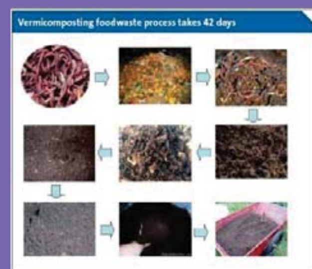
Maintenance

- Worms need to be removed every 60-90 days due to overpopulation (reproduction)
- Castings need to be removed periodically
- The worms need to be fed every day with enough feed to equal half their body weight.

Bedding

Common Bedding Material

Bedding Material	Absorbency	Bulking Pot.	C:N Ratio
Horse Manure	Medium-Good	Good	22 - 56
Hay - general	Poor	Medium	15 - 32
Straw	Poor	Medium-Good	48 - 150
Newspaper	Good	Medium	170
Bark - hardwoods	Poor	Good	116 - 436
Bark -- softwoods	Poor	Good	131 - 1285
Corrugated cardboards	Good	Medium	563
Shrub trimmings	Poor	Good	53
Hardwood chips, shavings	Poor	Good	451 - 819
Softwood chips, shavings	Poor	Good	212 - 1313
Leaves (dry, loose)	Poor-Medium	Poor-Medium	40 - 80
Cron stalks	Poor	Good	60-73



Food

Common Worm Feed Stocks

Food	Advantages	Disadvantages
Fresh food scraps (e.g., peels, other food prep waste, leftovers, commercial food processing wastes)	Excellent nutrition, good moisture content, possibility of revenues from waste tipping fees	Extremely variable; high N can result in overheating; meat & high-fat wastes can create anaerobic conditions and odours, attract pests, so should NOT be included without pre-composting
Pre-composted food wastes	Good nutrition; partial decomposition makes digestion by worms easier and faster; can include meat and other greasy wastes; less tendency to overheat.	Nutrition less than with fresh food wastes
Biosolids (human waste)	Excellent nutrition and excellent product; can be activated or non-activated sludge, septic sludge; possibility of waste management revenues	Heavy metal and/or chemical contam-ination (if from municipal sources); possibility of pathogen survival if process not complete
Grains (e.g., feed mixtures for animals, such as chicken mash)	Excellent, balanced nutrition, easy to handle, no odour, can use organic grains for certified organic product	Higher value than most feeds, therefore expensive to use; low moisture content; some larger seeds hard to digest and slow to break down

Previous Vermicompost

The City of Easton donated a vermicomposting bin to Lafayette College. There have been several previous attempts at vermicomposting that were unsuccessful.

•**The most recent student project**

- •10,000 worms
- •Bedding- shredded paper and finished compost
- •Feed- food wastes from the Lafayette College dining services
- •No regular feeding schedule and no additional help
- •Some froze to death and driven out by maggots competing for the food source

Proposal for Vermicompost on Campus

- A bin has been provided by the City of Easton, still in brand new condition
- There is a working heater available
  - •Temperatures must be monitored to keep temperature above freezing
- If biosolids are used in vermicompost, pH needs to be measured
- Finished compost from the existing compost at Metzgar can be used as bedding in bin in addition to cardboard and newspaper which can be obtained from the mailroom recycling
- Scraps from Sodexo kitchen can be used as feed
  - Mainly vegetable scraps at first
  - About five pounds every day
- Purchase about ten pounds of worms (10,000 worms)
  - Cost; about $150.00
- During the school year, we can work in conjunction with student lead groups, such as LEAP to maintain the vermicompost
  - •During interim and other breaks a non-student group, such as Plant Operations
- Every sixteen to nineteen days, half of the worms can be removed from the bin and released into the wild

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"Vermicomposting." *EPA.gov*. US Environmental Protection Agency, 3 Nov. 2011. Web. 20 Nov. 2011. <http://www.epa.gov/osw/conserve/rrr/composting/vermi.htm>.

Poster #15

‘Pard Pedals

Kathleen Delsener ’14, Joelle Neilson ’12, and Jennifer White ’14

In cities like Portland, Boston, Washington D.C, and Paris, to name a few, community bike sharing programs are becoming increasingly popular. For our project we propose "‘Pard Pedals," an autonomous community bike sharing program that will act as an alternative source of transportation for both students and staff at Lafayette College. The program will run similar to the systems in metropolitan areas, but on a smaller scale and price. With the support of the student body, shown in a survey sent out to the entire school, the program would reduce cars on campus, utilize the new green pathways that have replaced old roads, and promote a healthier lifestyle. The main goal is to decrease the amount of carbon dioxide gases released around campus, but the self-run program will also act as a model for other small communities to follow. The program will start small but will grow to become a multi-structural and campus wide success.

‘PARD PEDALS

Kathleen Delsener, Joelle Neilson, and Jennifer White
CE 321: Introduction to Environmental Engineering




I. BACKGROUND

How many bicycles will be available to use?

The program will begin with eighteen bikes that can be shared by both students and faculty.

Where will these bike be located?

• There will be three sheltered and checkpoint access only sites on campus at Farinon Student Center, Kirby Sports Center, and Sullivan Parking Deck.
•There will also be additional regular bike racks located at other popular locations around campus.

Who will maintain the bikes?

•Students would participate through a paid work study program.
•Professional bike mechanics would train the students about the logistics.

Where will this maintenance be performed?

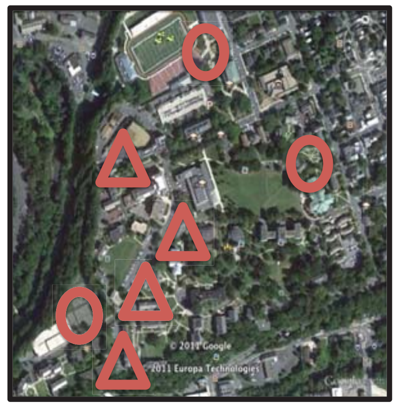
•A bike house would be established off campus where several students would live year round.
•A mechanic shop would be set up in a shed in the back yard as well as in the basement of the house.

Where will all of the equipment come from?

•Several bike shops in the area have already offered to provide the program with any style bike as well as maintenance supplies.

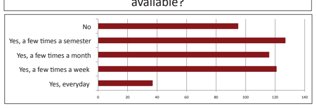
Who will provide the finances for the program?

• The students involved in the program will apply for grants to help fund project.
•Alumni will have the option to “sponsor a bike” and get their name on the bicycle.



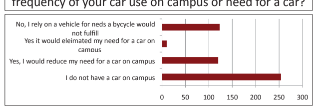
II. SURVEY RESULTS

Question: Would you use a community bike if it were available?



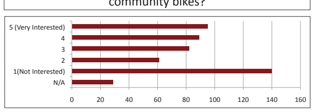
Survey results show that 80.85% of students would use the community bike program, with 23.39% saying they would use it a few times a month.

Question: Would having community bicycles affect the frequency of your car use on campus or need for a car?



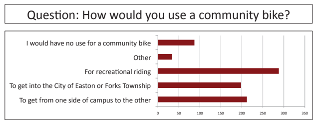
Results show that while most students do not have a car on campus, 24.19% say that a community bike will reduce their car use and 2% say it will eliminate their need for a car entirely.

Question: Would you be interested in a paid work study position to contribute to the maintenance of our community bikes?



Results show that 184 students are interested in a work study program.

Question: How would you use a community bike?



Results show that most students would use the bike for recreational riding.

III. CASE STUDY

Brandeis University - DeisBikes

• Mission Statement:
  • “To promote bicycling as a desirable means of transportation in a greater effort to strengthen a culture of sustainability on campus.”
• Background
  • Began in March of 2009 by the Brandeis Student Union
  • The bikes were the first environmentally friendly transportation on campus
  •Students could rent bicycles up to an entire day
• Future
  • This past Spring the school made plans to expand DeisBike to DeisBike2.0 where they willl start a semester long rental program as well as increase thier number of rentals to an additonal forty bikes
•Resource

•Oglesby, Scott, and Jessie Stettin. "DEIS BIKES." *Environmental Studies Program*. Ed. Albert Feldman. Brandeis University. Web. 26 Nov. 2011. <http://www.brandeis.edu/programs/environmental/undergrad/greeningcourse/

IV. SHORT TERM COSTS

“Not everyone can spend millions of dollars to have their name on a building, but many people can spend hundreds of dollars to have their name on a bike.”

Item	Cost (dollars)	Number of Items	Estimate Total (dollars)
Bike	750	18	13500
Storage:			
Bike Rack	200	5	1000
Fence	680	2	1360
Gate	250	1	250
10x10Pavillion	5,000	2	10,000
Supplies:			
Air Tubes	5.5	15	82.5
Seats	45	15	675
Handles Bars	30	15	450
Rims	55	15	825
Tire Pumps	100	10	1000
Chains	50	15	750
Chain Lubricant	7	15	105
Pedals	10	50	500

Item	Cost (dollars)	Number of Items	Estimate Total (dollars)
Fourth Hand	30	10	300
Allen Wrench	20	10	200
Tires	50	15	750
Tire Pry Tool	20	10	200
Tire Partch	10	15	150
Misc.			
Locks	10	50	500
Baskets	25	18	450
Storage Rack	100	10	1000
Check Points		3	
Maintenance :			
Seasonal	Can be done by local bike owners		
Bike House	Included in student's tuition		
Work Rack	100	3	300

TOTAL:
34,350

V. LONG TERM COSTS

	Cost (dollars)	Hrs/Time	Students/Hr	Total/Week	Total/Semester
Work Study:					
Daily	7.25	1	6	261	2915
Weekly	7.25	6	3	130.5	2000

TOTAL:
5,000

VI. BENEFITS

•Lafayette’s bike sharing program will help students earn financial funding through a part-time work program. Currently Lafayette offers 300 work study opportunities. The bike sharing program will provide additional employment to a number of students.

•Implementing a bike sharing program will help Lafayette develop a stronger connection with the city of Easton. The bike sharing program will encourage students to venture off of campus grounds and into the Easton community.

•The bike sharing program will give alumni an opportunity to give back to Lafayette College by being able to donate a bicycle. The donation will give alum the chance to contribute on a much smaller scale.

•The bike sharing program will reduce the number of cars on campus, which will ultimately create a more eco-friendly environment. There are close to 470 students who park their vehicles on campus as well as 892 employees. By offering this new form of transportation these numbers will decrease.

•The program will gives students who do not have a car a faster mode of transportation.

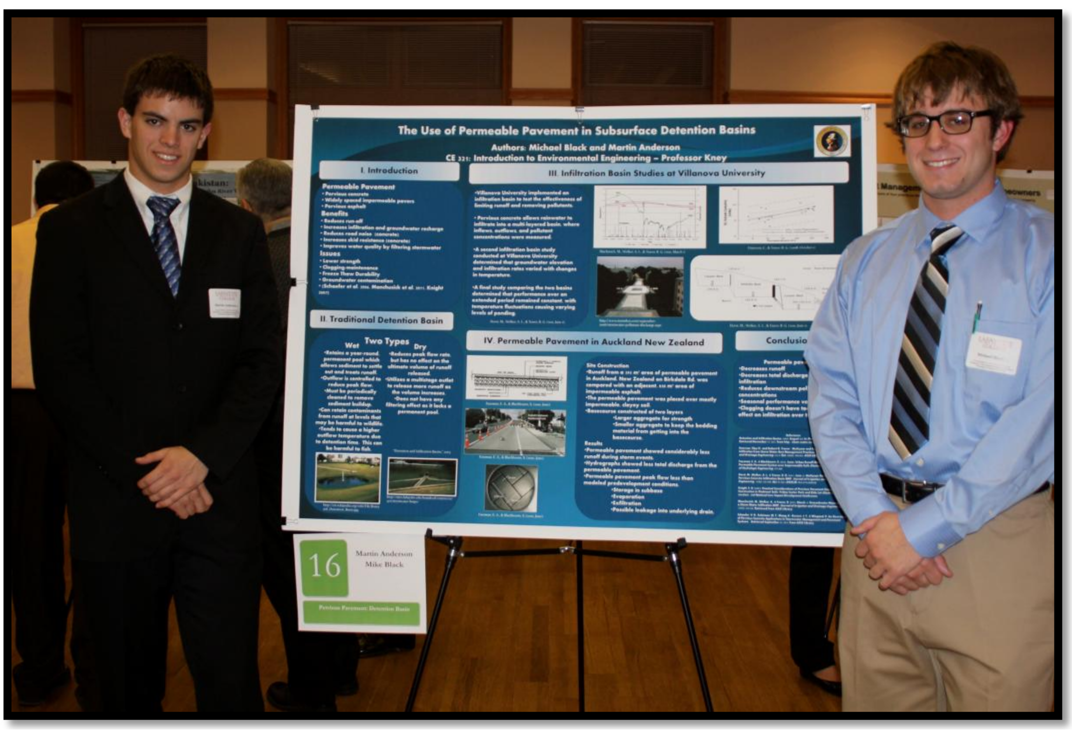
•The bike sharing program will promote a healthier life-style. Riding a bike is not only a physical activity but it is also a leisure exercise, so it will keep the students fit and stress free.

Poster #16

The Use of Permeable Pavement in Subsurface Detention Basins

Michael Black '12 and Martin Anderson '14

We studied permeable pavement and its use in subsurface detention basins. Subsurface detention basins are a storm water best management practice that is helpful in areas lacking space for a traditional detention basin. Subsurface detention basins control more parameters than a normal detention basin. In addition to managing peak flow, subsurface detention basins also reduce the total volume of runoff. They also filter storm water and allow it to infiltrate into the groundwater. We examined two case studies. There are two subsurface detention basins in the vicinity of Villanova University in Southeastern Pennsylvania. One is a walkway on the campus and the other is part of a parking lot. The walkway study monitored how well subsurface detention basins reduce runoff and their effectiveness at removing pollutants. The parking lot study measured the effects of subsurface detention basins on the groundwater table and the temperature of the groundwater. The second case study we examined was a section of roadway in Auckland, New Zealand. The second study measured the runoff mitigating effects of subsurface detention basins compared to the runoff of an adjacent area of conventional pavement. All studies looked at the long-term durability and effectiveness of permeable pavement.



The Use of Permeable Pavement in Subsurface Detention Basins

Authors: Michael Black and Martin Anderson

CE 321: Introduction to Environmental Engineering – Professor Kney

I. Introduction

Permeable Pavement
- Pervious concrete
- Widely spaced impermeable pavers
- Pervious asphalt

Benefits
- Reduces run-off
- Increases infiltration and groundwater recharge
- Reduces road noise (concrete)
- Increases skid resistance (concrete)
- Improves water quality by filtering stormwater

Issues
- Lower strength
- Clogging/maintenance
- Freeze Thaw Durability
- Groundwater contamination
- (Schaefer et al. 2006, Manchusick et al. 2011, Knight 2007)

II. Traditional Detention Basin

Two Types

Wet

•Retains a year-round, permanent pool which allows sediment to settle out and treats runoff.
•Outflow is controlled to reduce peak flow.
•Must be periodically cleaned to remove sediment buildup.
•Can retain contaminants from runoff at levels that may be harmful to wildlife.
•Tends to cause a higher outflow temperature due to detention time. This can be harmful to fish.

Dry

•Reduces peak flow rate, but has no effect on the ultimate volume of runoff released.
•Utilizes a multistage outlet to release more runoff as the volume increases.
•Does not have any filtering effect as it lacks a permanent pool.

"Detention and Infiltration Basins," 2003

http://en.wikipedia.org/wiki/File:Boneyard_Detention_Basin.jpg

http://sites.lafayette.edu/brandesd/courses/ce-421/stormwater-bmps/

III. Infiltration Basin Studies at Villanova University

•Villanova University implemented an infiltration basin to test the effectiveness of limiting runoff and removing pollutants.

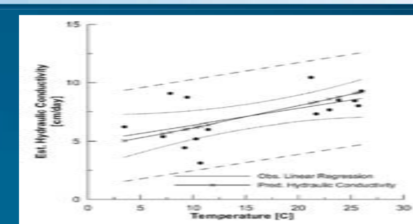
• Pervious concrete allows rainwater to infiltrate into a multi-layered basin, where inflows, outflows, and pollutant concentrations were measured.

•A second infiltration basin study conducted at Villanova University determined that groundwater elevation and infiltration rates varied with changes in temperature.

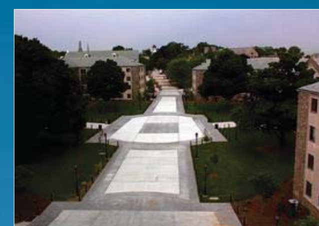
•A final study comparing the two basins determined that performance over an extended period remained constant, with temperature fluctuations causing varying levels of ponding.

Horst, M., Welker, A. L., & Traver, R. G. (2011, June 1).

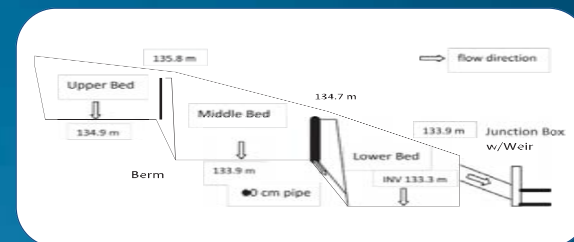
Machusick, M., Welker, A. L., & Traver, R. G. (2011, March 1)



Emerson, C., & Traver, R. G. (2008, October 1)

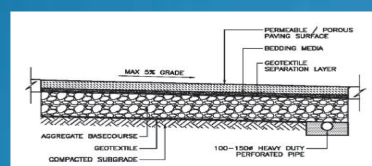


http://www.stormh2o.com/september-2006/stormwater-pollutant-discharge.aspx



Horst, M., Welker, A. L., & Traver, R. G. (2011, June 1).

IV. Permeable Pavement in Auckland New Zealand



Fassman, E. A., & Blackbourn, S. (2010, June).

Fassman, E. A., & Blackbourn, S. (2010, June).

Fassman, E. A., & Blackbourn, S. (2010, June).

Site Construction

•Runoff from a 395 m^2 area of permeable pavement in Auckland, New Zealand on Birkdale Rd. was compared with an adjacent, 850 m^2 area of impermeable asphalt.
•The permeable pavement was placed over mostly impermeable, clayey soil.
•Basecourse constructed of two layers
  - •Larger aggregate for strength
  - •Smaller aggregate to keep the bedding material from getting into the basecourse.

Results

•Permeable pavement showed considerably less runoff during storm events.
•Hydrographs showed less total discharge from the permeable pavement.
•Permeable pavement peak flow less than modeled predevelopment conditions.
  - •Storage in subbase
  - •Evaporation
  - •Exfiltration
  - •Possible leakage into underlying drain.

Conclusions

Permeable pavement :
•Decreases runoff
•Decreases total discharge by enabling infiltration
•Reduces downstream pollutant concentrations
•Seasonal performance varies
•Clogging doesn't have too much of an effect on infiltration over time

References

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Poster #17

Best Management Practices for Homeowners

Rebecca Rolwood '14 and Christian Modesto '14

We researched Best Management Practices (BMPs) for Homeowners and compiled a list of four practices we thought were relatively easy and inexpensive, hoping to encourage individuals to implement these practices. BMPs are methods and techniques that are the most sensible ways of decreasing the amount of pollution and contaminants from non-point sources. Our list included rain barrels, rain gardens, improved driveways and walkways, and wisely placed gutters and drainage pipes. We also researched how to determine the amount of runoff produced by a property, which will be helpful in deciding what size and how many BMPs are practical. Our hope is that our research would be furthered in the future by adding to our list and including detailed instructions, producing a complete packet that would be made readily available to the public.

Best Management Practices for Homeowners

An analysis of four practices that allow homeowners to minimize stormwater runoff from their property.

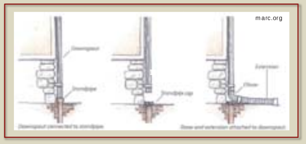
R. Rolwood and C. Modesto

Background

Best Management Practices (BMPs) are the most sensible ways of decreasing the amount of pollution and contaminants from non-point sources

- Stormwater management on an individual basis is especially important
- Properly dealing with excess stormwater can prevent pollution from entering the water ways by reducing the chances of stormwater sewer system overflowing
- Homeowners need to have solutions that are relatively easy to create and inexpensive to build in order to be encouraged to implement the following suggested practices

Gutters and Drainage Pipes



Description: Wisely placed gutters and drainage pipes prevent excess runoff from entering the stormwater sewer system and instead guide water onto the ground to be absorbed.

Installation and Materials:
- Direct into a rain barrel, rain garden, or onto the lawn to be absorbed
- Gutter extension pieces cost under $10 each and can be purchased from a hardware store or online
- Direct water at least 10 feet away from structures to prevent flooding problems

Maintenance: Clean gutters periodically, especially after large storms to prevent clogging and overflow.

Rain Gardens/Bioretention

Description: A simple rain garden composed of soil and plants will absorb runoff and naturally filter pollutants.

Installation and Materials:
- Remove grass and soil from premeasured area
- The average rain garden is 150-300 square feet
- Fill bowl-shaped area with soil mixed with compost or buy special soil mix
- Use native plants if possible
- Downspouts should be placed so that they will drain into the garden

Maintenance: Weeding and watering are necessary every other day while plants establish roots
no need to add fertilizer

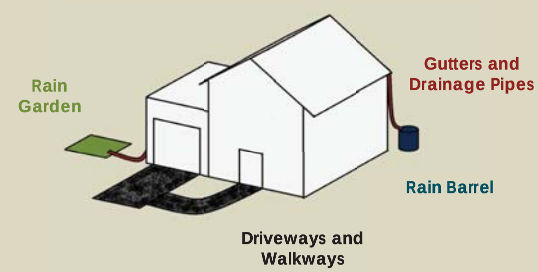
Suggested Native Pennsylvanian Plants for Rain Gardens

Name	Sun/Shade	Moisture
Butterfly Weed (Asclepias tuberosa)	FS, PS	dry to moist
Swamp Milkweed (Asclepias incarnata)	FS, PS	moist to wet
Cardinal Flower (Lobelia cardinalis)	FS, PS, S	moist to wet
Great Blue Lobelia (Lobelia siphilitica)	FS, PS, S	moist to wet
Bee Balm (Monarda didyma)	FS, PS, S	moist to wet
Blazing Star (Liatris spicata)	FS, PS	dry to moist
Blue Flag (Iris versicolor)	FS, PS	moist to wet
Tussock Sedge (Carex stricta)	FS	moist to wet
Black chokeberry (Photinia melanocarpa)	FS, PS, S	dry to wet
Spicebush (Lindera benzoin)	PS, S	moist to wet

modified from whitpaintownship.net

FS - Full Sun
PS - Partial Sun
S - Shade

Model House



Conclusion

We want individuals to know that they can help improve stormwater management, saving money for both themselves and their municipality, by implementing best management practices on their own properties.

Using our research, we created a list of relatively simple BMPs for homeowners. This pamphlet provides descriptions and instructions for implementing the suggested BMPs for homeowners. Our hope is that homeowners will follow the suggested best management practices, increasing sustainable actions along with environmental awareness.

Resources

Best Management Practices from www.state.hi.us
Conservative Practices for Homeowners from www.maine.gov
A Homeowner's Guide to Stormwater Management from www.delawareestuary.org
Homeowner Tips for Improving Water Quality from www.marc.org
Rain Gardens from www.raingardens.org
Stormwater Management for Homeowners from des.nh.gov
Toronto Homeowner's Guide to Rainfall from www.riversides.org

Special Thanks to Matt Glennon and the Bushkill Stream Conservancy
Images thanks to Professor David Brandes unless otherwise stated

Driveways and Walkways

Description: Using permeable pavement instead of solid asphalt or concrete allows water to pass through the surface and soak into the ground beneath.

Installation and Materials:
General Suggestions
- Make paved areas as small/narrow as possible
- Instead of a concrete patio, build a wooden deck
- Leave gaps between paving stones or driveway tire tracks
- Do not use impermeable liner under the pavement; use a substitute like cloth

Maintenance: Monitor driveways and walkways and repair as needed.

Rain Barrels

Description: Collects rain water from roof and stores it for later use.
Water can be used to water lawn, garden and indoor plants.

Installation and Materials:
- Elevate rain barrel on a level area
- Direct water from gutters into barrel
- Average cost for a preassembled rain barrel ranges from $80 to $200 and can be purchased from a local hardware store or the internet
- Building your own rain barrel can cost less than buying a preassembled one. Materials include: drum, vinyl hose, PVC male adapter, vinyl gutter elbow, and water proof sealant, all of which can be bought from a local hardware store.

To determine the size and number of rain barrels needed, calculate the roof runoff an average rainfall will produce.

Maintenance:
- Drain spouts and rain barrel screen should be checked for debris
- Rain barrels should be stored away or flipped upside down during freezing weather

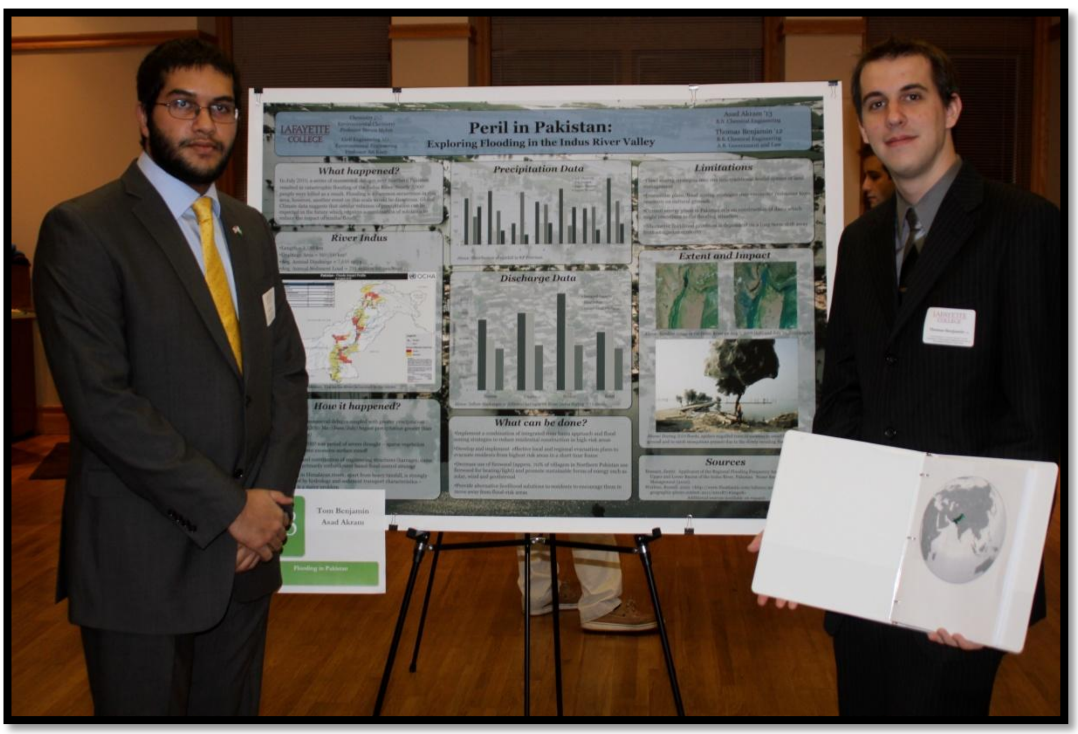
Roof Area (sq ft)	Total Rainfall in One Storm (Gallons)		
	1 in (4 times/yr)	0.4 in (24 times/yr)	0.2 in (44 times/yr)
900	555	222	110
800	490	195	98
700	430	172	86
600	370	148	74
500	304	122	61
400	245	98	49
300	185	74	37

Poster #18

Peril in Pakistan: Exploring Flooding in the Indus River Valley

Asad Akram '13 and Thomas Benjamin '12

In 2010, a series of monsoonal deluges caused massive flooding in the Indus River Valley in Pakistan, which affected over 14 million people, killed over 2000 people, and caused over $10 billion dollars in damages. The factors that made this disaster catastrophic for Pakistan, including climate, economic, cultural, and political factors were explored. Possible solution strategies such as the implementation of an integrated river basin approach, flood zoning, change in energy policy, and a shift from an agrarian economy were weighed against limitations such as of economic, cultural, and political reasons.



LAFAYETTE COLLEGE

Chemistry 252:
Environmental Chemistry
Professor Steven Mylon

Civil Engineering 321:
Environmental Engineering
Professor Art Kney

Peril in Pakistan:
Exploring Flooding in the Indus River Valley

Asad Akram '13
B.S. Chemical Engineering

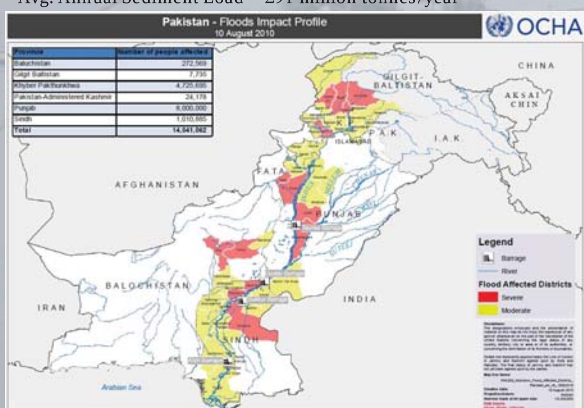
Thomas Benjamin '12
B.S. Chemical Engineering
A.B. Government and Law

What happened?

In July 2010, a series of monsoonal deluges over Northern Pakistan resulted in catastrophic flooding of the Indus River. Nearly 2,000 people were killed as a result. Flooding is a common occurrence in this area, however, another event on this scale would be disastrous. Global Climate data suggests that similar volumes of precipitation can be expected in the future which requires a combination of solutions to reduce the impact of similar floods.

River Indus

- Length = 3,180 km
- Drainage Area = 960,000 km^2
- Avg. Annual Discharge = 7,610 m^3/s
- Avg. Annual Sediment Load = 291 million tonnes/year

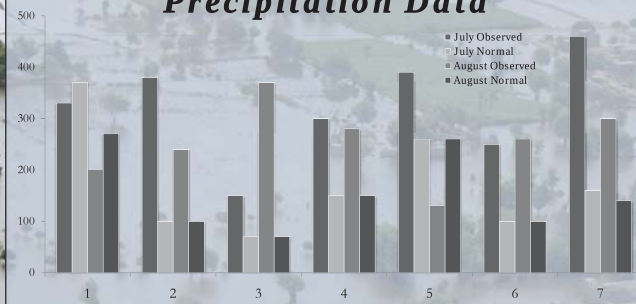


Above: Map of Pakistan. The Indus River is located in the center.

How it happened?

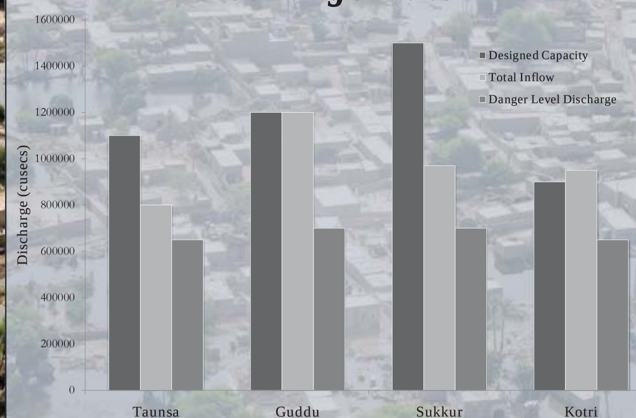
- Location of monsoonal deluges coupled with greater precipitation than average (2010 May/June/July/August precipitation greater than previous years)
- Summer of 2009 was period of severe drought – sparse vegetation cover to prevent excessive surface runoff
- Influence and contribution of engineering structures (barrages, dams etc.) and a primarily embankment based flood control strategy
- Flooding in Himalayan rivers, apart from heavy rainfall, is strongly influenced by hydrology and sediment transport characteristics – siltation is a major problem

Precipitation Data



Above: Distribution of rainfall in KP Province.

Discharge Data



Above: Inflow discharges at different barrages on River Indus during 2010 floods.

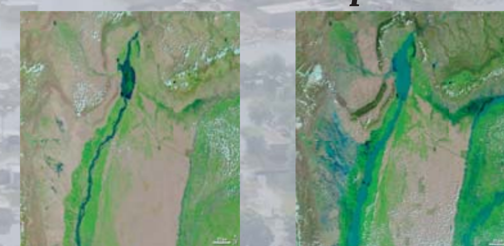
What can be done?

- Implement a combination of integrated river basin approach and flood zoning strategies to reduce residential construction in high-risk areas
- Develop and implement effective local and regional evacuation plans to evacuate residents from highest risk areas in a short time frame
- Decrease use of firewood (approx. 70% of villagers in Northern Pakistan use firewood for heating/light) and promote sustainable forms of energy such as solar, wind and geothermal
- Provide alternative livelihood solutions to residents to encourage them to move away from flood-risk areas

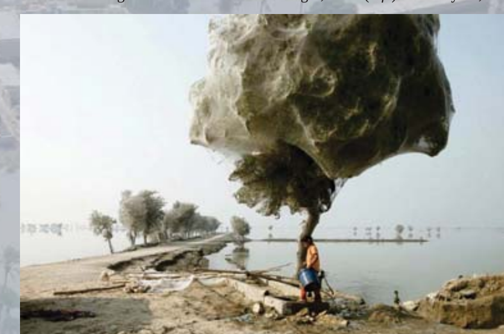
Limitations

- Flood zoning strategies may run into traditional feudal system of land management
- Evacuation plans/flood zoning strategies may encounter resistance from residents on cultural grounds
- Current energy plans in Pakistan rely on construction of dams which might contribute to the flooding situation
- Alternative livelihood provision is dependent on a long-term shift away from an agarian economy

Extent and Impact



Above: Satellite image of the Indus River on Aug 1, 2009 (*left*) and July 31, 2010 (*right*)



Above: During 2010 floods, spiders engulfed trees in cocoons to avoid the flooded ground and to catch mosquitoes present due to the slowly receding floodwaters.

Sources

Hussain, Zamir. Applicaion of the Regional Flooding Frequency Analysis to the Upper and Lower Basins of the Indus River, Pakistan. Water Resources Management (2010).

Watkins, Russell. 2010. <http://www.theatlantic.com/infocus/2011/11/national-geographic-photo-contest-2011/100187/#img08>

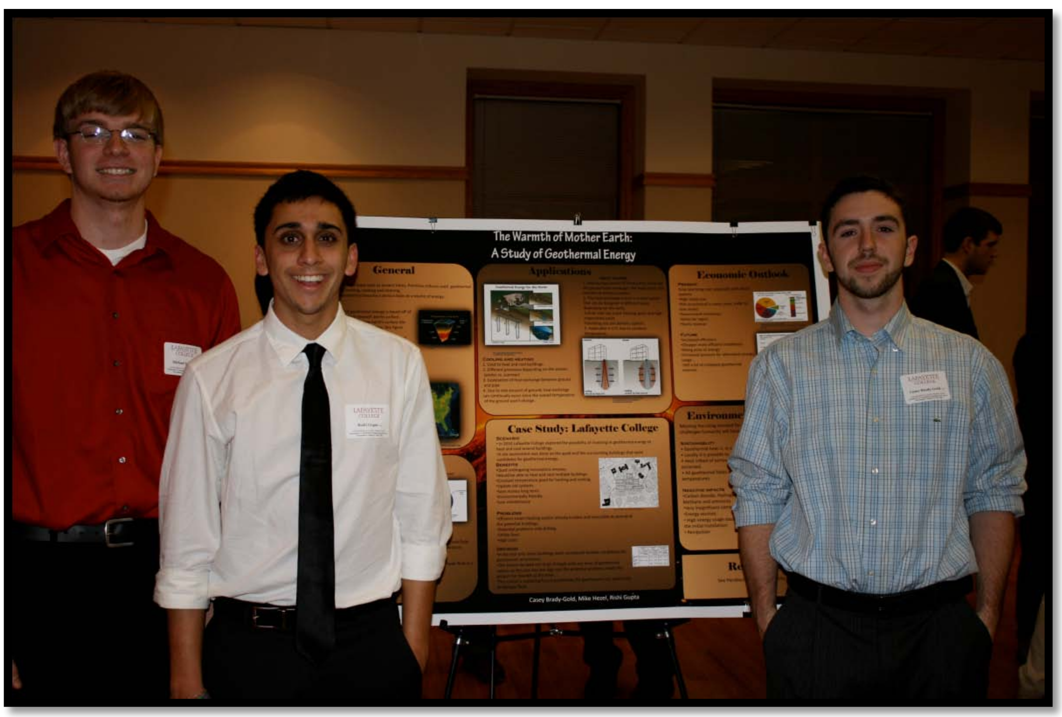
Additional sources available on request.

Poster #19

The Warmth Of Mother Earth

Casey Brady-Gold '14, Mike Hezel '14 and Rishi Gupta '14

Our group explored the topic of geothermal energy for the environmental poster project. Meeting the rising demand for energy is one of the biggest challenges facing humanity in the coming century. Expanding alternative energy usage is going to be extremely important moving forward which is why our group decided to research this topic. Geothermal energy utilizes the heat gradient of earth's crust to generate electricity or heat and cool buildings. Because geothermal potential varies by region we decided to explore methods that are most applicable to the surrounding region, primarily the heating and cooling of building through direct systems or heat pumps. While our technical component focused primarily on applications of geothermal energy on the East Coast, we looked at the environmental and economic outlook of geothermal energy from a global perspective. Currently geothermal energy occupies a very small segment of the energy market. After researching this topic we believe that geothermal energy will continue to expand and became more dominant as we move to cleaner, more sustainable alternative energy sources.

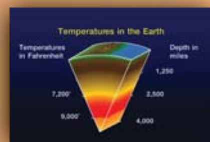


The Warmth of Mother Earth:
A Study of Geothermal Energy

General

History
•Geothermal Energy dates back to ancient times. Primitive cultures used geothermal hot springs for bathing, cooking and cleaning.
•After WWII geothermal became a serious topic as a source of energy.

Basics
•The idea behind geothermal energy is based off of the thermal gradient beneath earths surface.
•Generally the deeper below earth's surface the greater the temperature conditions. See figure below.
•There are 2 types of geothermal use, direct and indirect.
•Indirect involves electrical generation, while direct involves heating or cooling of buildings.



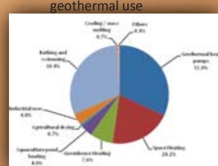
What is the Status of Geothermal in Today's World?
•The United States is currently the largest producer of geothermal energy
•Indirect Geothermal Systems are mostly found In areas with higher geothermal gradients
•The picture to the right displays the heat gradient Across the U.S.
•West coast better suited for Geothermal energy

http://www.consumerenergyreport.com/wp-content/uploads/2011/10/geothermal-United-States-google.jpg

Fundamentals

Types
•Direct and Indirect use
•Heat Pumps
•Breakdown of different uses of Geothermal energy
•Main application on East coast is heating and cooling in the form of heat pumps.
• The west coast has potential for electrical generation

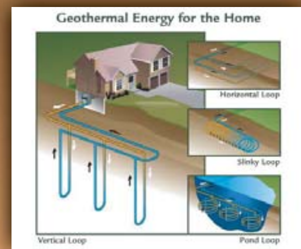
Breakdown of Direct geothermal use



Horizontal Well Layout

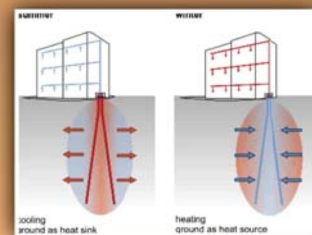
Process
1. Role of the Heat Source, reservoir, and fluid.
2. Relatively constant ground temperature.
3. Circulation of Fluid.
4. Extraction of heat from the fluid.
5. Difference between using man made fluid in a pipe and natural fluid.
6. Requirements of Heat source.
7. Improvements and changes.

Applications



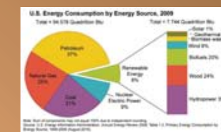
Heat Pumps
1. Heat pumps consist of three parts; these are the ground heat exchanger, the heat pump unit and the air delivery system.
2. The heat exchange occurs in a pipe system that can be designed in different ways depending on the earth.
3.Fluid used has a low freezing point and high evaporation point.
4.Building use and delivery system.
5. Applicable in U.S. due to constant temperature.

Cooling and Heating
1. Used to heat and cool buildings.
2. Different processes depending on the season. (winter vs. summer)
3. Explanation of Heat exchange between ground and pipe
4. Due to vast amount of ground, heat exchange can continually occur since the overall temperature of the ground won't change.

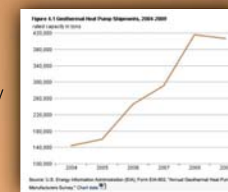


Economic Outlook

Present
•Low operating cost, especially with direct systems.
•High Initial cost.
•Not economical in many cases. (refer to case study)
•Government Incentives.
•Varies by region.
•Yearly revenue



Future
•Increased efficiency
•Cheaper more efficient installation.
•Rising price of energy
•Increased pressure for alternative energy usage.
•Still a lot of untapped geothermal reserves



Case Study: Lafayette College

Scenario
• In 2010 Lafayette College explored the possibility of investing in geothermal energy to heat and cool several buildings.
•A site assessment was done on the quad and the surrounding buildings that were candidates for geothermal energy.

Benefits
•Quad undergoing renovations anyway.
•Would be able to heat and cool multiple buildings.
•Constant temperature good for heating and cooling.
•Update old systems.
•Save money long term.
•Environmentally friendly.
•Low maintenance

See list of references for case study citations.

Problems
•Efficient steam heating system already in place and accessible to several of the potential buildings.
•Potential problems with drilling.
•Utility lines
•High costs

Decision
•In the end only three buildings were considered feasible candidates for geothermal renovations.
•The School decided not to go through with any form of geothermal system as the cost was too high and the potential problems made the project not feasible at the time.
•The school is exploring future possibilities for geothermal use, potentially at Metzger field.

Environmental Impact

Meeting the rising demand for energy is one of the biggest challenges humanity will have to face in the coming century.

Sustainability
• Geothermal heat is, in a practical sense, infinite on a global scale.
• Locally it is possible to exhaust a geothermal resource.
• Heat infeed of surrounding earth must equal that being extracted.
• All geothermal fields will eventually regain functional temperatures.

Negative Impacts
•Carbon dioxide, Hydrogen sulfide, Methane and ammonia.
•Very insignificant compared to other
•Energy sources.
• High energy usage associated with the initial installation.
• Reinjection

References

See Handout for full list of works cited

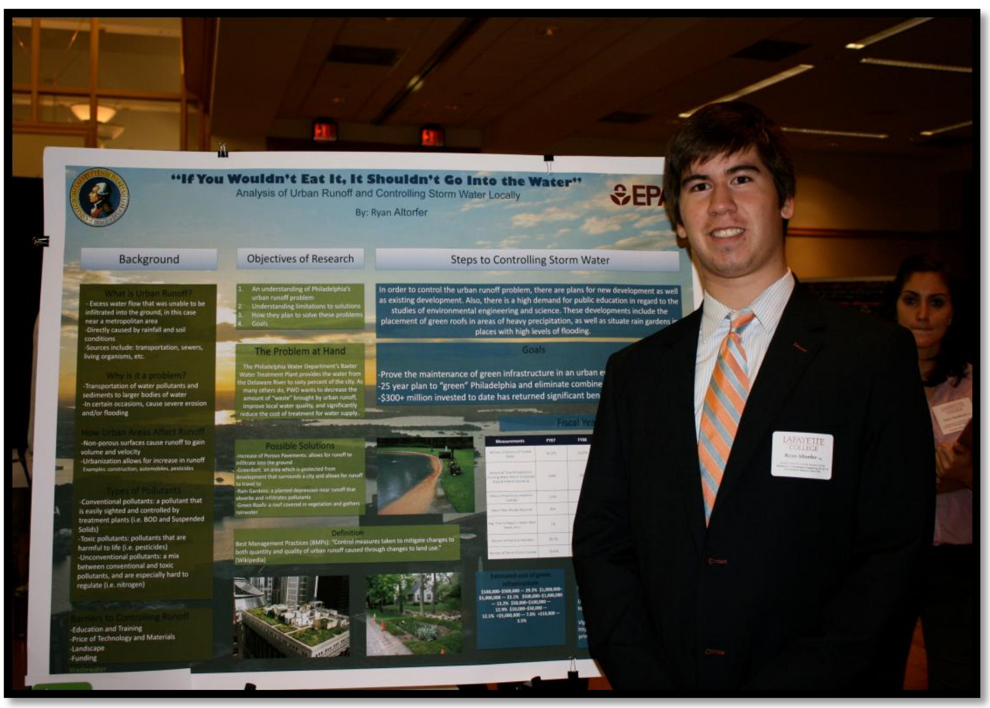
Casey Brady-Gold, Mike Hezel, Rishi Gupta

Poster #20

“If You Wouldn’t Eat It, It Shouldn’t Go Into the Water”

Ryan Altorfer ‘14

This research is focused on the Philadelphia Water Department’s problem with urban runoff. Similar to many other water departments, they want to increase the water quality of the Delaware River, reduce the amount of waste brought on by urban runoff, and cut the costs of treatment. But with every project comes barriers, which include but are not restricted to educating, training, and funding. Even so, the department continues to implement its focus on the best management practices of porous roads, greenbelts, rain gardens, and green roofs. Porous roads allow for the infiltration of water into the ground rather than letting it accumulate into other bodies of water. Both the greenbelts and rain gardens are areas near places of urban runoff that also infiltrate water into the ground, but allow for vegetation. Green roofs are similar to this, but are placed upon roofs of buildings to keep toxic pollutants such as metals to be taken into runoff. There is continued focus on existing and new developments that will help improve the quantitative and qualitative factors of controlling urban runoff.



“If You Wouldn’t Eat It, It Shouldn’t Go Into the Water”

Analysis of Urban Runoff and Controlling Storm Water Locally

By: Ryan Altorfer

Background

What is Urban Runoff?

- Excess water flow that was unable to be infiltrated into the ground, in this case near a metropolitan area
-Directly caused by rainfall and soil conditions
-Sources include: transportation, sewers, living organisms, etc.

Why is it a problem?

-Transportation of water pollutants and sediments to larger bodies of water
-In certain occasions, cause severe erosion and/or flooding

How Urban Areas Affect Runoff

-Non-porous surfaces cause runoff to gain volume and velocity
-Urbanization allows for increase in runoff
Examples: construction, automobiles, pesticides

Types of Pollutants

-Conventional pollutants: a pollutant that is easily sighted and controlled by treatment plants (i.e. BOD and Suspended Solids)
-Toxic pollutants: pollutants that are harmful to life (i.e. pesticides)
-Unconventional pollutants: a mix between conventional and toxic pollutants, and are especially hard to regulate (i.e. nitrogen)

Barriers to Controlling Runoff

-Education and Training
-Price of Technology and Materials
-Landscape
-Funding

Objectives of Research

1. An understanding of Philadelphia’s urban runoff problem
2. Understanding limitations to solutions
3. How they plan to solve these problems
4. Goals

The Problem at Hand

The Philadelphia Water Department’s Baxter Water Treatment Plant provides the water from the Delaware River to sixty percent of the city. As many others do, PWD wants to decrease the amount of “waste” brought by urban runoff, improve local water quality, and significantly reduce the cost of treatment for water supply..

Possible Solutions

-Increase of Porous Pavements: allows for runoff to infiltrate into the ground
-Greenbelt: an area which is protected from development that surrounds a city and allows for runoff to travel to
-Rain Gardens: a planted depression near runoff that absorbs and infiltrates pollutants
-Green Roofs: a roof covered in vegetation and gathers rainwater

Definition

Best Management Practices (BMPs): “Control measures taken to mitigate changes to both quantity and quality of urban runoff caused through changes to land use.” (Wikipedia)

Steps to Controlling Storm Water

In order to control the urban runoff problem, there are plans for new development as well as existing development. Also, there is a high demand for public education in regard to the studies of environmental engineering and science. These developments include the placement of green roofs in areas of heavy precipitation, as well as situate rain gardens in places with high levels of flooding.

Goals

-Prove the maintenance of green infrastructure in an urban environment
-25 year plan to “green” Philadelphia and eliminate combined sewer overflows
-$300+ million invested to date has returned significant benefits

Fiscal Year Data

Measurements	FY07	FY08	FY09	FY10	FY11
Millions of Gallons of Treated Water	95,374	93,679	91,747	91,560	94,170
Percent of Time Philadelphia’s Drinking Water Met or Surpassed State & Federal Standards	100%	100%	100%	100%	100%
Miles of Pipeline Surveyed for Leakage	1,024	1,113	931	1,133	1,110
Water Main Breaks Repaired	824	687	802	646	850
Avg. Time to Repair a Water Main Break (hrs.)	7.6	8	8	7.8	8
Percent of Hydrants Available	99.7%	99.7%	99.7%	99.6%	99.6%
Number of Storm Drains Cleaned	76,478	75,804	77,012	72,802	111,444

Estimated cost of green infrastructure:

$100,000–$500,000 — 29.2% $1,000,000–$5,000,000 — 22.1% $500,000–$1,000,000 — 13.2% $50,000–$100,000 — 12.9% $10,000–$50,000 — 12.1% <$5,000,000 — 7.0% >$10,000 — 3.5%

References

Philadelphia Water Department
http://www.phila.gov/water/

U.S. Environmental Protection Agency
http://www.epa.gov/

Viginia Tech Civil Engineering Department
http://www.cee.vt.edu/ewr/environmental/teach/gwprimer/group18/urbanr.htm

Wastewater

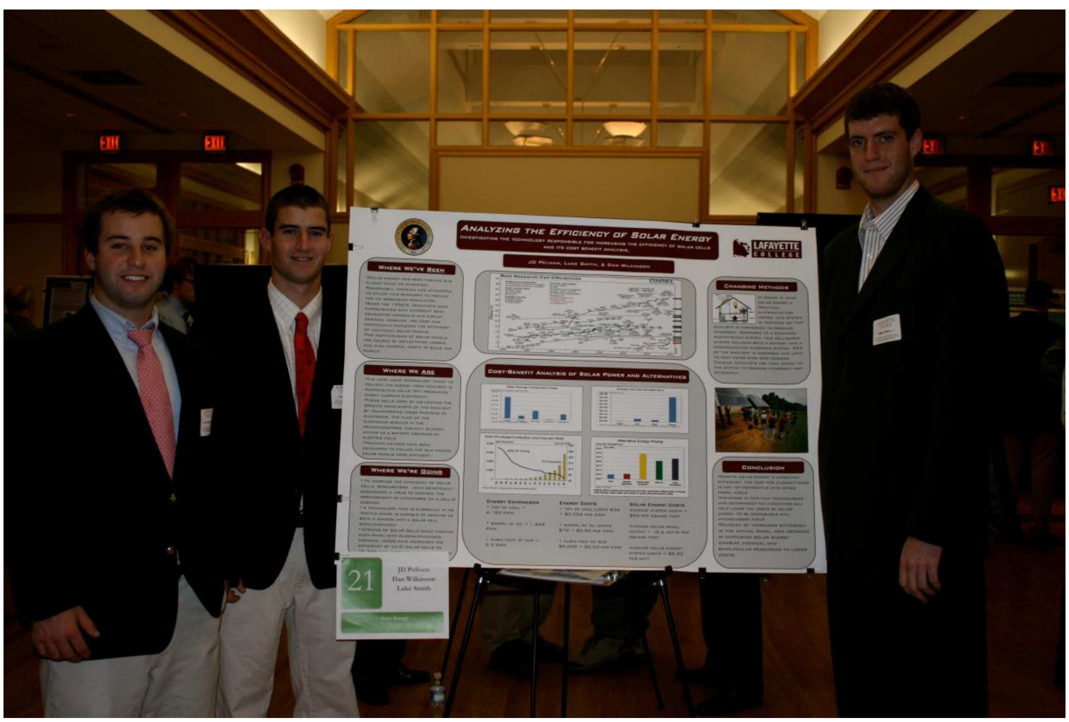
Clean Water

Poster #21

Analyzing the Efficiency of Solar Energy

JD Pelham '12, Luke Smith '14, and Dan Wilkinson '12

We researched the past, present, and future aspects of solar technology. In order to get a better understanding of where solar technology is going, analyzing the history of the technology was critical to see the path that solar technology is moving towards. Along with the history of solar energy, we also compared solar power to other alternative forms of energy by completing a cost-benefit analysis. Within the various forms of energy options, the efficiency of solar energy is not where it needs to be in terms of an economically feasible option. Through our research, we found that solar companies are taking steps towards making solar energy more efficient. We believe that with the help of government incentives, solar technology will continue to get better. Advances in thin-film technologies and government tax incentives will help lower the costs of solar energy to be comparable with hydrocarbon fuels. Outside of increased efficiency in the actual panel, new methods in capturing solar energy combine chemical and bimolecular resources to lower costs.



Analyzing the Efficiency of Solar Energy

Investigating the technology responsible for increasing the efficiency of solar cells and its cost benefit analysis,

JD Pelham, Luke Smith, & Dan Wilkinson

Where We've Been

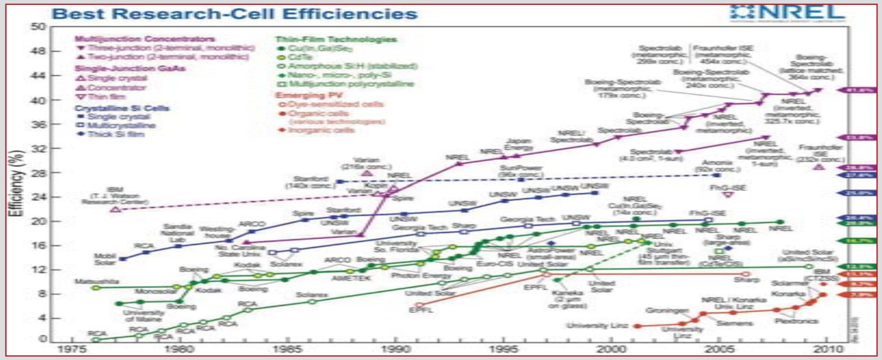
•Solar energy has been fueling our planet since its existence. Reasonably, mankind has attempted to utilize this resource to provide for an increasing population.
•Since the 1950's, scientists have experimented with different semi-conductor materials and circuit designs, however, the cost has continually exceeded the efficiency of individual solar panels.
•The inefficiencies of solar panels are caused by reflectance losses and high material costs to build the panels

Where We Are

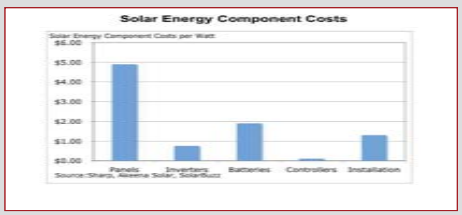
•The most used technology today to collect the energy from sunlight is photovoltaic cells (PV) producing direct current electricity.
•These cells work by collecting the specific wavelength of the sunlight by transferring these photons to electrons. The flow of the electrons results in the semiconductors (usually silicon) acting as a battery creating an electric field.
•Tracking devices have been developed to follow the sun making solar panels more efficient.

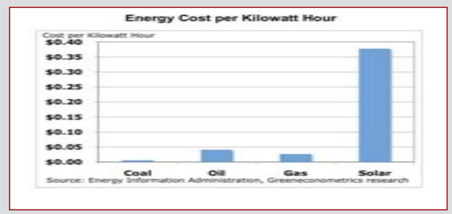
Where We're Going

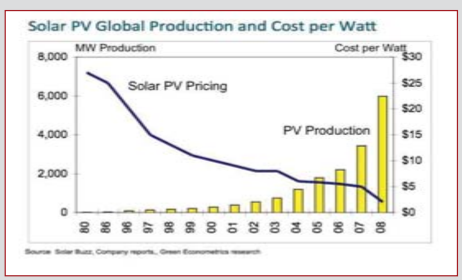
• To increase the efficiency of solar cells, researchers have genetically engineered a virus to control the arrangement of nanotubes on a cell's surface
• A technology that is currently in its testing stage is capable of serving as both a window and a solar cell simultaneously
• Etching of solar cells while coating each panel with plasma-enhanced chemical vapor have increased the efficiency of mc-Si solar cells to 16.34% with further improvements to come.

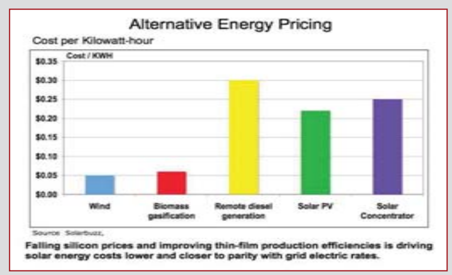


Cost-Benefit Analysis of Solar Power and Alternatives









Energy Comparison

1 ton of coal = 6,182 KWH

1 barrel of oil = 1,699 KWH

1 cubic foot of gas = 0.3 KWH

Energy Costs

1 ton of coal costs $36 = $0.006 per KWH

1 barrel of oil costs $70 = $0.05 per KWH

1 cubic foot of gas $0.008 = $0.03 per KWH

Solar Energy Costs

Average system costs = $95 per square foot

Average solar panel output = 10.6 watts per square foot

Average solar energy system costs = $8.95 per watt

Changing Methods

In order to make solar energy a practical alternative for homes, this system is designed so that sunlight is harnessed to produce hydrogen. Compared to a standard photovoltaic system, this cell-based system includes both a battery and a photocatalytic hydrogen system. 95% of the sunlight is absorbed and used to heat water over 200 degrees Celsius. Catalysts are then added to the system to produce hydrogen very efficiently.

Conclusion

•Despite solar energy's improving efficiency, the cost per kilowatt-hour is not yet competitive with other fossil fuels
•Advances in thin-film technologies and government tax incentives will help lower the costs of solar energy to be comparable with hydrocarbon fuels
•Outside of increased efficiency in the actual panel, new methods in capturing solar energy combine chemical and bimolecular resources to lower costs.

Poster #22

Methane Hydrates: Energy Solution or Environmental Hazard?

Richard Albertini '13 and Ashley Kaminski '13

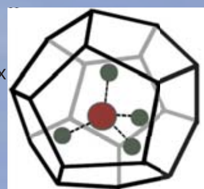
Methane hydrates are clathrate structures, a molecule complex of low molecular weight gas surrounded by a larger complex of water molecules, in the deep sea and permafrost regions containing large quantities of natural gas. If the methane from these sources could be safely harvested, natural gas reserves would be significantly increased. However, methane has a role as a potent greenhouse gas, and hydrate destabilization could be disastrous for the environment if not contained. Though no commercial production is currently in place, large energy companies are researching methods to extract methane from hydrates without disturbing other reserves. This poster examines the prevalence of these clathrates within the hydrate stability zone (HSZ) globally. Different techniques of extraction of methane from hydrates are also examined, as well as the economic and environmental benefits associated with doing so. The potential environmental costs are illuminated and research in the Prudhoe Bay is touched upon.

Methane Hydrates: Energy Solution or Environmental Hazard?

Richard J. Albertini, Ashley J. Kaminski

Background

What is a hydrate?

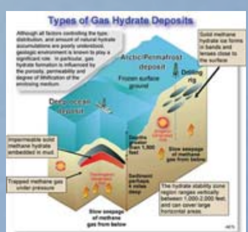


http://large.stanford.edu/courses/2010/ph240/harrison1/

A hydrate is a solid crystalline molecule complex formed at low temperatures and high pressures of water and low molecular weight gases. There are different structures of hydrates. Structure I (sI) have the highest natural abundance. The internal molecules is called the guest. The ideal guest to water ration in an sI hydrate is 1:5.75.

Where do methane hydrates form?

Methane (CH_4) hydrates form in deep ocean sediments and in permafrost regions. These regions provide the necessary temperature and pressure that create the hydrate stability zone (HSZ). This exists at depths from 4-400 m on land, and below 400 m in the ocean.



http://www.netl.doe.gov/technologies/oil-gas/futuresupply/methanehydrates

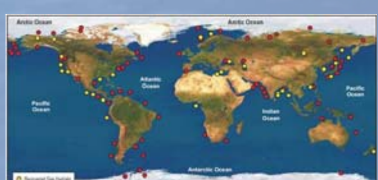
What is the source of the gas?

Methane comes from the decomposition of organic matter either by anaerobic bacteria, microbial, or by heat, thermogenic.

This is the same as traditional natural gas formation.

Methane hydrates also form in pipes during the transportation and drilling of petroleum.

Where are Methane Hydrates



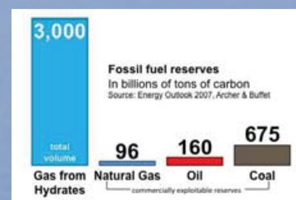
http://www.globalcarbonproject.org/news/MethaneHydrates.html

Methane hydrates are everywhere. Hydrates represent 53% of total fossil fuels world wide.

Location of hydrate layers is done with reflection seismic, often bottom-simulating reflector (BSR), which uses acoustic properties to map areas beneath the surface. This in conjunction with bathymetry and sea-floor morphology gives an accurate picture of the sea floor.

Benefits of Methane Hydrates

1. Nearly a quarter of US energy comes from natural gas, and the need is likely to grow by at least 10% over the next 25 years.
2. The United States can reduce its dependence on foreign energy by increasing domestic supply
3. US has a base reserve of approximately 2,000 trillion cubic feet of natural gas right now.
4. The Gulf of Mexico is estimated to contain between 11,000 and 34,000 trillion cubic feet of natural gas in methane hydrates. If one third of this becomes technically recoverable, the US can double its natural gas reserves.
5. Natural gas emits less CO_2 per unit energy than other fossil fuel sources.
6. Oil is six times as expensive as natural gas on a per unit energy basis.



Recovery Techniques

Thermal Injection

- •Steam, hot water, other hot fluid
- •Expensive on shore, economically unfeasible off shore

Pressure Reduction

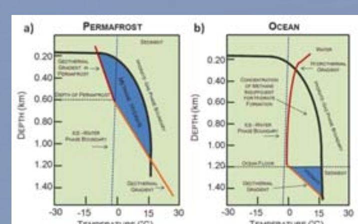
- •Operates in gas pockets with embedded or adjacent solid hydrates
- •Most appropriate method for large-scale recovery.

Inhibitor Stimulation

- •Alcohols, brines, and other electrolytes lower the freezing point
- •Slower process but lower energy input needed

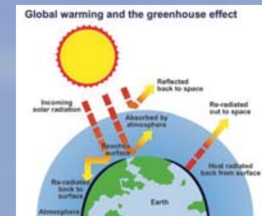
Replacement Method

- •Carbon dioxide hydrates are stable at lower pressure.
- •Injection of CO_2 forms hydrates and releases heat that decomposes the methane hydrates.



http://large.stanford.edu/courses/2010/ph240/harrison1/

Green House Gas



http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=9E705000-1

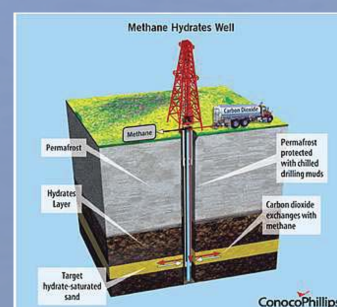
A green house gas is any gas that has a change in dipole moment that allows absorbance of the IR light emitted from earth. These include water, CO_2, CH_4, and CFCs. CO_2 is one of the most prominent green house gases and is released from all fossil fuel combustion. But, the burning of natural gas (methane) produces half the CO_2 as burning coal and almost half as much as oil.

$$2\text{Coal(CH)} + 2\tfrac{1}{2}O_2 \rightarrow 2CO_2 + H_2O$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Methane Gas Hydrates: Potential as Future Energy Source

Case Study: Prudhoe Bay



NETL: Methane Hydrates – National Energy Technology Laboratory

- •US Department of Energy and ConocoPhillips conducted a field trial of methane extraction by inhibitor stimulation in situ in Prudhoe Bay, Alaska.
- •Entering its final production stage.
- •Consists of site and well preparation, well perforation, initial nitrogen injection, CO_2 injected and shut-in for exchange, stepwise depressurization and flowback above hydrate stability pressures.
- •$21.5 million in project funding.
- •Project timescale: October 1, 2008 to June 30, 2013.

Environmental Concerns

What are the problems with using methane?

- •Methane is 21 times the global warming potential (GWP) as CO_2.
- •There are already numerous sources of methane such as wetlands, cows, rice patties, landfills and hydroelectric power plants that are more difficult to control.
- •CO_2 would still be produced.

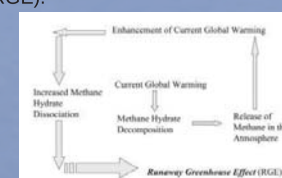
http://arb.ca.gov/cc/inventory/data/data.htm

What if the hydrates stability zone was disrupted?

Hydrates are less dense than water and float. As the hydrates move into less pressurized areas the structure breaks down forming water and CH_4 gas. If there was a rapid release of methane this could significantly impact the Earth's surface, potentially increasing the temperature by 0.006°C -0.08°C annually.

What would the rise in temperature do?

A rise in temperature would cause more hydrate instability, gas release and further temperature increase. This is called the run away green house effect (RGE).



Methane Gas Hydrates: Potential as Future Energy Source

Are there any other negative effects?

As exploration expands to the ocean, there is an increased chance of well blow out. The environmental effects of this were seen with the BP Deep Water Horizon disaster.

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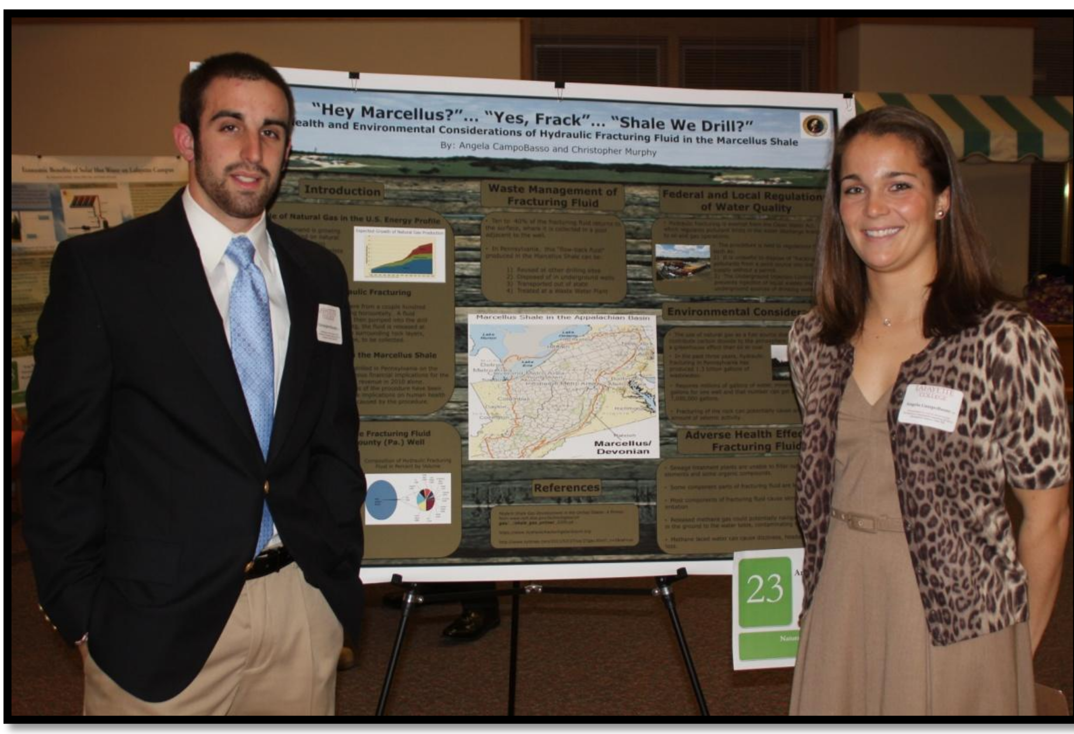
Poster #23

"Hey Marcellus"… "Yes Frack"… "Shale we drill?"

Angela CampoBasso '12 and Christopher Murphy '12

There is great controversy in Pennsylvania today surrounding unconventional natural gas drilling in the Marcellus Shale. The process, called hydraulic fracuturing, entails drilling vertically into the shale, then drilling horizontally. A fluid composed of sand, water, and chemicals is then pumped into the drill pipes. In the horizontal region of the drilling, the fluid is released at high pressure, which then fractures the surrounding rock layers, releasing embedded gases, such as methane, to be collected. Many are linking documented cases of water contaminated to gases, radioactive elements, and chemical agents associated with procedure. We focused on this aspect of the debate, researching what the DEP is doing to regulate both how the industry handles its wastewater and how it interacts with freshwater systems. From there, we traced the adverse environmental and subsequent human health effects of exposure to these byproducts of hydraulic fracturing.



"Hey Marcellus?"... "Yes, Frack"... "Shale We Drill?"

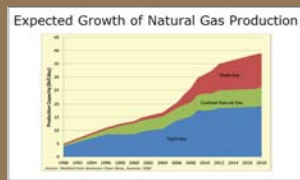
The Health and Environmental Considerations of Hydraulic Fracturing Fluid in the Marcellus Shale

By: Angela CampoBasso and Christopher Murphy

Introduction

The Role of Natural Gas in the U.S. Energy Profile

The world's energy demand is growing rapidly and our most relied on natural resources, oil and coal, are being exhausted. The United States is replete with natural gas, enough to, given current production rates, satisfy our energy needs for the next 90 years.



An Overview of Hydraulic Fracturing

Hydraulic fracturing entails drilling anywhere from a couple hundred feet to two miles into the earth, then drilling horizontally. A fluid composed of sand, water, and chemicals is then pumped into the drill pipes. In the horizontal region of the drilling, the fluid is released at high pressure. This fluid then fractures the surrounding rock layers, releasing embedded gases, such as methane, to be collected.

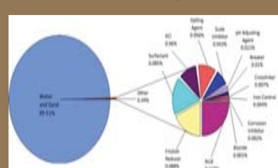
The "Fracking" Controversy in the Marcellus Shale

To date, more than 4,000 wells have been drilled in Pennsylvania on the Marcellus Shale. The wells have had enormous financial implications for the state, creating 44,000 jobs and $4 billion in revenue in 2010 alone. However, adverse environmental implications of the procedure have been well documented. A prevailing concern is the implications on human health as a result of drinking water contamination caused by the procedure.

Chemical Composition of the Fracturing Fluid Used by a Susquehanna County (Pa.) Well

Additive	Purpose	Common Usage
Hydrochloric Acid	Dissolves minerals and initiates fracturing of rock	Swimming pool cleaner
Ethylene glycol	Prevents scale deposits in the piping	Antifreeze, household cleaners
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, Sterilization of medical equipment
Quartz sand	Proppant, allows the fractures to remain open so the gas can escape	Allows the fractures to remain open so gas can escape
Citric Acid	Prevents precipitation of metal oxides	Food additive

Composition of Hydraulic Fracturing Fluid in Percent by Volume



Waste Management of Fracturing Fluid

- Ten to 40% of the fracturing fluid returns to the surface, where it is collected in a pool adjacent to the well.

- In Pennsylvania, this "flow-back fluid" produced in the Marcellus Shale can be:

  1) Reused at other drilling sites
  2) Disposed of in underground wells
  3) Transported out of state
  4) Treated at a Waste Water Plant

Marcellus Shale in the Appalachian Basin

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https://www.hydraulicfracturingdisclosure.org

http://www.nytimes.com/2011/02/27/us/27gas.html?_r=1&ref=us

Federal and Local Regulations of Water Quality

- Hydraulic fracturing is exempt from the Clean Water Act, which regulates pollutant limits in the water discharge linked to oil and gas operations.

- The procedure is held to regulations though, such as:
  1) It is unlawful to dispose of "fracking" pollutants from a point source into the water supply without a permit.
  2) The Underground Injection Control program prevents injection of liquid wastes into underground sources of drinking water.

Environmental Considerations

- The use of natural gas as a fuel source does not directly contribute carbon dioxide to the atmosphere and exhibits less of a greenhouse effect than oil or coal.

- In the past three years, hydraulic fracturing in Pennsylvania has produced 1.3 billion gallons of wastewater.
- Requires millions of gallons of water, minimum of 1,000,000 gallons for one well and that number can get as high as 7,000,000 gallons.
- Fracturing of the rock can potentially cause an appreciable amount of seismic activity.

Adverse Health Effects of Fracturing Fluid

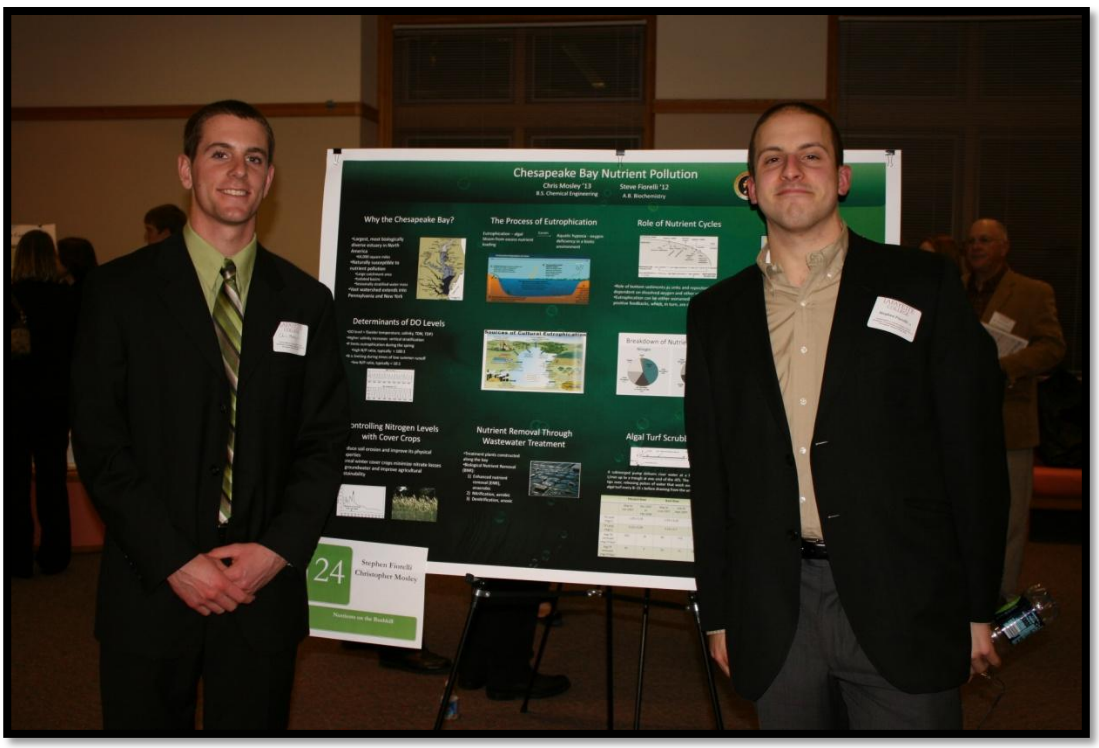
- Sewage treatment plants are unable to filter out radioactive elements and some organic compounds.
- Some component parts of fracturing fluid are known carcinogens.
- Most components of fracturing fluid cause skin or respiratory irritation
- Released methane gas could potentially navigate through crevices in the ground to the water table, contaminating the drinking water.
- Methane laced water can cause dizziness, headaches, and memory loss.

Poster #24

Nutrient Pollution in the Chesapeake Bay

Chris Mosley '13 and Stephen Fiorelli '12

For our Environmental Poster Project, we researched nutrient pollution in the Chesapeake Bay. Nutrient pollution, or Eutrophication, is a serious type of contamination that occurs in water systems across the world, involving an overabundance of key nutrients such as Nitrogen and Phosphorous compounds. These substances wash into the water from various sources and cause an overgrowth of algae that result in oxygen depletion and subsequent death of plant and animal life in the affected aquatic ecosystem. The Chesapeake Bay is particularly susceptible to nutrient pollution given its large catchment area relative to its volume of water, its numerous tributaries and isolated basins, the significant human population in the area, and the large presence of commercial agriculture in the region. Our project addresses the sources of nutrient pollution in the Chesapeake Bay, particularly those of agriculture and animal husbandry, and the dominant role of manure and fertilizers as big contributors. We explored various methods of preventing agricultural runoff such as nutrient management strategies, erosion control, and new technologies that treat polluted waters in the bay.



Chesapeake Bay Nutrient Pollution

Chris Mosley '13
B.S. Chemical Engineering

Steve Fiorelli '12
A.B. Biochemistry

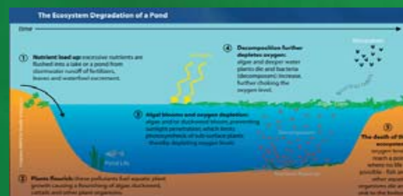
LAFAYETTE COLLEGE

Why the Chesapeake Bay?

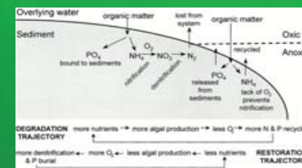
- •Largest, most biologically diverse estuary in North America
  - •64,000 square miles
- •Naturally susceptible to nutrient pollution
  - •Large catchment area
  - •Isolated basins
  - •Seasonally stratified water mass
- •Vast watershed extends into Pennsylvania and New York

The Process of Eutrophication

Eutrophication – algal bloom from excess nutrient loading —Causes→ Aquatic hypoxia - oxygen deficiency in a biotic environment

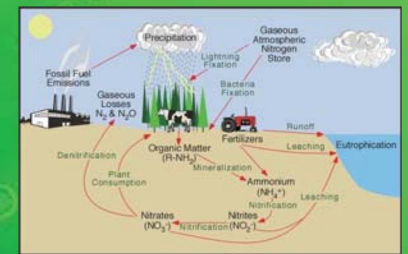


Role of Nutrient Cycles



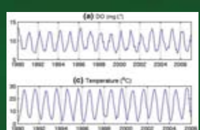
- •Role of bottom sediments as sinks and repositories is heavily dependent on dissolved oxygen and other variables
- •Eutrophication can be either worsened or mediated depending on positive feedbacks, which, in turn, are determined by conditions

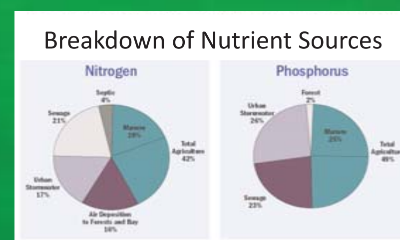
Nitrogen Cycle



Determinants of DO Levels

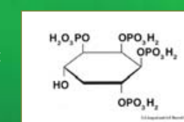
- •DO level = f(water temperature, salinity, TDN, TDP)
- •Higher salinity increases vertical stratification
- •P limits eutrophication during the spring
  - •high N/P ratio, typically > 100:1
- •N is limiting during times of low summer runoff
  - •low N/P ratio, typically < 10:1





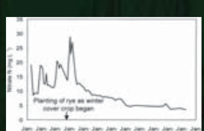
Treatment for Manure Problem

- •Reducing nutrients in manure:
  - •Addition of phytate enzyme to hog and poultry feed
  - • Switch primary cattle feed from grain to pasture
- •Alternative uses for manure:
  - •Compost
  - •Direct combustion
  - •Biomass production for co-generating electricity



Controlling Nitrogen Levels with Cover Crops

- •Reduce soil erosion and improve its physical properties
- •Cereal winter cover crops minimize nitrate losses to groundwater and improve agricultural sustainability



Nutrient Removal Through Wastewater Treatment

- •Treatment plants constructed along the bay
- •Biological Nutrient Removal (BNR):
  1) Enhanced nutrient removal (ENR), anaerobic
  2) Nitrification, aerobic
  3) Denitrification, anoxic

Algal Turf Scrubbers

A submerged pump delivers river water at a flow rate of 55 L/min up to a trough at one end of the ATS. The trough fills and tips over, releasing pulses of water that wash over the attached algal turf every 8–15 s before draining from the unit.

	Patuxent River		Bush River		Patapsco River	
	May to Oct 2007	Dec 2007 to Feb 2008	May to June 2007	July to Sept 2007	Oct to Nov 2007	Nov 2007 to April 2008
TN Level (mg/L)	1.29 ± 0.25		1.03 ± 0.20		1.05 ± 0.42	
TP Level (mg/L)	0.23 ± 0.09		0.14 ± 0.7		0.11 ± 0.09	
Avg TN removed (mg/m^2day)	250	16	85	<10	150 (max)	45 (max)
Avg TP removed (mg/m^2day)	45	3	10	<1	18 (max)	4 (max)

Implications for Humans

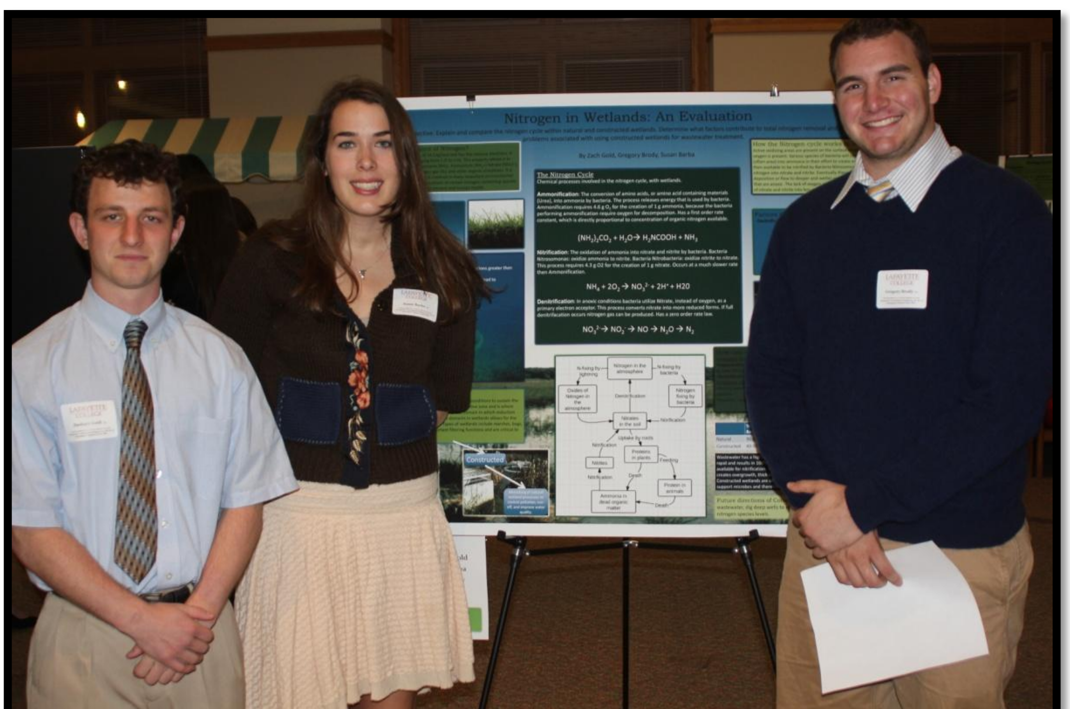
- •Adverse health effects
  - •Pathogenic organisms from algal blooms
  - •Seafood contamination
- •Significant reduction in recreational activity
  - •Beach closures, no swimming advisories
- •Fishing industry suffers
  - •Decline in blue crab population
  - •Spawning and nursing ground for striped bass at risk

Poster #25

Nitrogen and Wetlands: An Evaluation

Zach Gold '13, Greg Brody '12, and Susan Barba '12,

This project explores the importance of the nitrogen cycle within wetlands and the chemical processes that govern the cycle. A comparison of the nitrogen removal efficiencies of natural and constructed wetlands is conducted, as well as an evaluation of problems involved with the use of wetlands, both constructed and natural, in wastewater treatment. Potential improvement strategies are outlined to solve these problems. The nitrogen cycle is a crucial process. Nitrogen chemical species are abundant on Earth. Nitrogen gas is the most abundant atmospheric gas and essential for all life forms. However, excess of nitrogen species in aqueous environments can have adverse effects on both human health and the environment. Wetlands have the ability to remove nitrogen from aqueous systems through chemical transformation driven by bacteria and sequestration. The chief problem concerning the use of both constructed and natural wetlands for wastewater treatment is that anoxic wetland conditions quickly ensue following the high wastewater hydraulic loading of wetlands during wastewater treatment. This inhibits the completion of the nitrogen cycle, because to complete the nitrogen cycle oxygenated and anoxic areas must be present. Despite this problem, wetlands are an effective and affordable means of nitrogen removal.



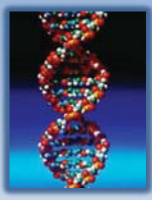
Nitrogen in Wetlands: An Evaluation

Objective: Explain and compare the nitrogen cycle within natural and constructed wetlands. Determine what factors contribute to total nitrogen removal and evaluate problems associated with using constructed wetlands for wastewater treatment.

By Zach Gold, Gregory Brody, Susan Barba

What is the importance of Nitrogen?

Nitrogen has a molecular mass of 14.11g/mol and has five valance electrons. It can have an oxidation state ranging from (-)3 to (+)5. This property allows it to exist in many forms including Ammonia (NH_3), Ammonium (NH_4+) Nitrate ($NO_3$2-), Nitrite (NO_2-), Amino acids, Nitrogen gas (N_2) and other organic complexes. It is utilized by all living organisms and is involved in many important environmental processes. However, excess concentrations of certain nitrogen containing species can have adverse effects on the environment and human health.



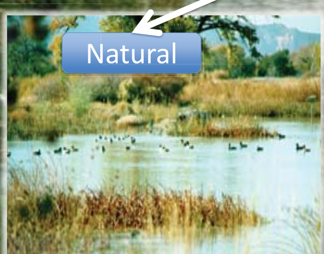
Adverse Effects:

•Ammonia is toxic to infants if present in aqueous concentrations greater then 10mg/L.
•The introduction of nitrogen species into an environment can lead to **eutrofication**.

What is a wetland?

A wetland is an ecosystem that relies on both wet and dry conditions to sustain the organisms within it. The dry domain is referred to as the active zone and is where oxidation occurs. It is typically far smaller then the wet domain in which reduction occurs. The alternating oxidation and reduction domains in wetlands allows for the cycling of many important chemical species. Types of wetlands include marshes, bogs, swamps, and estuaries. They provide important filtering functions and are critical to maintaining biodiversity.

Natural



Constructed

The Nitrogen Cycle

Chemical processes involved in the nitrogen cycle, with wetlands.

Ammonification: The conversion of amino acids, or amino acid containing materials (Urea), into ammonia by bacteria. The process releases energy that is used by bacteria. Ammonification requires 4.6 g O_2 for the creation of 1 g ammonia, because the bacteria performing ammonification require oxygen for decomposition. Has a first order rate constant, which is directly proportional to concentration of organic nitrogen available.

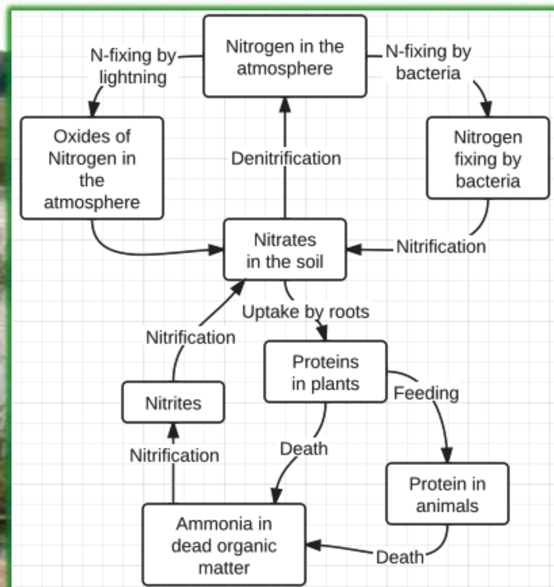
$$(NH_2)_2CO_2 + H_2O \rightarrow H_2NCOOH + NH_3$$

Nitrification: The oxidation of ammonia into nitrate and nitrite by bacteria. Bacteria Nitrosomonas: oxidize ammonia to nitrite. Bacteria Nitrobacteria: oxidize nitrite to nitrate. This process requires 4.3 g O2 for the creation of 1 g nitrate. Occurs at a much slower rate then Ammonification.

$$NH_4 + 2O_2 \rightarrow NO_3^{2-} + 2H^+ + H20$$

Denitrification: In anoxic conditions bacteria utilize Nitrate, instead of oxygen, as a primary electron acceptor. This process converts nitrate into more reduced forms. If full denitrifacation occurs nitrogen gas can be produced. Has a zero order rate law.

$$NO_3^{2-} \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$



How the Nitrogen cycle works in Wetlands?

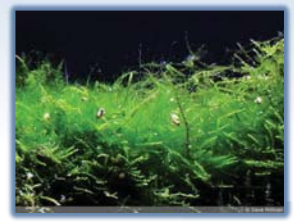
Active oxidizing areas are present on the surface of water or wherever oxygen is present. Various species of bacteria will convert decaying matter (often urea) into ammonia in their effort to create energy. This ammonia is then available to be nitrified by Bacteria Nitrosomonas which oxidize the nitrogen into nitrate and nitrite. Eventually these products are transported by deposition or flow to deeper and wetter environments in the wetland– those that are anoxic. The lack of oxygen allows denitrification to occur, conversion of nitrate and nitrite into less oxidized species, even into nitrogen gas.

Factors that effect the rate of these processes

- **Denitrification**

•*Temperature Dependence*: Positive correlation between temperature and rates of nitrification and denitrification. Latitudes 0-30° are 34% more efficient at removing nitrogen then latitudes >50°.

•*pH Dependence*: Increased acidity makes too reducing of an environment. Therefore, microorganisms that perform denitrification die.




How can wetlands remove nitrogen?

Permanent Sinks

•**Sequestration in Peaty sediments**: composed of 1-3% dry mass nitrogen, sequester 2470-7410 kg total Nitrogen/acre (change to acre and use) in upper 20-50cm of sediment.
•**Denitrification**: 75,000 megatons of N_2(g) are produced by denitrification in wetlands.

Temporary Sinks

•Rooted plants, algae and submerged rooted plants absorb 25% of nitrogen during the growing seasons.
•However, return almost all of that nitrogen to the water column when they die and decompose.

	% Nitrogen Removal
Natural	96-68%
Constructed	40-55%

Why are natural wetlands more efficient at N removal then constructed?

High hydraulic loading with wastewater decreases efficiency.

Wastewater has a high concentration of urea which sparks an immediate ammonification that is rapid and results in 100% conversion to ammonia. Oxygen is quickly depleted and therefore none is available for nitrification. Therefore much of the ammonia will exit the wetland untreated. This creates overgrowth, thick root mats that reduce storage volume of the wetland and cause pooling. Constructed wetlands are often built in habitats in which the soils are not sufficient to supply and support microbes and therefore constant replenishment of microorganisms is required.

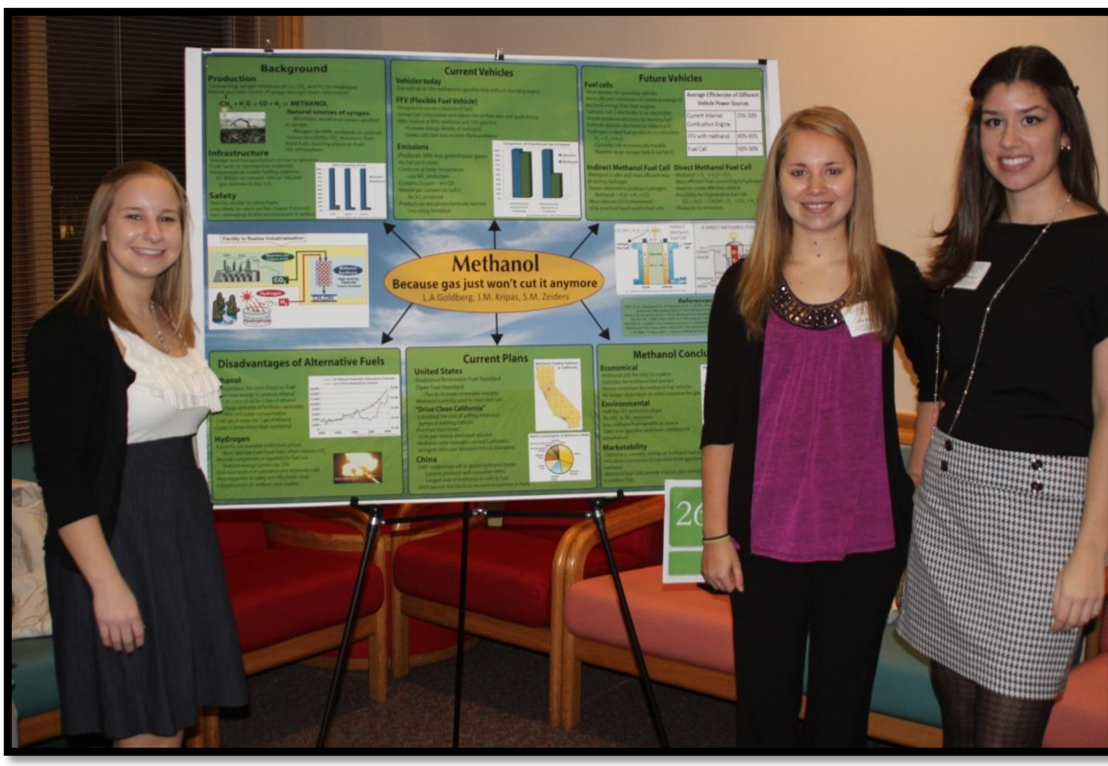
Future directions of Constructed Wetlands: microbial pre-treatment of wastewater, dig deep wells to ensure not all oxygen is depleted, monitor various nitrogen species levels.

Poster #26

Methanol: The Best Alternative Fuel

Laura Goldberg '12, Julia Kripas '15, and Samantha Zeiders '15

As gas prices rise and reserves fall, the United States is beginning to invest in alternative fuels for vehicles. Our investigation shows that methanol is the preferred alternative fuel source. We performed extensive research on methanol; from how it is produced to ways in which it can be incorporated into current and future vehicles. Methanol is easily produced from methane gas and water and requires the same infrastructure as gasoline for distribution. No additional capital investment is therefore required. Furthermore, methanol provides a smooth transition away from gasoline since it can be used in current engines, flexible fuel vehicles as well as in future fuel cells that produce zero greenhouse emissions. We investigated current plans that demand the use of alternative fuel and found that California and China have already decided to invest in methanol. After comparing methanol to its leading competitors, we determined that it is the most economical, environmental and marketable of all the alternative fuels.



Methanol

Because gas just won't cut it anymore

L.A.Goldberg, J.M. Kripas, S.M. Zeiders

Background

Production

-Converting syngas (mixture of CO, CO_2 and H_2) to methanol
Natural gas: main source of syngas through steam reformation

-$CH_4 + H_2O \rightarrow CO + H_2 \rightarrow$ METHANOL

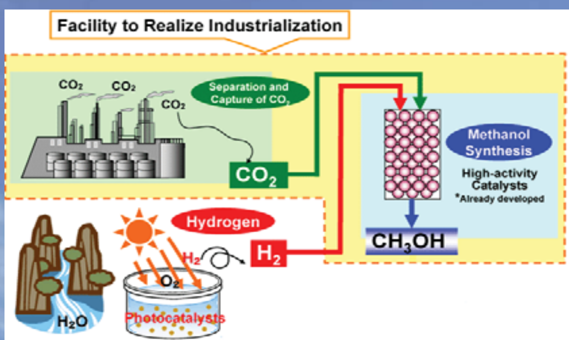
-Natural sources of syngas:
-Biomass: wood and wastes: gasified to syngas
-Biogas: landfills, wetlands, or swamps
-Future possibility: CO_2 emissions from fossil fuels, burning plants or from the atmosphere

Infrastructure

-Storage and transportation similar to gasoline
-Coat tanks in nonreactive materials
-Inexpensive to create fueling stations:
-$1 Billion to convert 10% of 180,000 gas stations in the U.S.

Safety

-Toxicity similar to other fuels
-Less likely to catch on fire (Vapor Pressure)
-Less damaging to the environment if spilled



Current Vehicles

Vehicles today

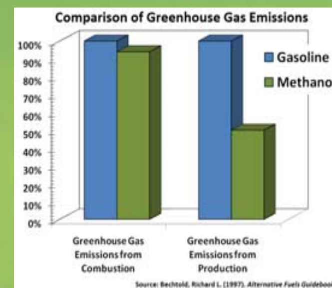
-Can add up to 15% methanol to gasoline now without changing engine

FFV (Flexible Fuel Vehicle)

-Designed to run on a mixture of fuels
-Senses fuel composition and adjusts the air/fuel ratio and spark timing
-M85: mixture of 85% methanol and 15% gasoline
-Increases energy density of methanol
-Solves cold start and invisible flame problems

Emissions

-Produces 50% less greenhouse gases
-No fuel particulates
-Combusts at lower temperature
- Less NO_x production
-Contains Oxygen = less CO
-Natural gas contains no Sulfur
- No SO_2 produced
-Products are less photochemically reactive
- Less smog formation



Future Vehicles

Fuel cells

-Ideal solution for powering vehicles
-More efficient conversion of chemical energy to electrical energy than heat engines
-Galvanic cell: 2 electrodes in an electrolyte
-Anode produces electrons by burning fuel
-Cathode absorbs electrons by reducing O_2
-Hydrogen is ideal fuel: produces no emissions
-$H_2 + O_2 \rightarrow H_2O$
-Currently not economically feasible
-Requires large storage tank in car for H_2

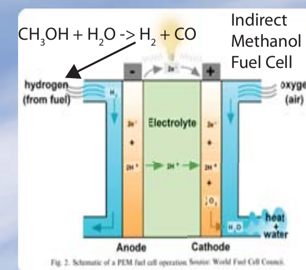
Average Efficiencies of Different Vehicle Power Sources	
Current Internal Combustion Engine	25%-30%
FFV with methanol	40%-45%
Fuel Cell	50%-60%

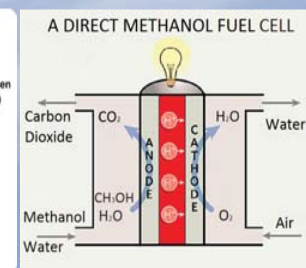
Indirect Methanol Fuel Cell

-Methanol is safer and more efficient way of storing hydrogen
-Steam reformed to produce hydrogen:
Methanol + $H_2O \rightarrow H_2 + CO$
-Must remove CO (contaminant)
-Only practical liquid used in fuel cells

Direct Methanol Fuel Cell

-Methanol + $O_2 \rightarrow H_2O + CO_2$
-More efficient than converting to hydrogen
-Need to create effective catalyst
-Possibility for regenerative fuel cell:
$CO_2 + H_2O \rightarrow CH_3OH + O_2 \rightarrow CO_2 + H_2O$
-Produces no emissions





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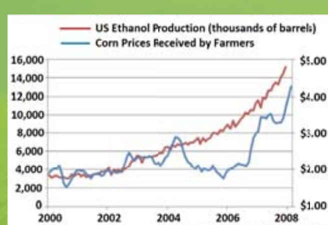
Disadvantages of Alternative Fuels

Ethanol

-Competition for corn: Food vs. Fuel
-Takes more energy to produce ethanol
-1.43 Liters of oil for 1 liter of ethanol
-Uses huge amounts of fertilizers/pesticides
- NOx and water contamination
-1700 gal of water for 1 gal of ethanol
-Costs 3 times more than methanol



Hydrogen

-Currently not available in the form of fuel:
-Must separate from fossil fuels, which releases CO_2
-Must be compressed or liquefied for fuel use
-Reduces energy content by 25%
-2nd most explosive substance and extremely cold
-Very expensive to safely and effectively store
-Infrastructure: $1 million/ new station

Current Plans

United States

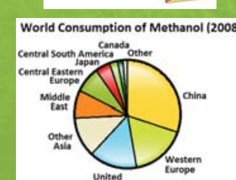
-Established Renewable Fuel Standard
-Open Fuel Standard:
-Plan to increase renewable energies
-Methanol currently used in most race cars

"Drive Clean California"

-Subsidized the cost of adding methanol pumps at existing stations
-Purchase incentives:
- $500-per-vehicle methanol voucher
-Methanol auto emissions exceed California's stringent Ultra Low Emission Vehicle Standards

China

-2007: established self as global methanol leader
-Largest producer and consumer (40%)
-Largest user of methanol as vehicle fuel
-2009: passed standards to increase proportion in fuels



Methanol Conclusions

Economical

-Methanol sells for only $2 a gallon
-Subsidies for methanol fuel pumps
-Money incentives for methanol fuel vehicles
-No longer dependent on other countries for gas

Price Comparison of Different Fuels ($/gal in 2010 before tax and distribution)	
Reformulated Gasoline	$2.13
Methyl Tertiary Butyl Ether	$2.44
n-Butane	$1.56
Ethanol	$1.52
Methanol	$0.88

http://alfin2300.blogspot.com/2011_07_01_archive.html

Environmental

-Half the CO_2 emissions of gas
-No NO_x or SO_2 emissions
-Use methane from landfills as source
-Safer than gasoline and lower combustion temperature

Marketability

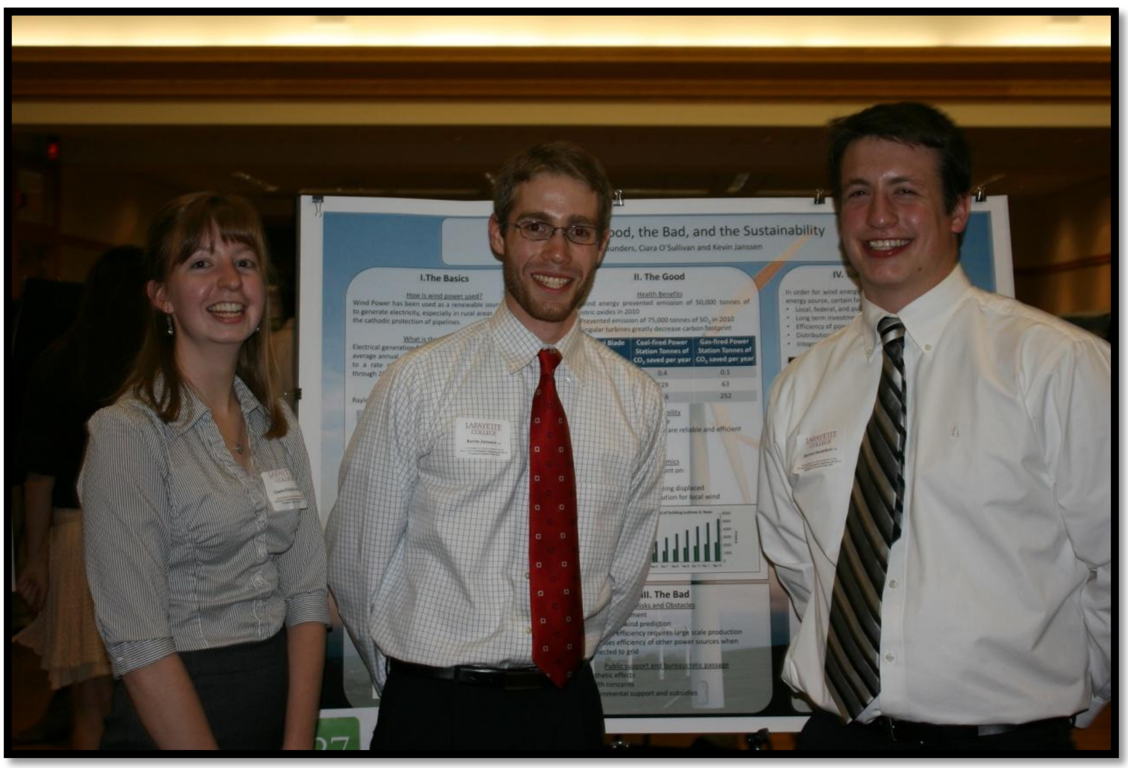
-California is currently setting up methanol fuel pumps
-FFV allows consumers to transition from gasoline to methanol
-Methanol Fuel Cells provide a future, zero emission way to produce fuel

Poster #27

Wind Power: The Good, the Bad, and the Sustainability

Steven Saunders '12, Ciara O'Sullivan '12, and Kevin Janssen '12

Our research on wind power aimed to consider several factors in order to fully examine the usefulness of wind energy, such as the cost-effectiveness, environmental effects, energy output, and the basic function of a wind turbine. Our analysis compared the positives and negatives of this sustainable energy to determine a realistic role for wind power in the future. We also considered the efficacy of a reliance on wind as a sustainable energy option for future and current societies, since it provides benefits that other sources of energy cannot, such as its ability to be a stand-alone power unit to give electricity to remote sites. Continued research and technological development, such as urban construction that utilizes integrated wind turbines, is necessary to continue the growth of wind power as a major energy source.



Wind Power: The Good, the Bad, and the Sustainability

With Steven Saunders, Ciara O'Sullivan and Kevin Janssen

I.The Basics

How is wind power used?

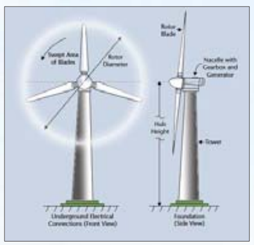
Wind Power has been used as a renewable source of energy to generate electricity, especially in rural areas, as well as for the cathodic protection of pipelines.

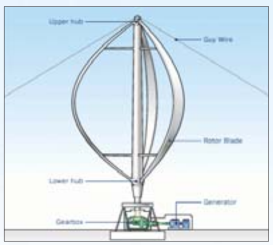
What is the rate of growth?

Electrical generation from wind power has increased from an average annual growth rate of 32% from 2004 through 2008 to a rate of 39% from 2005 through 2009. From 1999 through 2009, wind energy generated has grown 1,300%.

How is wind measured?

Rayleigh speed distribution for wind: $P_{turb} = C_p 1/2 \rho A v^3$

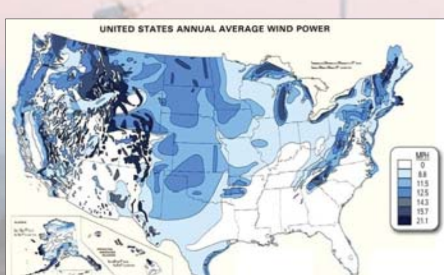




Horizontal Blade Diameter (m)	Annual Energy (kWh)	Standard Home at 4000 kWh/a (no. of homes)
1	374	0.09
5	9350	2
15	84,153	21
25	233,758	58
50	935,032	234

Where is wind power most effective?

Remote places where the average wind speed is above 4 m/s produce power at less cost than gas or diesel generation.



II. The Good

Health Benefits

- Wind energy prevented emission of 50,000 tonnes of nitric oxides in 2010
- Prevented emission of 75,000 tonnes of SO_2 in 2010
- Singular turbines greatly decrease carbon footprint

Horizontal Blade Diameter (m)	Coal-fired Power Station Tonnes of CO_2 saved per year	Gas-fired Power Station Tonnes of CO_2 saved per year
1	0.4	0.1
25	229	63
50	916	252

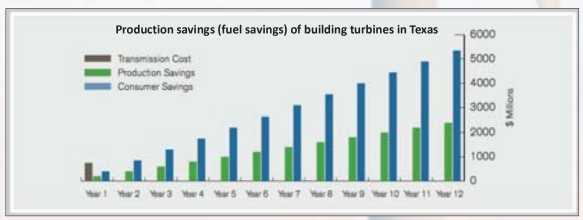
Accessibility

- Wind is a renewable resource
- The turbines and generators are reliable and efficient
- Variety in project magnitude
- Brings power to rural areas

Economics

Long term investment dependent on:

- size of turbine
- conventional generation being displaced
- The Rayleigh speed distribution for local wind



III. The Bad

Risks and Obstacles

- Terrain development
- Variability in wind prediction
- Maximum efficiency requires large scale production
- Decreases efficiency of other power sources when connected to grid

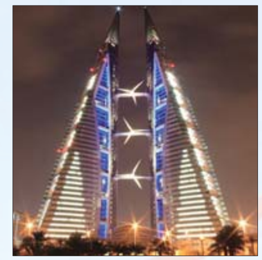
Public support and bureaucratic passage

- Aesthetic effects
- Health concerns
- Governmental support and subsidies

IV. The Sustainability

In order for wind energy to become a viable and sustainable energy source, certain factors need to be considered:

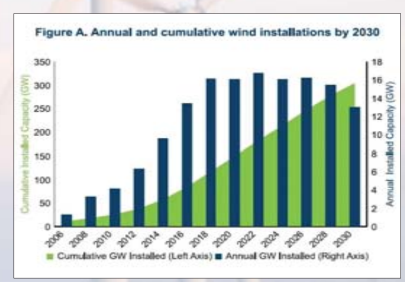
- Local, federal, and public support of projects
- Long term investment contingency
- Efficiency of power storage and transmission
- Distribution of wind power integration
- Integration into high energy urban areas



V. Conclusions

Wind energy should continue to be an expanding area of renewable energy research because:

- Wind power can be brought to remote third world areas due to the high efficiency and low upkeep
- Decreases in pollutants from other energy sources, leading to local health benefits
- Implementation in urban environments can directly support high energy areas



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Poster #28

Economic Benefits of Solar Hot Water on Lafayette Campus

Sebastian Orillac '13, Sang Woo Lee '13, and Matt Schrader '13

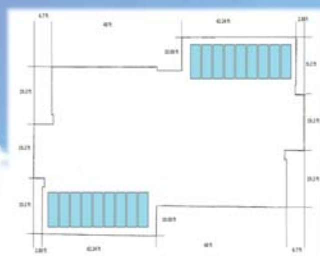
We investigated the economic feasibility of installing a solar thermal water heating system on one of the buildings on Lafayette's Campus. Solar thermal is used to heat water using the Sun's energy. There are two types of solar thermal collectors, flat panel and evacuated tubes. Flat panel collectors were used in this study because of they are less expensive (though they are also less efficient). Farber Hall was chosen as the building for the study. Using solar thermal specifications from a certified solar thermal installer we determined the requirements for Farber Hall. We also found the cost of energy currently being used to heat water in Farber Hall from Plant Operations. Using that information, we calculated that it would take 117 years for total cost of installation and maintenance of solar thermal to be cost beneficial. Despite its environmental benefits installing solar thermal is not feasible on Lafayette's campus.

Economic Benefits of Solar Hot Water on Lafayette Campus

By Sebastian Orillac, Sang Woo Lee, and Matt Schrader

Introduction:

The mechanics behind different types of solar thermal will be explained along with feasibility of installing the system onto one of the building on Lafayette campus. The extent of economic benefits and possible energy savings will also be discussed.



Farber Hall *Dimensions of Farber Hall*

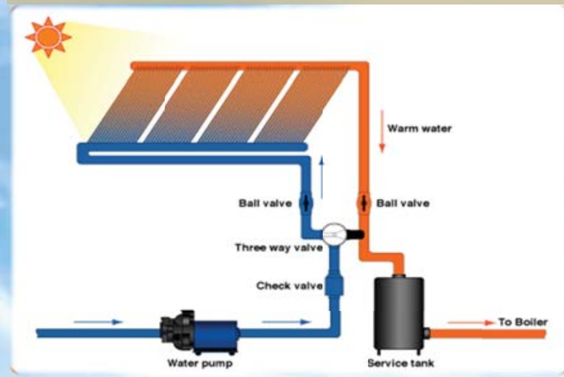
Solar Thermal Specifications and Costs

Requirements/Costs according to Solar Hot Water (a certified solar thermal installation company)	Requirements/ Costs applied to Farber Hall
20 gallons of water storage for the first two people in a building and 15 for the rest	910 gallons of water storage
0.75 square feet of solar thermal panels per gallon on water	682.5 square feet of panels
$2700 per 100 gallons of storage	$24,570 for water storage
$1000 for one 4' X 10' panel	$18,000 for (18) panels

Sizing Panels for Farber

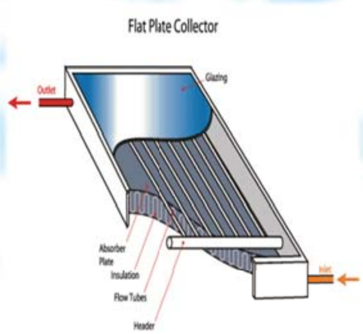
- •682.5 square feet of panels required to heat water for Farber
- •According to our calculations the roof of Farber hall is 5,538 square feet
- •18, 4 ft X 10 ft panels would suffice for Farber
- •There is easily room for these panels as seen by blue boxes

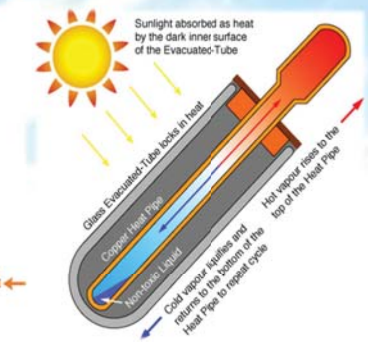
What is Solar Thermal?



Solar thermal is based on effectively heating water by transforming solar energy into thermal energy, and storing the heated water until it is used. The scale of the system depends on its application.

Evacuated Tubes vs. Flat Panel





Evacuated Tubes make use of vacuum between two layers of glass and minimizes convection and conduction heat losses.

Unlike evacuated tubes, flat panels radiates heat. It is more common of the two types. Flat Panels are less costly and less effective compared to evacuated tubes.

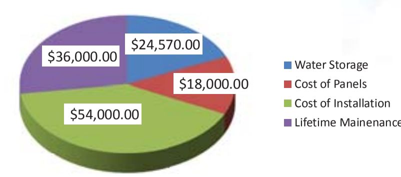
Energy Used Now

Plant operations does not separate general building heating from heating water. To estimate the cost of heating water over the course of the year we selected a month with high student usage and low heating needs: September. The cost of gas for the month of September was $70.60. Using this number the estimated spent on heating water over the entire year is $847.20.

Total Cost

- •$24,570 for storage of water
- •$18,000 for panels
- •$54,000 for installation ($3,000 per panel), work permits, 3 year guarantee
- •Initial Cost $96,570
- •35% Government Tax Rebate: -$33,799
- •**Total Initial Cost: $62,770**
- •Approximate Lifetime maintenance cost of $2,000 per panel (such as new fluid for panel), total $36,000
- •Approximately $847.20 was spent on water last year for Farber Hall
- •Would take under 117 years to be cost beneficial

Total Cost of Solar Thermal Over Lifetime



Conclusions

Though solar energy decreases carbon emissions and is beneficial to the environment, it is not economically feasible to transform a single building here at Lafayette College. With the heating infrastructure set up here at Lafayette water heating is not extremely expensive. Even with government subsidies, by our calculations, solar thermal at Lafayette will take over a century to break even. Considering the expected lifetime of a solar panel is approximately 35 years we would not come close to recouping the cost. However it might be more reasonable to have solar thermal on an off campus apartment that is not apart of the Lafayette heating infrastructure and also would not require such a large investment.

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Photo Gallery


afayette College Engineering Brain Bowl
There's No Planet B
Sustainability Through Engineering Applications
Lafayette College
Acopian Engineering Center
November 12, 2011

Production Team

Design By: Rebecca Citrin

Photography By: Hannah Greisbach

Review By: Rebecca Citrin and Laura Spadaccini

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