Water Challenges in the 21st Century: Local to Global

13th Annual Multidisciplinary Environmental Poster Session

December 8, 2016 | 7-9 p.m.
Farinon College Center (1st and 2nd Floors)

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Event Summary

The 2016 Environmental Poster Presentation was the culmination of a semester long assignment in which students worked in multi-disciplinary teams to research topics related to Water Challenges. As our global population grows, the demand for water will greatly increase as will the environmental impacts on waterways throughout the world. The impacts will play out through water availability and quality and from the growing stress due to climate change, energy scarcity, land use decisions, and the requirements of industry and minerals processing. Therefore, managing our water assets is one of the most pressing global issues of the 21st century. These challenges must be met from both local and global perspectives as we consider better ways to manage our assets to better serve our growing populations as well as preserve the environmental integrity of our systems for future generations. It is based on these ideas we chose our 2016 theme: *Water Challenges in the 21st Century: Local to Global.*

Each poster team included two or three students with at least two different disciplinary perspectives represented. Participating classes and instructors for this event were: CE 321: Environmental Engineering and Science, Professor Arthur Kney; CHEM 252: Environmental Chemistry, Professor Melissa Galloway; ECON 202: Environmental Economics, Professor James DeVault; EVST 100: Intro to the Environment Professor Andrea Armstrong; and GOVT 231: Global Environmental Politics, Professor Katalin Fabian.

Participants gained valuable knowledge through literature-based investigation as well as direct experimental research where feasible. At the outset, students assembled into teams, organized topics, delved into background information, designed investigations, defended draft versions, critiqued one another, self-assessed their efforts and ultimately crafted their final poster. The opportunity to present their findings in a public, adjudicated forum occurred on Thursday, December 8, 2016 at the Farinon Student Center. From 7:00 to 9:00 pm, 43 posters dominated the atrium and the Marlo room to showcase the efforts of more than 128 students judged by 81 professionals and community members. Each poster was subjected to extensive evaluation by multiple judges assessing criteria that included presentation, organization, professionalism, aesthetics, authoritative command of the subject matter and rigor. As in previous years, prizes were awarded to the top-scoring posters. In addition, students enrolled in multiple participating courses assumed responsibility for the mechanics of hosting the conference, working with College staff to mobilize volunteers, design publicity materials, manage the session set-up and coordinate the array of judges. These student leaders deserve recognition for helping to pull off all of the details for this public event.

This event would not have been possible without our judges, who hailed not only from the Lehigh Valley, but from New York, New Jersey, Philadelphia, and Harrisburg. By participating, our judges raised expectations and enhanced the caliber of the Poster Presentation, thereby strengthening the educational experience. Students were motivated to develop life-long independent and collaborative skills—in critical thinking, in multidisciplinary approaches, in professional conduct—and in communication skills. Students and judges alike conveyed how much they learned from one another at the event. To our judges—thank you from the entire Leadership Team.

If you would like more information about the Environmental Poster Presentation or these courses, please contact Dr. James DeVault at devaultj@lafayette.edu, Dr. Arthur Kney at kneya@lafayette.edu, or Kimberly Rodriguez at rodrikim@lafayette.edu.

Awards

1st place

Poster #28
Case Studies in Environmental Justice: Violations of the Clean Water Act
Casey Banta-Ryan, Grace Housman, and Chris Melka

2nd place

Poster #35
Dam Removal on the Bushkill Creek
Katie Millar, Emily Moore, and Morgan Nobles

Honorable mention

Poster #2
Microplastic Pollution: From the Great Lakes to the St. Lawrence Seaway
Justine Perrotti, Lisa Salomon, and Caroline Shaffer

Poster #8
What's in Your Water?: A Comprehensive Study of Lafayette College's Drinking Water from Plant to Fountain
Thomas Beier, Jonathan Maschio, and Brian Pinke

Poster #41
The Untapped Potential of America's Wastewater Treatment Plants
Devon Cantrel, Olli Fosu, and Christopher Gallo

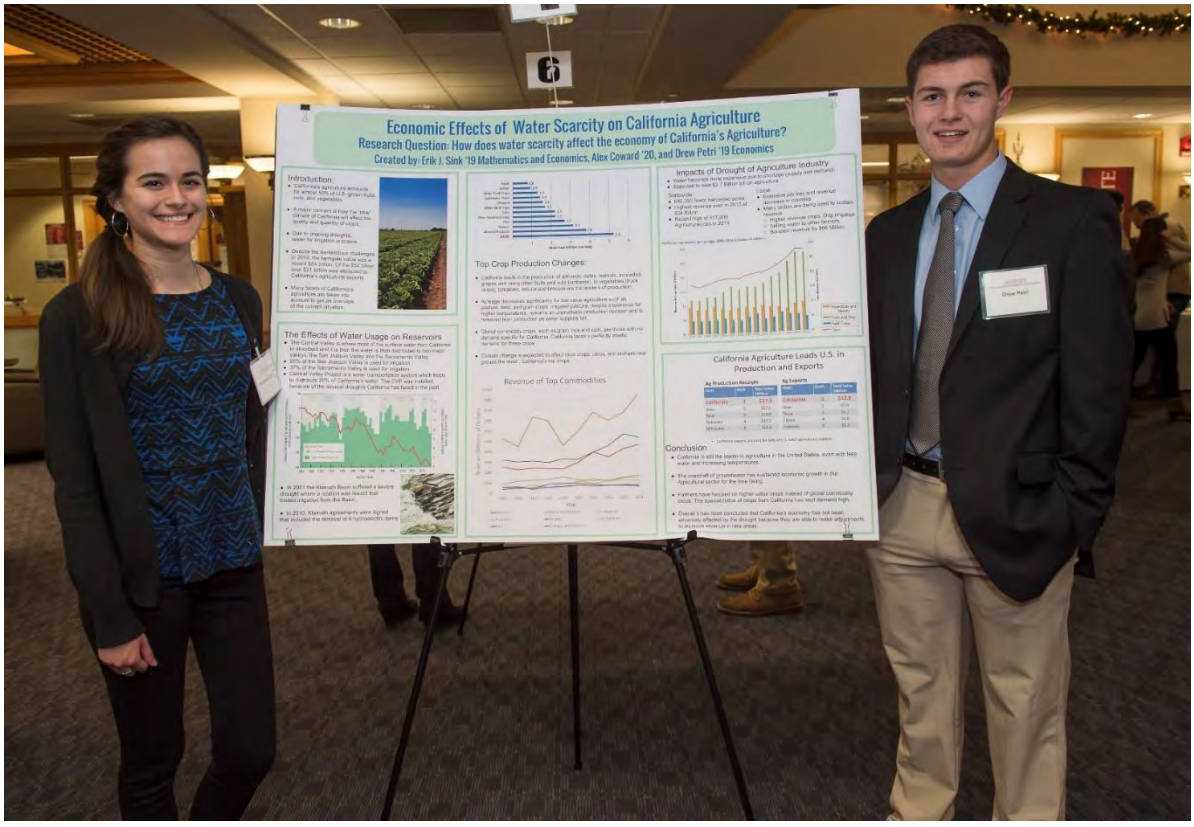
Poster Summaries and Pictures

Poster #1

Economic Effects of Water Scarcity on California Agriculture

Alexandria Coward, Drew Petri, and Erik Sink

Our poster seeks to reveal some of the effects recent droughts have had on the economy of California's agricultural sector. We first took a look at California's water sources and how the depletion of these areas affects the agricultural output. The water sources we focused on were the Central Valley, the San Joaquin Valley, the Sacramento Valley, and the Klamath Basin. We analyzed how much water is taken out of these reservoirs and how quickly the groundwater storage recharged. Then we analyzed how the state uses water efficiently and how the government plans to preserve water for the future. The second section focused on California's top crops, the revenue gained for these crops, and how resilient these crops are to climate change i.e. how resilient are they to changes in water availability. These crops included alfalfa, citrus, orchard crops (tree nuts), and pastures. The third section provides information on the economic impact of recent droughts in California. Data is provided regarding changes in output and revenue as a result of these droughts. Trends in the price of water are analyzed. Finally, agricultural jobs in California are also evaluated to include changes in productivity in the economy. A conclusion is then made on the current state of California's economy based on all the above questions.



Economic Effects of Water Scarcity on California Agriculture

Research Question: How does water scarcity affect the economy of California's Agriculture?

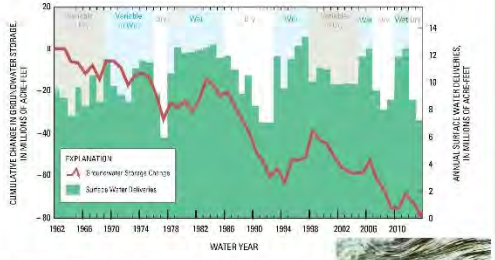
Created by: Erik J. Sink '19 Mathematics and Economics, Alex Coward '20, and Drew Petri '19 Economics

Introduction:

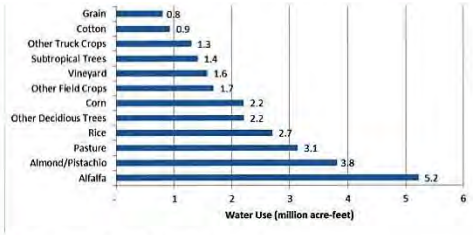
- California's agriculture accounts for almost 50% of U.S.-grown fruits, nuts, and vegetables.
- A major concern is how the "new" climate of California will affect the quality and quantity of crops.
- Due to ongoing droughts, water for irrigation is scarce.
- Despite the tremendous challenges in 2014, the farmgate value was a record $54 billion. Of the $54 billion, over $21 billion was attributed to California's agricultural exports
- Many facets of California's agriculture are taken into account to get an overview of the current situation.

The Effects of Water Usage on Reservoirs

- The Central Valley is where most of the surface water from California is absorbed and it is then the water is then distributed to two major valleys, the San Joaquin Valley and the Sacramento Valley
- 95% of the San Joaquin Valley is used for irrigation
- 37% of the Sacramento Valley is used for irrigation
- Central Valley Project is a water transportation system which helps to distribute 20% of California's water. The CVP was installed because of the several droughts California has faced in the past.

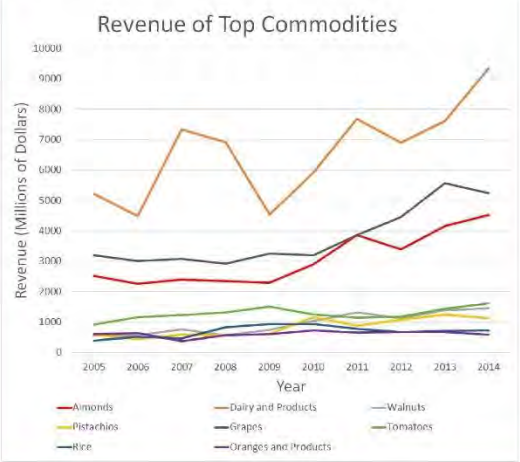


- In 2001 the Klamath Basin suffered a severe drought where a rotation was issued that limited irrigation from the Basin.
- In 2010, Klamath agreements were signed that included the removal of 4 hydroelectric dams



Top Crop Production Changes:

- California leads in the production of almonds, dates, walnuts, avocados, grapes and many other fruits and nuts (orchards). In vegetables (truck crops), tomatoes, lettuce and broccoli are the leaders of production.
- Acreage decreases significantly for low value agriculture such as pasture, field, and grain crops. Irrigated pasture, despite a tolerance for higher temperatures, remains an unprofitable production decision and is removed from production as water supplies fall.
- Global commodity crops, such as grain, rice and corn, are those with no demand specific for California. California faces a perfectly elastic demand for these crops.
- Climate change is expected to affect truck crops, citrus, and orchard crop groups the most , California's top crops.



Impacts of Drought of Agriculture Industry

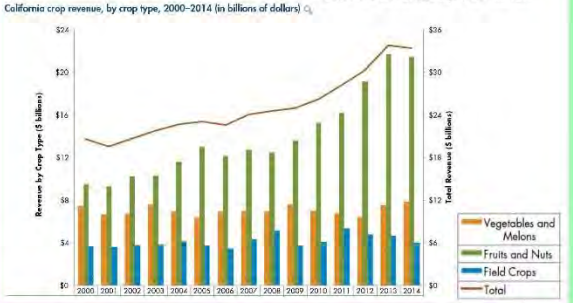
- Water becomes more expensive due to shortage (supply and demand)
- Expected to take $2.7 Billion toll on agriculture

Statewide:

- 640,000 fewer harvested acres
- Highest revenue ever in 2013 at $34 Billion
- Record high of 417,000 Agricultural jobs in 2014

Local:

- Extensive job loss and revenue decrease in counties
- Many tactics are being used to sustain revenue
  - Higher revenue crops, Drip irrigation
  - Selling water to other farmers
  - Boosted revenue by $66 Million



California Agriculture Leads U.S. in Production and Exports

Ag Production Receipts

State	Rank	Total Value $Billion
California	1	$37.5
Iowa	2	$23.2
Texas	3	$19.9
Nebraska	4	$17.3
Minnesota	5	$15.1

Ag Exports

State	Rank	Total Value $Billion
California	1	$12.8
Iowa	2	$7.0
Texas	3	$6.1
Illinois	4	$5.8
Nebraska	5	$5.3

- California exports account for 14% of U.S. total agricultural exports

Conclusion

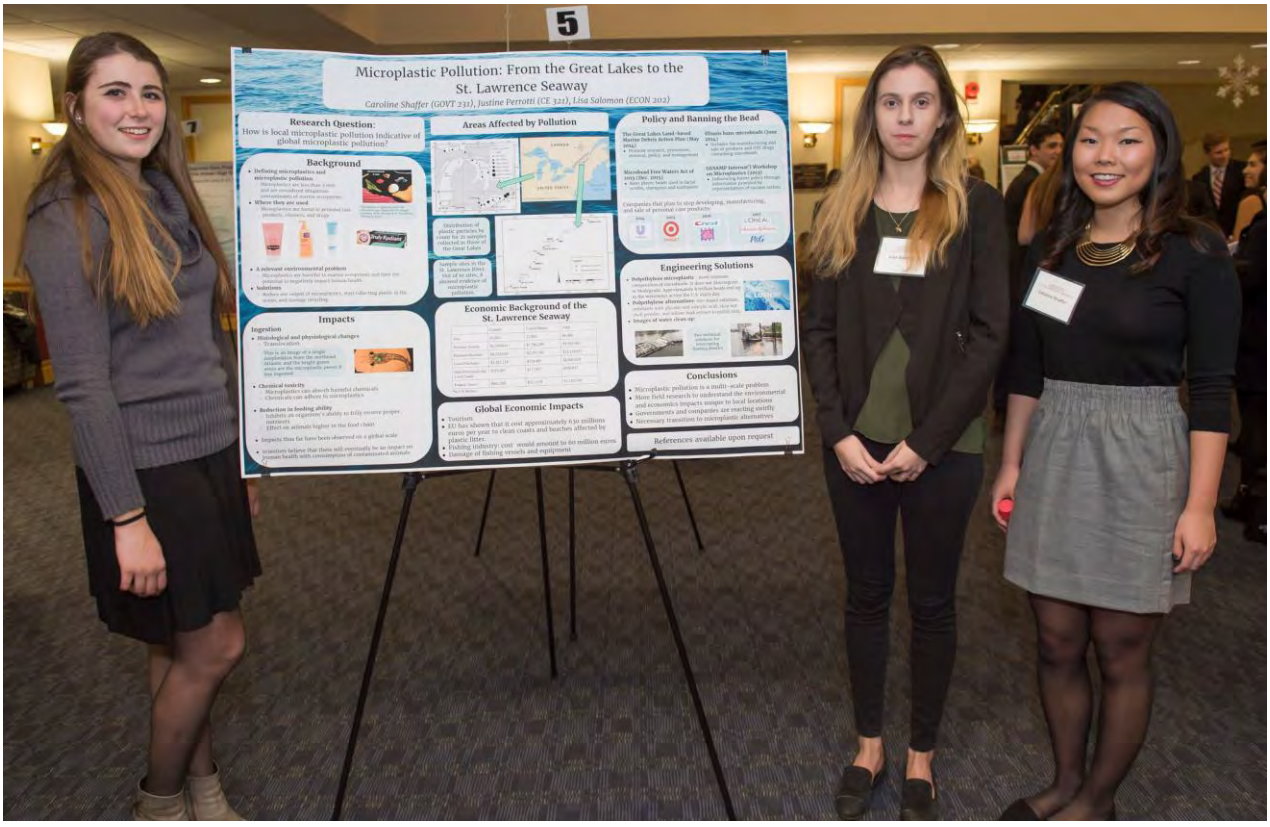
- California is still the leader in agriculture in the United States, even with less water and increasing temperatures.
- The overdraft of groundwater has sustained economic growth in the Agricultural sector for the time being.
- Farmers have focused on higher-value crops instead of global commodity crops. The specialization of crops from California has kept demand high.
- Overall it has been concluded that California's economy has not been adversely affected by the drought because they are able to make adjustments to increase revenue in new areas.

Poster #2

Microplastic Pollution: From the Great Lakes to the St. Lawrence Seaway

Justine Perrotti, Lisa Salomon, and Caroline Shaffer

The purpose of our poster is to study how local microplastic pollution may be indicative of global microplastic pollution. We specifically looked at the Great Lakes and the St. Lawrence Seaway because it is an international body of water which has been observed to have the world's most contaminated marine sediment because of the concentrations of microplastic. Microplastic pollution poses an environmental problem because the microplastics infiltrate and disrupt marine ecosystems and the marine biota. There have already been observed negative impacts of microplastic pollution with wildlife on a global scale due to chemical contamination. From an economic standpoint, microplastic pollution is very costly. Globally, it affects tourism due to the cleaning of coasts and beaches, tourism being one of the biggest industries for revenue. It also affects the fishing industry and damages fishing vessels as well as equipment. Many states have set policies to ban microbeads—a common form of microplastic—particularly around the Great Lakes. There are also national policies created to mitigate microplastic pollution across the globe. Many companies that manufacture products with microbeads have banned or have a goal to ban them in future years. In order to fix this problem we need to reduce our output of microplastics by making cosmetics with more eco-friendly materials and start collecting plastic in the ocean before the break down. Overall, our research has shown us that this is a growing problem that can and needs to be addressed through more field research, stricter policies, and focusing on microplastic alternatives.



Microplastic Pollution: From the Great Lakes to the St. Lawrence Seaway

Caroline Shaffer (GOVT 231), Justine Perrotti (CE 321), Lisa Salomon (ECON 202)

Research Question:

How is local microplastic pollution indicative of global microplastic pollution?

Background

- **Defining microplastics and microplastic pollution**
  - Microplastics are less than 5 mm and are considered ubiquitous contaminants of marine ecosystems
- **Where they are used**
  - Microplastics are found in personal care products, cleaners, and drugs

Microplastic fragments from the shoreline near Plymouth UK (Image courtesy of M. Browne & R. Thompson, Plymouth Univ.)

- **A relevant environmental problem**
  - Microplastics are harmful to marine ecosystems and have the potential to negatively impact human health
- **Solutions**
  - Reduce our output of microplastics, start collecting plastic in the ocean, and manage recycling

Impacts

Ingestion

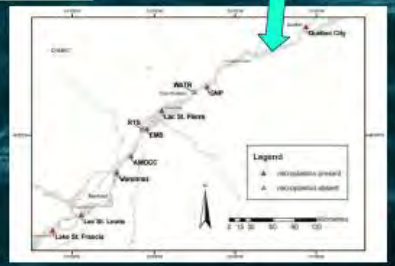
- **Histological and physiological changes**
  - Translocation

This is an image of a single zooplankton from the northeast Atlantic and the bright green areas are the microplastic pieces it has ingested.

- **Chemical toxicity**
  - Microplastics can absorb harmful chemicals
  - Chemicals can adhere to microplastics
- **Reduction in feeding ability**
  - Inhibits an organism's ability to fully receive proper nutrients
  - Effect on animals higher in the food chain
- Impacts thus far have been observed on a global scale
- Scientists believe that there will eventually be an impact on human health with consumption of contaminated animals

Areas Affected by Pollution

Distribution of plastic particles by count for 21 samples collected in three of the Great Lakes



Sample sites in the St. Lawrence River. Out of 10 sites, 8 showed evidence of microplastic pollution.

Economic Background of the St. Lawrence Seaway

	Canada	United States	Total
Jobs	63,041	22,965	86,006
Personal Income	$2,798,643	$1,786,299	$4,585,942
Business Revenue	$9,522,050	$2,797,763	$12,319,813
Local Purchases	$2,321,135	$524,495	$2,845,629
State/Provincial and Local Taxes	$323,447	$177,427	$500,873
Federal Taxes	$862,260	$321,534	$1,183,794

*in US Dollars

Global Economic Impacts

- Tourism
- EU has shown that it cost approximately 630 millions euros per year to clean coasts and beaches affected by plastic litter.
- Fishing industry: cost would amount to 60 million euros
- Damage of fishing vessels and equipment

Policy and Banning the Bead

The Great Lakes Land-based Marine Debris Action Plan (May 2014)
- Promote research, prevention, removal, policy, and management

Illinois bans microbeads (June 2014)
- Includes the manufacturing and sale of products and OTC drugs containing microbeads

Microbead Free Waters Act of 2015 (Dec. 2015)
- Bans plastic beads used in facial scrubs, shampoos and toothpaste

GESAMP Internat'l Workshop on Microplastics (2013)
- Influencing future policy through information provided by representatives of various sectors

Companies that plan to stop developing, manufacturing, and sale of personal care products:

2014 Unilever | 2015 Target | 2016 Crest | 2017 L'Oréal, Johnson & Johnson, P&G

Engineering Solutions

- **Polyethylene microplastic** - most common composition of microbeads. It does not disintegrate or biodegrade. Approximately 8 trillion beads end up in the waterways across the U.S. every day.
- **Polyethylene alternatives**: rice-based exfoliant, exfoliants with glycolic and salicylic acid, shea nut shell powder, and willow bark extract to polish skin.
- **Images of water clean up:**

Two technical solutions for intercepting floating plastics

Conclusions

- Microplastic pollution is a multi-scale problem
- More field research to understand the environmental and economics impacts unique to local locations
- Governments and companies are reacting swiftly
- Necessary transition to microplastic alternatives

References available upon request

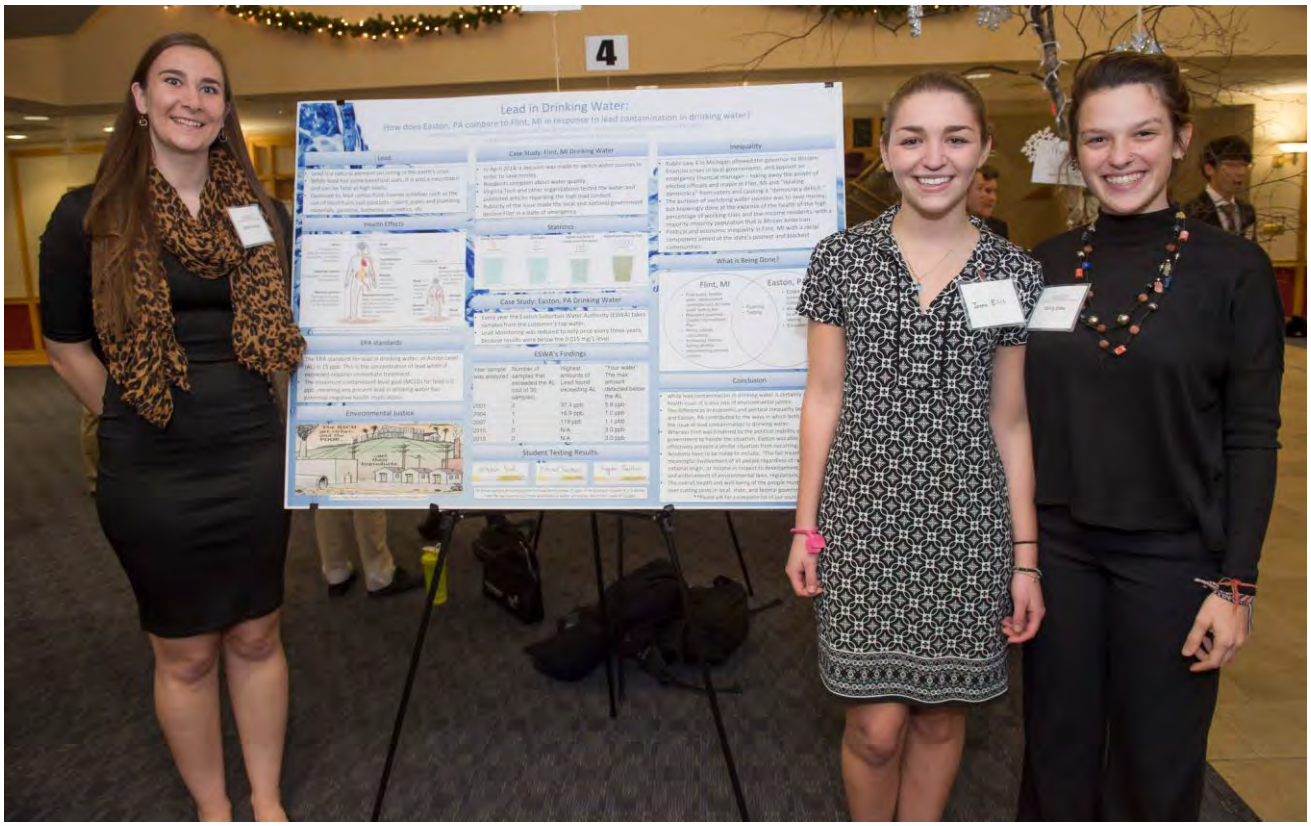
Poster #3

Lead in Drinking Water: How does Easton, PA compare to Flint, MI in response to lead contamination in drinking water?

Jenna Ellis, Ellen Graham, and Emily Saba

Recently Flint, Michigan has been in the news due to the discovery of severe lead contamination in the city's water supply. This shocking discovery prompted our group to research the implications and presence of lead contaminated water in both Easton, PA and Flint, MI. We researched and tested Easton's water for contamination, and compared it to the water contamination data of Flint, Michigan. Lead is a neurotoxin found in the earth's crust that can be fatal at high levels. The most common way for lead to enter drinking water is through contact with the lead pipes that carry the water to faucets in older structures. The consumption of lead can lead to a variety of adverse health effects and it is extremely dangerous for children. The EPA standards allow minimal amounts of lead in the drinking water, although any level of lead in drinking water is detrimental to health.

We also analyzed the political, socioeconomic, and health implications of the contaminated water in Flint, MI. In the United States, local governments are responsible for providing services such as clean drinking water. But in the case of Flint, the city council ignored these responsibilities resulting in an issue of environmental justice, affecting the lower-class citizens of the city. We used Easton, PA as a means of comparison to analyze the different responses that city governments take when faced with the problem of lead in drinking water. This poster depicts our research regarding this juxtaposition.



Lead in Drinking Water:

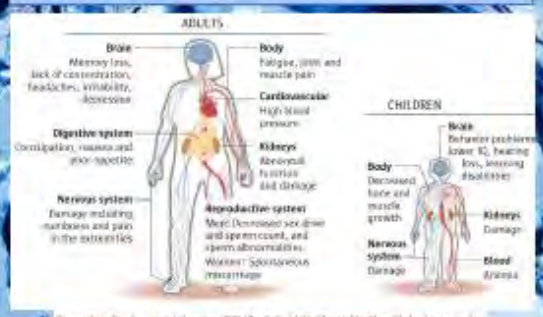
How does Easton, PA compare to Flint, MI in response to lead contamination in drinking water?

Emily Sabia '19 Environmental Economics (ECON 202), Jenna Ellis '19 Environmental Economics (ECON 202), and Ellen Graham '18 Global Environmental Politics (GOVT 233)

Lead

- Lead is a natural element occurring in the earth's crust.
- While lead has some beneficial uses, it is also a neurotoxin and can be fatal at high levels.
- Exposure to lead comes from human activities such as the use of fossil fuels and products – paint, pipes and plumbing materials, gasoline, batteries, cosmetics, etc.

Health Effects



EPA standards

- The EPA standard for lead in drinking water, or Action Level (AL) is 15 ppb. This is the concentration of lead which if exceeded requires immediate treatment.
- The maximum contaminant level goal (MCLG) for lead is 0 ppb, meaning any present lead in drinking water has potential negative health implications.

Environmental Justice

Case Study: Flint, MI Drinking Water

- In April 2014, a decision was made to switch water sources in order to save money.
- Residents complain about water quality.
- Virginia Tech and other organizations tested the water and published articles regarding the high lead content.
- Publicity of the issue made the local and national government declare Flint in a state of emergency.

Statistics

Case Study: Easton, PA Drinking Water

- Every year the Easton Suburban Water Authority (ESWA) takes samples from the customer's tap water.
- Lead Monitoring was reduced to only once every three years, because results were below the 0.015 mg/L level.

ESWA's Findings

Year sample was analyzed	Number of samples that exceeded the AL (out of 30 samples)	Highest amounts of Lead found exceeding AL	"Your water" The max amount detected below the AL
2001	2	37.4 ppb	5.8 ppb
2004	1	18.9 ppb	1.0 ppb
2007	1	119 ppb	1.1 pbb
2010	0	N/A	3.0 ppb
2013	0	N/A	3.0 ppb

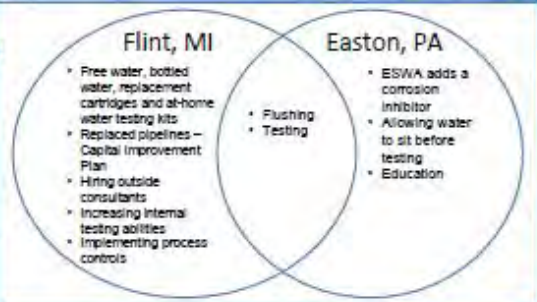
Student Testing Results

All three samples tested negative for lead levels above 15 ppb. If the blue bar closest to 1 is darker than the bar closest to 2, then lead levels in water are below the Action Level of 15 ppb.

Inequality

- Public Law 4 in Michigan allowed the governor to declare financial crises in local governments, and appoint an emergency financial manager – taking away the power of elected officials and mayor in Flint, MI and "stealing democracy" from voters and causing a "democracy deficit."
- The purpose of switching water sources was to save money, but knowingly done at the expense of the health of the high percentage of working-class and low-income residents, with a majority-minority population that is African American.
- Political and economic inequality in Flint, MI with a racial component aimed at the state's poorest and blackest communities.

What is Being Done?



Conclusion

- While lead contamination in drinking water is certainly a significant health issue, it is also one of environmental justice.
- The differences in economic and political inequality between Flint, MI and Easton, PA contributed to the ways in which both cities addressed the issue of lead contamination in drinking water.
- Whereas Flint was hindered by the political inability of the city government to handle the situation, Easton was able to quickly and effectively prevent a similar situation from occurring.
- Solutions have to be made to include, "The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in respect to development, implementation, and enforcement of environmental laws, regulations, and policies."
- The overall health and well-being of the people must take precedence over cutting costs in local, state, and federal governments.

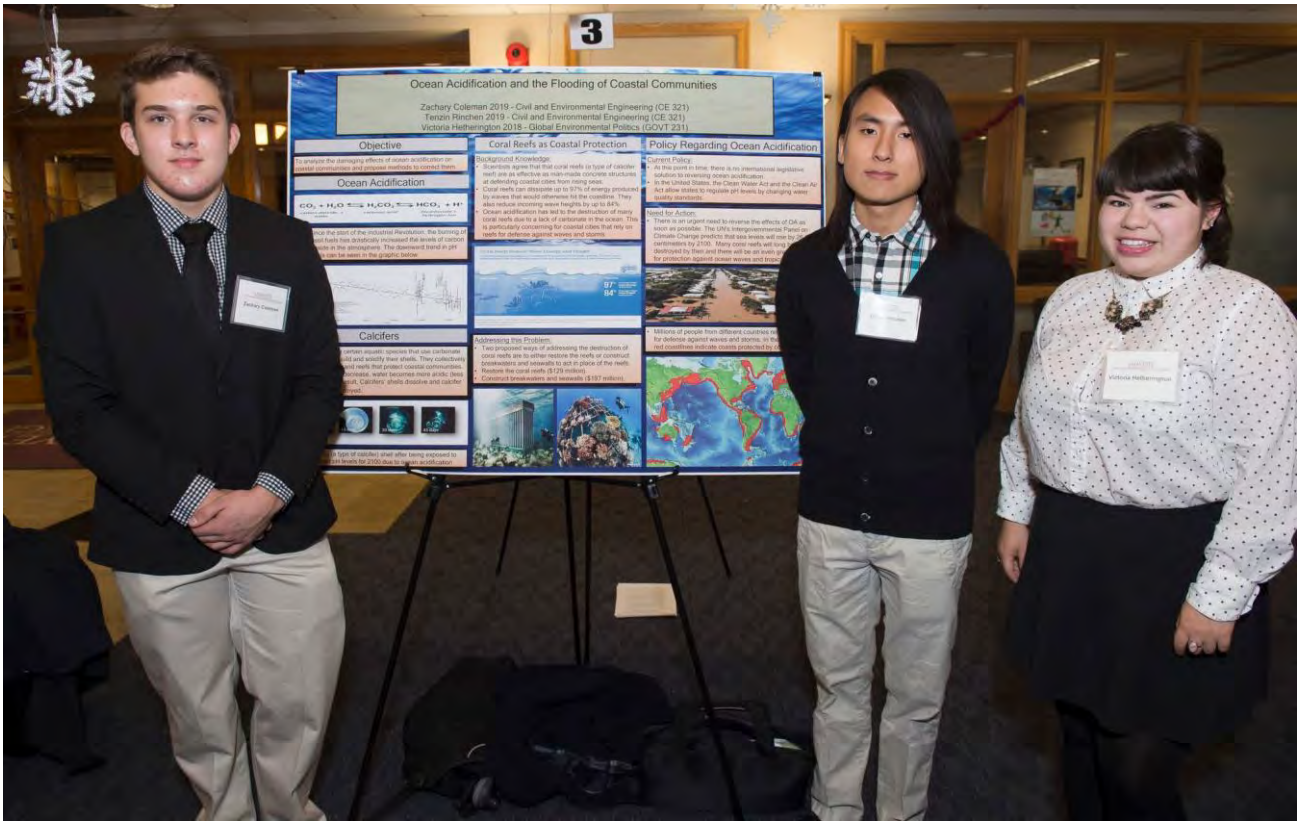
Please ask for a complete list of our sources.

Poster #4

Ocean Acidification and the Flooding of Coastal Communities

Zachary Coleman, Victoria Hetherington, and Tenzin Chogyal Rinchen

Since the industrial revolution, the concentration of carbon dioxide in the atmosphere has noticeably increased. Apart from Global Warming, another less known side effect of this is the phenomenon called ocean acidification. Ocean acidification, or "OA" for short, can best be described as the decrease in the pH levels of the oceans (the ocean becomes more acidic) caused by uptake of about a quarter of the total CO 2 present in the atmosphere. In the 21st century, ocean acidification brings with it a multitude of problems that affect a variety of careers, making it a multidisciplinary problem at the local and global level. One such problem is increased flood damage to coastal cities and communities. As ocean acidification continues to dissolve coral reefs, coastal cities become increasingly threatened by flooding. As this becomes more prominent, civil engineers are hard-pressed to find a solution to maintain current infrastructure and reverse ocean acidification. Now, state, local, and national governments are tasked with passing stricter legislation to regulate carbon dioxide emissions to prevent further ocean acidification.



Ocean Acidification and the Flooding of Coastal Communities

Zachary Coleman 2019 - Civil and Environmental Engineering (CE 321)
Tenzin Rinchen 2019 - Civil and Environmental Engineering (CE 321)
Victoria Hetherington 2018 - Global Environmental Politics (GOVT 231)

Objective

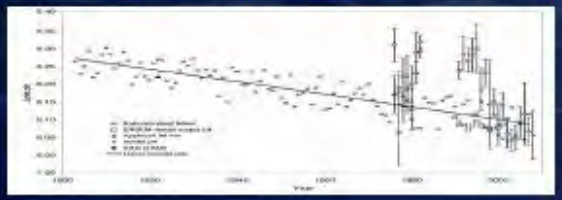
To analyze the damaging effects of ocean acidification on coastal communities and propose methods to correct them.

Ocean Acidification

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

carbon dioxide + water — carbonic acid — bicarbonate + hydrogen ion

- Since the start of the Industrial Revolution, the burning of fossil fuels has drastically increased the levels of carbon dioxide in the atmosphere. The downward trend in pH levels can be seen in the graphic below.



Calcifers

- Calcifers are certain aquatic species that use carbonate (a base) to build and solidify their shells. They collectively form barriers and reefs that protect coastal communities.
- As pH levels decrease, water becomes more acidic (less basic). As a result, Calcifers' shells dissolve and calcifer reefs are destroyed.

A pteropod's (a type of calcifer) shell after being exposed to the projected pH levels for 2100 due to ocean acidification

Coral Reefs as Coastal Protection

Background Knowledge:

- Scientists agree that that coral reefs (a type of calcifer reef) are as effective as man-made concrete structures at defending coastal cities from rising seas.
- Coral reefs can dissipate up to 97% of energy produced by waves that would otherwise hit the coastline. They also reduce incoming wave heights by up to 84%.
- Ocean acidification has led to the destruction of many coral reefs due to a lack of carbonate in the ocean. This is particularly concerning for coastal cities that rely on reefs for defense against waves and storms.

Addressing this Problem:

- Two proposed ways of addressing the destruction of coral reefs are to either restore the reefs or construct breakwaters and seawalls to act in place of the reefs.
- Restore the coral reefs ($129 million).
- Construct breakwaters and seawalls ($197 million).

Policy Regarding Ocean Acidification

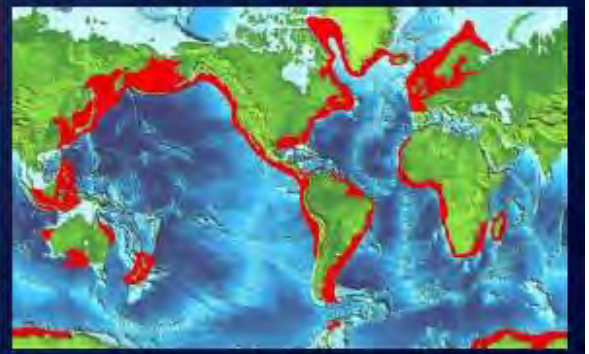
Current Policy:

- At this point in time, there is no international legislative solution to reversing ocean acidification.
- In the United States, the Clean Water Act and the Clean Air Act allow states to regulate pH levels by changing water quality standards.

Need for Action:

- There is an urgent need to reverse the effects of OA as soon as possible. The UN's Intergovernmental Panel on Climate Change predicts that sea levels will rise by 26-82 centimeters by 2100. Many coral reefs will long be destroyed by then and there will be an even greater need for protection against ocean waves and tropical storms.

- Millions of people from different countries rely on coral reefs for defense against waves and storms. In the graphic below, red coastlines indicate coasts protected by coral reefs



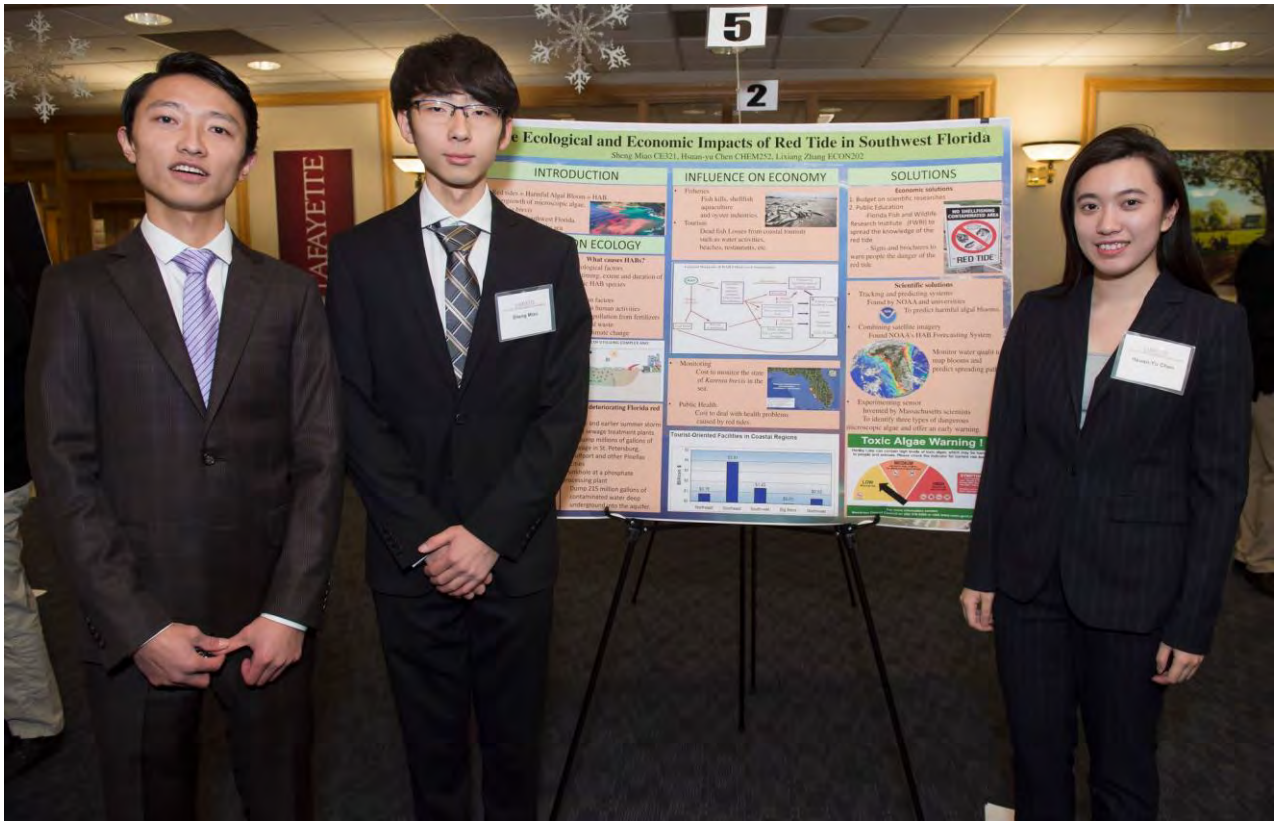
Poster #5

The Ecological and Economic Impacts of Red Tide in Southwest Florida

Hsuan-yu Chen, Sheng Miao, and Lixiang Zhang

Red tide happens when harmful algal blooms (HAB) occur when colonies of algae grow out of control and producing harmful effects on natural resource, local economies and human health. The cause of the blooming of red tide in Southwest Florida can be largely associated with the increased nutrient-rich land runoff from increased human activities. Some factors that may contribute to the bloom are reduced salinity, optimal light and nutrients, warm surface temperatures, transport in ballast water of ships and pollution. Sewage and fertilizer found in urban runoff contribute a high level of phosphates and nitrates into the ocean environment. Burning of fossil fuels also contributes to the amount of nitrogen, and is considered the greatest source to the open ocean environment.

From economic perspective, red tide has influenced Southwest Florida residents in four main aspects, fisheries, tourism, public health and monitoring, especially the tourism, which is a major part in Florida's economy. Government plays an important role in making policies dealing with red tide, promoting the knowledge of red tide to the public, measuring the economic influence from red tide, and deciding the budget for red tide. With government's support, scientists continue conducting researches of harmful algal blooms (HAB) to develop technologies that detect, measure and prevent red tides.



The Ecological and Economic Impacts of Red Tide in Southwest Florida

Sheng Miao CE321, Hsuan-yu Chen CHEM252, Lixiang Zhang ECON202

INTRODUCTION

- Red tides = Harmful Algal Bloom = HAB.
- Overgrowth of microscopic algae, *Karenia brevis*
- Happens in Southwest Florida.
- Produces toxins in the sea

INFLUENCE ON ECOLOGY

What causes HABs?

- Physical and chemical factors

-water salinity (salt concentration)
-temperature and sun light
-Nutrients (N and P)
-environmental tolerance of a specific HAB specie

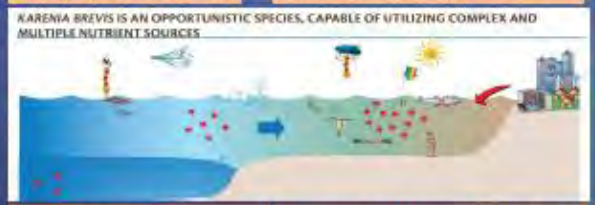
What causes HABs?

- Biological factors

-The timing, extent and duration of specific HAB species

- Human factors

-Based on human activities
-Nutrient pollution from fertilizers and animal waste
-Global climate change



Species causing Florida red tides

Karenia brevis, (K. brevis).

Reasons deteriorating Florida red tides

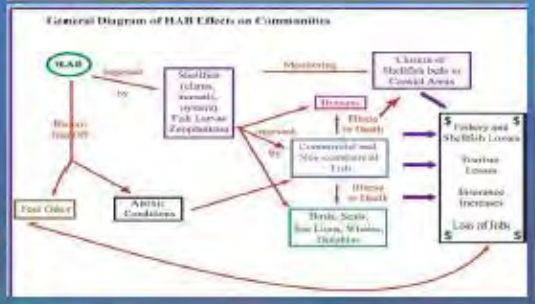
Hermine and earlier summer storm
Lead sewage treatment plants to dump millions of gallons of sewage in St. Petersburg, Gulfport and other Pinellas cities

A sinkhole at a phosphate processing plant
Dump 215 million gallons of contaminated water deep underground into the aquifer.

INFLUENCE ON ECONOMY

- Fisheries
  Fish kills, shellfish aquaculture and oyster industries.

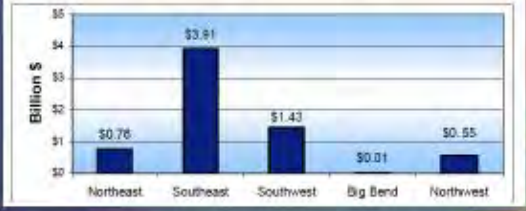
- Tourism
  Dead fish Losses from coastal tourism such as water activities, beaches, restaurants, etc.



- Monitoring
  Cost to monitor the state of *Karenia brevis* in the sea.

- Public Health
  Cost to deal with health problems caused by red tides.

Tourist-Oriented Facilities in Coastal Regions



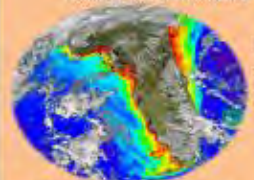
SOLUTIONS

Economic solutions

1. Budget on scientific researches
2. Public Education
   -Florida Fish and Wildlife Research Institute (FWRI) to spread the knowledge of the red tide
   - Signs and brochures to warn people the danger of the red tide

Scientific solutions

- Tracking and predicting systems
  Found by NOAA and universities
  To predict harmful algal blooms.
- Combining satellite imagery
  Found NOAA's HAB Forecasting System



Monitor water qualit to map blooms and predict spreading path.

- Experimenting sensor
  Invented by Massachusetts scientists
  To identify three types of dangerous microscopic algae and offer an early warning.

Poster #6

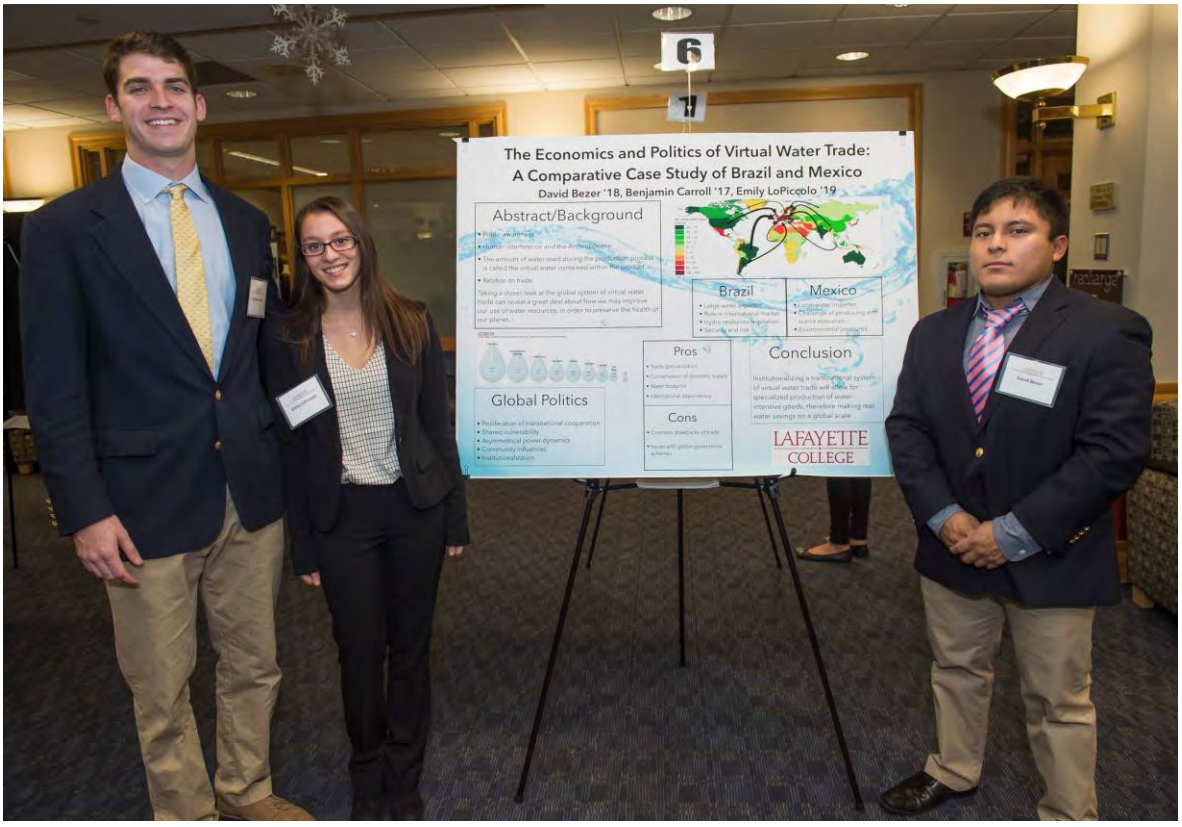
The Economics and Politics of Virtual Water Trade: A Comparative Case Study of Brazil and Mexico

David Bezer, Benjamin Carroll, and Emily LoPiccolo

Water usage is a critical part in agricultural production and industrial goods. The water amount used during the production process is the virtual water contained within the product. Along with the exchange of goods/services is the hidden flow of virtual water. Taking a closer look at the global system of virtual water trade (VWT) can reveal a great deal about how we may improve our use of water resources, in order to preserve the health of our planet.

Study of the conditions of each actors' water resources can help improve the efficiency of VWT. "The economic argument behind VWT is, according to international trade theory, nations should export products that possess a comparative advantage in production, while they should import products in which they possess a comparative disadvantage" (Hoekstra, 2003). Therefore, nations with abundant water resources should specialize in the production of goods that have a high virtual water content. This allows water-scarce nations to conserve domestic supply and put it towards other purposes.

This project presents a comparative case study of two nations, water-scarce Singapore and water-abundant Nepal. VWT is closely linked to both economics and politics. It can be used as an instrument for greater water security and smarter water use. Also, "VWT can be an instrument in solving geopolitical problems and even prevent wars over water" (Hoekstra, 2003). Assuring VWT efficiency requires a multidisciplinary and transnational approach. World nations can join the VWT system, to make real water savings on a global scale.



The Economics and Politics of Virtual Water Trade: A Comparative Case Study of Brazil and Mexico

David Bezer '18, Benjamin Carroll '17, Emily LoPiccolo '19

Abstract/Background

- Public awareness
- Human interference and the Anthropocene
- The amount of water used during the production process is called the virtual water contained within the product
- Relation to trade

Taking a closer look at the global system of virtual water trade can reveal a great deal about how we may improve our use of water resources, in order to preserve the health of our planet.

Brazil

- Large water exporter
- Role in international market
- Hydro resources legislation
- Security and risk

Mexico

- Large water importer
- Challenge of producing with scarce resources
- Environmental pressures

Global Politics

- Proliferation of transnational cooperation
- Shared vulnerability
- Asymmetrical power dynamics
- Community influences
- Institutionalization

Pros

- Trade specialization
- Conservation of domestic supply
- Water footprint
- International dependency

Cons

- Common drawbacks of trade
- Issues with global governance schemes

Conclusion

Institutionalizing a transnational system of virtual water trade will allow for specialized production of water-intensive goods, therefore making real water savings on a global scale.

LAFAYETTE COLLEGE

Poster #7

Dam Denial: Considering Patagonian Dam Proposals as Applied to Outcomes of the Aswan High Dam

Lara Henderson, Claire Kellner, and Theodore Vuchinich

Our poster examines the benefits and consequences brought to Egypt, the Nile, and the Mediterranean Coast via the construction of the Aswan High Dam, and uses these to understand why a dam project in Patagonia with similar intentions was proposed and subsequently denied. Our group chose to explore the environmental, political, and social variables which prompted the countries of Egypt and Chile to make contrasting decisions regarding dam construction or lack thereof. These regions have similar circumstances which were evaluated thoroughly in order to assess whether or not dam construction would be advantageous and ultimately profitable to local communities and ecosystems. It is pertinent to note that these differing time periods reflect different relationships between man and the environment. For example, as both regions are culturally and environmentally rich, the destructive nature of dam construction was heavily weighed in Patagonia, but somewhat overlooked in Egypt, due to Egypt's primary focus of industrialization rather than environmental attention during the year 1960. In contrast, there is extensive concern over protecting Patagonia's pristine environment and biodiversity in this modern era. This concern is what eventually caused Chile to prioritize conservation over energy security considerations. Thus, Chile's choice is representative of the start of a new age for global environmental awareness and protection.

Dam Denial: Considering Patagonian Dam Proposals as Applied to Outcomes of the Aswan High Dam

Lara Henderson GOVT 231, Theodore Vuchinich EVST 100 & CE 321, Claire Kellner EVST 100

Research Question

What social and political variables prompt the countries of Egypt and Chile to formulate contrasting opinions and policy regarding the construction and maintenance of dams?

Dams In General

Dams are structures constructed on rivers to generate hydroelectric power and store water for agricultural purposes. However, dams are also debated based on the variety of repercussions they impose.

Egypt & The Nile River

- Egypt consists of mostly desert and was dependent on the annual Nile flood for sediment deposit renewal and water for agriculture.
  - Black land – fertile land near along Nile riverbanks
  - Red land – barren desert
- Nile is an integral part of Egypt's agriculture, trade, and draw for tourism.
- Nile flooded unpredictably, causing problems for residents & agriculture.
- President Nasser believed the solution to unpredictability was the Aswan High Dam.
- Aswan Dam and Nasser Reservoir completed in 1970
- Dam helps to promote industrialization and protect sustainable growth

Patagonia & the Baker and Pascua Rivers

- Patagonia is a vast region shared by Chile and Argentina
- Sparsely populated and largely undeveloped
- Ecologically diverse
- Chile struggles to provide power for their growing economy due to limited fossil fuel resources.
- A series of five dams were proposed to generate hydroelectric power.
- Dam construction was debated for nine years before finally being rejected by the Chilean government.

How Are These Regions Related?

- Patagonia is considered one of the last regions of untouched wilderness.
- Egyptian culture tied to rich history and innumerable archeological sites left behind by ancient Egyptians.
- Both in need of infrastructure to support growth.
- Representative of unique environmental and cultural identities.

Aswan Dam Benefits

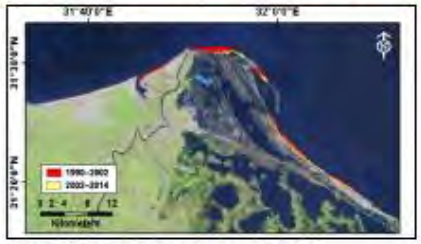
- Hydroelectric power
- Egypt remains unaffected during periods of drought or flooding – more farming capability
- Land rentals increased & more land taxes collected
- Political and fiscal success

Political & Fiscal Success

- Estimated that the dam would provide $2.9 million in "direct annual gain to the state," increasing annual agricultural production by $25.5 million and increasing land rental returns by $11.5 million.
- This brought significant population bloom and associated agricultural and industrial development.

Aswan Dam Drawbacks

- Erosion along the river and the coastline has worsened because sediment remains trapped behind the dam.
- Salinity has increased due to evaporation and reuse of water within reservoir leading to larger quantities of fertilizer needed for soil to remain viable.
- Various archeological sites were deconstructed and transported to avoid flooding, while dozens were left to be destroyed.
- Over 80,000 people were forced to become refugees – eventually Egypt paid $571,000 in reparations



Dam Proposal In Patagonia

In 2008, the company HidroAysén proposed the construction of five hydroelectric dams spanning 2400 kilometers through Patagonia on the Pascua and Baker Rivers. It is estimated that the dams and power transmission lines would cost almost 10 billion dollars, and generate 2,750 megawatts of electricity. In June of 2014, after many years of research, debate, impact assessment, and social protest, the dam project was officially rejected by the Chilean government. The project sparked a massive call for more transparent planning, an end to monopoly control of Chile's electricity system, and investment in truly renewable and sustainable energy.

The Project was Rejected Because:

- Construction would have required widespread deforestation and flooding.
  - Already endangered species would lose their natural habitats.
  - Ex: The Huemul deer, a species native to the Chilean and Argentinian mountains with fewer than 2,000 left on earth.
- Pre-existing natural reservoirs would be replaced by man made reservoirs and dams.
  - Reduction in water quality due to withheld sediment.
- Local tourism would be severely impacted.
- Construction and associated industrial activity projected to bring increased pollution, crime, prostitution, and housing issues.
- Deceptive Environmental Impact Assessments (EIA) submitted by HidroAysén were insufficient in providing critical information.
- Displacement of families and disruption of native livelihood would divide local communities.

Conclusive Connections

The Aswan dam offers a perfect example of dam implications in a culturally and environmentally sensitive region. It also shows the political climate which allowed for certain variables to be overlooked. The outcomes of Aswan dam can be examined in relation to possible outcomes of the HidroAysén project. Thus, the eventual denial of said Patagonian dams demonstrates liberal progress towards prioritization for environmental and cultural thinking.

Poster #8

What's in Your Water?: A Comprehensive Study of Lafayette College's Drinking Water from Plant to Fountain

Thomas Beier, Jonathan Maschio, and Brian Pinke

For our poster project, we were asked to study water challenges in the twenty-first century: local to global. We decided to start our project on the more local side of the spectrum; specifically looking into the potential water challenges Lafayette College faces. Our group, comprised of academic variety, brought together viewpoints from the chemical, civil and socio-environmental aspects of water science. With the help of Professor Kney and Mr. Tom DeFazio, we were able to comprehensively test the water quality of drinking fountains on Lafayette's campus. We chose to test ten fountains, aiming for a variety in location, age of building, and presence of a filter. The water quality tests we ran consisted of testing for pH, conductivity, alkalinity, nitrates, coliforms, and the presence of lead. In order to ensure that the conditions of the water being tested were constant and accurate, all of the samples were collected on the same day and tested following set procedures. In a narrow view, this merely paints a local picture of the quality of drinking water at Lafayette College; fortunately we did not find any major problems with our water. However, from a wider perspective, there are drinking water issues all around the globe, especially in undeveloped countries. Through this project we wish to demonstrate the responsibility of the scientific community to look out for the safety of the global populace. Whether it be developed or undeveloped countries, we have a duty to work towards the safety and the betterment of the world.

What's in Your Water?: A Comprehensive Study of Lafayette College's Drinking Water from Plant to Fountain

Jonathan Maschio EVST 100, Brian Pinke EVST 100, Thomas Beier CHEM 252
Lafayette College

Research Question

From the Easton Water Treatment Plant to Lafayette's water fountains, what is going on?

Introduction

Clean water supplied quickly and easily has always been a challenge for developing societies to overcome. However, even highly developed societies still fail in this regard. The purpose of this experiment is to provide a check of Lafayette's drinking water supply to determine its safety for human consumption.

Water fountains, both filtered and unfiltered, were tested for various factors such as:

- Presence of lead
- Alkalinity
- Nitrates
- pH and Conductivity
- Coliforms

These tests will paint a picture of the quality of water distributed around Lafayette's campus. A comparison to water data from the Easton Water Treatment Plant will also reveal if there are any potential problems with the transportation of water from the plant to Lafayette.

Why Care?

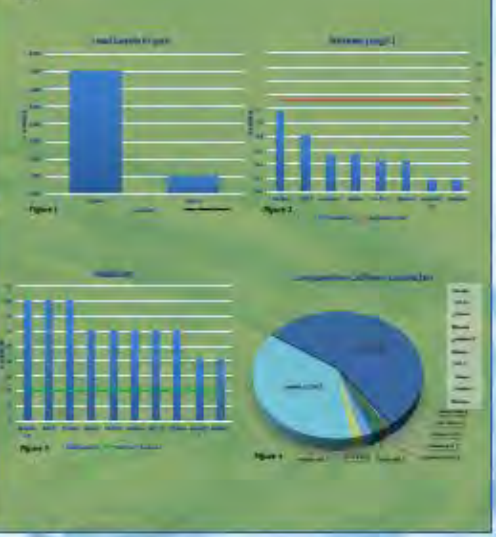
- Presence of Lead:
  - Particularly dangerous to young children
  - Damages physical and behavioral development
  - Exposure linked to nervous system damage, learning disabilities, impaired function of blood cells
- Alkalinity:
  - Determines water's ability to resist changes in pH
- Nitrates:
  - Potential to react with hemoglobin that hinders the body's ability to carry oxygen through its blood stream
  - Mainly hazardous to infants
- pH and Conductivity:
  - Lower pH leads to the leaching of metals from pipes
  - Higher pH has no specific health risks, but can cause problems to pipe structures and makes the water taste bad
  - Conductivity determines mineralization of water and amount of treatment chemicals added to the water
- Coliforms:
  - Determines bacterial levels in the water which indicates potential of disease causing bacteria in the water

Methods

- A multitude of tests were conducted on our water sample to ensure that any relevant problems with the water supply could be found.
- These tests were focused on ten water fountains across campus:
  - 8 unfiltered
  - 2 filtered
- The filtered water fountains were tested in buildings that also had an unfiltered water fountain

Data

Contaminants	Recommended Limits	Our Water	Typical Source
Total Alkalinity	–	30 ppm	Secondary drinking water standards; no health risks
pH	6.5 to 8.5	7.2	Secondary drinking water standards; no health risks
Lead	15 ppb	< 1 ppb	Corrosion of plumbing systems; erosion of natural deposits
Coliform	5% positive samples/month	0	Naturally present in environment
Nitrates	10 mg/L	–	Occurs naturally in groundwater usually near livestock



Locations:

1. Kirby Sports Center*
2. Kirby Sports Center
3. Acopian Engineering Center*
4. Acopian Engineering Center
5. Watson Hall
6. Kunkel Hall
7. Kamine Hall
8. Easton Hall
9. Pardee Hall
10. Farinon Student Center

* Filtered

Local to Global

- Living in a first world area, we expect clean drinking water and at times take it for granted
- Globally, people are often living in poverty or less optimal conditions yet these people still have a right to clean drinking water.
- Just as we tested our water to make sure it was clean, we should enable others in less enviable conditions to do the same.
- Universally clean drinking water is the ultimate goal.

Interdisciplinary Statement

This group brought together perspectives from Environmental Studies and Environmental Chemistry. Allowing us to look at drinking water problems as a water systems issue and a chemical issue.

Results/Discussions

Alkalinity

- All results fell within the safe range for alkalinity in drinking water (*Figure 2*)

Nitrates

- No nitrate tests exceeded the regulatory limit (*Figure 3*)

pH

- Acopian unfiltered and Kirby Sports Center filtered fall below the EPA pH regulation range (*Table 1*)
- Potential for detrimental health effects

Location

- No trends were found based of location of water fountains

Presence of Filtration

- No relationships between any of the factors tested and installation of a filter were found

Coliforms in drinking water

- The water from the unfiltered fountain in Acopian was the only sample to display Coliforms directly in the water
- This fountain also had a low conductivity which could suggest a low concentration of chemicals

Lead

- Kamine and Pardee both had measurable amounts of lead, both below the EPA regulatory limit of 15 ppb
- Acidic pH would indicate corrosion however the values were basic, indicating other factors at play
- Any amount can be detrimental to health

Conclusions

- Pre-test public convention held that the Lafayette College drinking water was of poor quality and required a filter in order to be drinkable.
- Experimental results provide that the water is quite clean with the exception of a few warning signs.
- More sample collections and retests would be required to reaffirm the data collected
- Future tests on Lafayette water quality should check for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) which have been found in water across the north east USA and are extremely detrimental to human health.

Acknowledgements

We would like to thank Professor Khey and Tom DeFazio for the assistance and funding that was provided to us. We would also like to thank Alex Hoffman for her assistance in sending the samples to Suburban Lab Testing. The results of this would not have been achievable without their assistance.

Poster #9

Water Resources: Scarcity and Solutions in the Jordan River Basin

Shaneena Alabado, Vanessa Pagano, and Rachel Tenney

Water covers 70% of the Earth's Surface, yet only 2.5% is freshwater. The Middle East possess only 1.1 % of the world's total freshwater supply, but contains 4.4% of the world's population. Water stress has worsened already fragile relationships between countries with shared water sources, with some countries taking more than their fair share.

This scarcity has prompted advancements in water recycling and desalination, particularly in Israel. In fact, today, approximately 50% of Israel's potable water comes from desalination and recycling, which has lessened Israel's demand for water from the Jordan River.

But water desalination also comes at a price. The plants are costly and brine discharge from the purification process can cause eutrophication and other adverse environmental effects. For example, in the Sorek plant in Israel, influent salt water undergo the desalination process through reverse osmosis. A combination of brine mixed with chemicals used in the process are then discharged into the sea. This begs the question is water desalination a viable solution to the Jordan River Basin's water crises? How would relieving the water stress placed on Israel affect its relationship with its neighbors?

Water Resources: Scarcity and Solutions in the Jordan River Basin

Shaneena C. Alabado, Vanessa Pagano, and Rachel Tenney
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WATER CRISIS

Water covers 70% of the Earth's surface, yet only 2.5% is freshwater, making freshwater a limited resource for many regions, as shown in Figure 1. **The Middle East possess only 1.1 % of the world's total potable water supply, but contains 4.4% of the world's population.** Up to 90% of the Middle East's surface water originates from rain fallen on foreign lands or from underground aquifers that are not replenished fast enough to meet demand. This forces the entire region to endure water stress.

One of the main freshwater resources in the Middle East is the Jordan River. Due to imbalances in political influence, military power, and technological investment capacity, some countries have become more water scarce while others, such as Israel, are accused of taking more than their fair share. **The region's long history of water stress continues and has led to conflicts and innovations.**

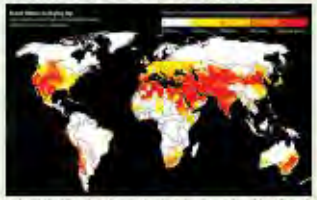


Figure 1: Global Freshwater Stress Levels: Stress level is a function of the population size and availability of freshwater

REGIONAL CONFLICT

- The last 60 years have seen only 44 violent disputes, 30 of which involved Israel and one of its neighbors.
- Regional conflict has stalled attempts to discuss and address shared environmental concerns and the idea of fair water rights.
  - The Jordan River cannot satisfy the entire regional need.
  - Palestine is currently barred from using Jordan River water by Israel.
  - Currently, up to 97% of the Jordan River's volume is withdrawn. If it is replaced, it is replaced with polluted wastewater, runoff, untreated sewage, etc.
  - The Lower River Basin and the Mountain Aquifer in Israel, for example, are extremely polluted.

Table 1: Utilization of the Jordan River by Country (2005) in Decreasing Order of Use: Israel uses far more than its fair share of the Jordan River.

Country	Water Quantity (MCM/year)	% Capacity Withdrawn
Israel	870	66
Jordan	235	18
Syria	160	12
Lebanon	5.00	0.5
Occupied Palestine Territories	0.00	0.0
*Remainder	50.0	3.4
Total	130	100

MITIGATING WATER STRESS

The Jordan River does not have the capacity to satisfy the needs of each country in the region, and the current withdrawal rates are unsustainable and damaging to the river. If Israel were to satisfy its own water demand through desalination, the Jordan River would be available to other countries for use.

Is water desalination a viable solution for the Jordan River Basin water crisis?

DISCUSSION: DESALINATION

- Desalination uses thermal and membrane processes to remove salt from seawater.
- Reverse Osmosis (RO) is the most widely-used membrane desalination technology. It is the most cost-effective and energy-efficient desalination process.
- In RO, pressure around 5-10 MPa forces seawater against semi-permeable polymer membranes to filter out salt ions, as shown in Figure 2.

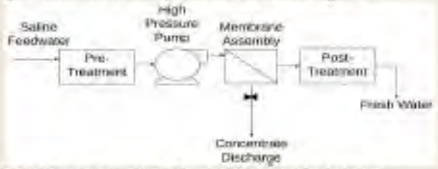


Figure 2: RO Process Schematic: The concentrate brine discharge is the most controversial aspect of the desalination process, as it is often released back into the sea.

Criticisms: Pollution-sensitivity; energy requirements; reliance on fossil fuels; ecosystem damage from waste brine
Improvements: Atom-thick carbon membranes are being developed; integration of renewable energy

ENVIRONMENTAL EFFECTS OF DESALINATION

A drawback of desalination is its impact on the environment, shown in Table 2.

Potential Environmental Impact		
Impact	**Spatial Extent**	**Source in the Facility**
Habitat alteration and changes in sediment transport	localized	intake & outfall systems (piping)
Entrainment and impingement of marine biota	localized to mid-range	intake system (suction heads)
Debris pollution (from intake screening)	localized	intake system (screening system)
Biological effects of residual chlorine & chlorination by-products	localized to mid-range	intake system (biofouling control)
Biological effects of increased seawater salinity	localized to mid-range	Concentrate outfall (RO brine)
Effects of residual chemicals (metals, antiscalants, membrane cleaning chemicals) and particulate matter in the concentrate	localized to mid-range	Concentrate outfall (process streams)

Table 2: Environmental Concerns of Desalination Discharge: Most of the issues associated with desalination are due to the release of brine wastewater.

Possible Solutions to Environmental Concerns:

- Currently implemented in Sorek is a special discharge system where brine is diluted and discharged 2 km offshore.
- Research is being conducted regarding a chemical-free system that uses porous lava stone to capture microorganisms in order to prevent membrane fouling, which lessens use of membrane preservatives.
- Increased use of environmentally-friendly antiscalants and inorganic and treatable cleaning solutions would also address environmental concerns.

CASE STUDY: JORDAN RIVER BASIN

There are benefits and drawbacks in the use of desalination plants in Israel as tabulated in Table 3. Israel relieves some of the water stress in the Jordan River Basin, shown in Figure 4, by desalinating Mediterranean water. It has 5 desalination plants supplying nearly 50% its water. The Sorek desalination plant near Tel Aviv, Israel, shown in Figure 3, currently provides 20% of Israel's drinking water.

Benefits	Drawbacks
Technology for efficient, economic, and environmentally-friendly desalination continues to improve.	High costs to build and maintain plants currently translate to high costs to consumers.
Desalination provides a way to break free from geographical constraints on freshwater supply.	Brine discharge is harmful to surrounding ecosystems.
Desalination in Israel would decrease stress on the Jordan River and Mountain Aquifer, improving: • Regional international relations • Availability of freshwater resources to landlocked countries	Israel's use of desalination cannot completely eliminate regional conflict due to: • Environmental concerns (such as pollution) • Geographical (such as) limited access to freshwater

Table 3: Benefits and Drawbacks of Desalination in Israel

- Sorek, the world's largest SWRO plant, is the first to slash RO costs by using 16 in. rather than 8 in. diameter pressure tubes, requiring 25% of the piping and hardware previously necessary.

Figure 3: Sorek desalination plant, near Tel Aviv, Israel

Figure 4: Map of the Jordan River Basin: Shows the countries utilizing the River and Mountain Aquifer

Alternatives:

- Damming is the only other current "solution" to water scarcity across the Middle East, but this is not a feasible permanent solution.
  - Drawbacks: Expensive to maintain; extremely detrimental to ecosystems; have catastrophic effects if breached; have become targets for terrorist organizations; "water hoarding" by upstream countries, such as Turkey

CONCLUSIONS

- Water stress causes and/or exacerbates political tensions in the Middle East, which makes discussion and collaboration on addressing the region's water crisis and related environmental concerns difficult.
- Current practices, including damming as well as drawing from the Jordan River and Mountain Aquifer, are not sufficient or appropriate sustainable water supplies.
- Desalination is the best solution to water scarcity in the Jordan River Basin.
- An ease in water stress due to Israel's use of desalination may bring about more cooperation and stability to Middle Eastern countries.

REFERENCES AVAILABLE UPON REQUEST

Poster #10

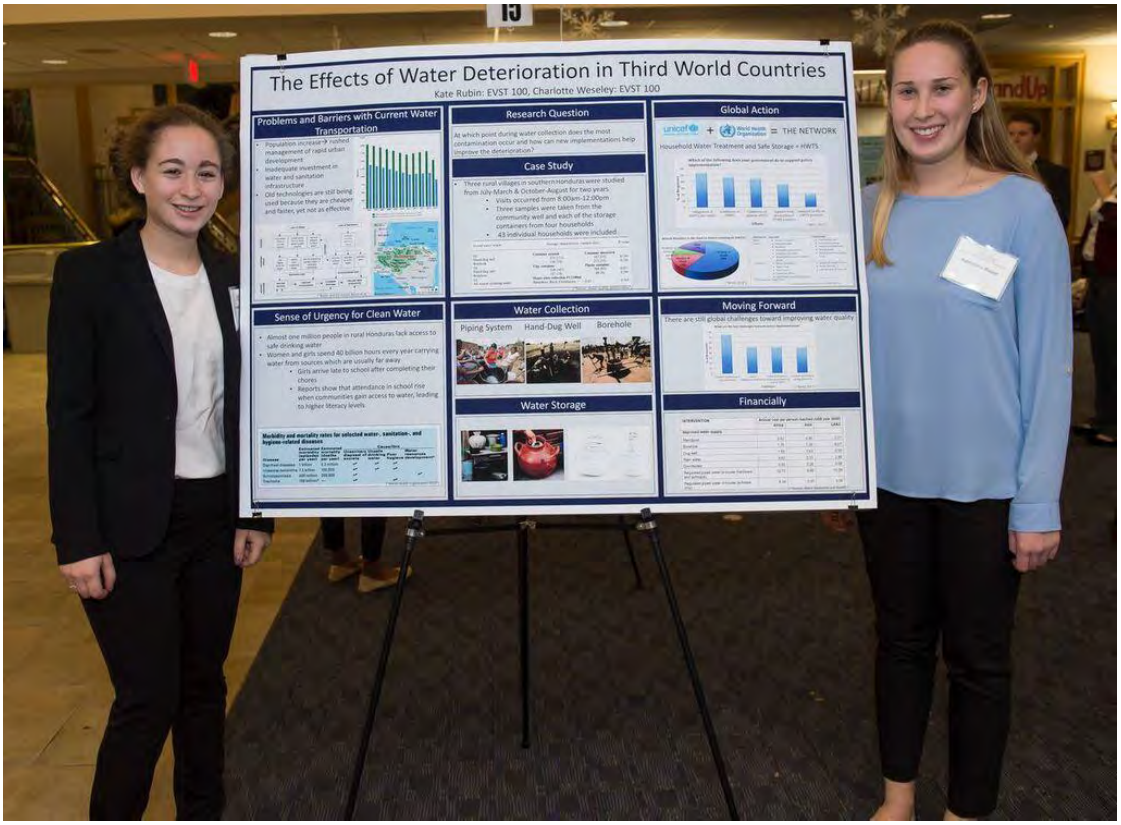
The Effects of Water Deterioration in Third World Countries

Kate Rubin and Charlotte Weseley

Rapid urbanization in third world countries has depleted access to natural resources, has disregarded environmental constraints and has rushed the management of urban development. Water scarcity has been and will continue to be one of the largest environmental constraints to long term success of a country. There has been inadequate investment in water and sanitation infrastructure and inadequate investment in improved technology due to increased cost. Because it is a naturally occurring resource, water is not preserved in the most beneficial way nor is it conserved in the correct way.

Third world countries are known to have women spend their mornings collecting water and improperly transporting it to their homes. Girls go with their mothers and show up late to school which hinders their education. It is proven that proper attendance in school rises when communities gain proper access to clean water, which in turn raises the literacy level.

Focusing specifically on how water is collected and transported in rural villages in Honduras exemplifies the sense of urgency for clean water. A case study was taken into account to determine where water contamination occurred during the collection process and how new implementations could improve the sanitation and decrease disease spread. Global action has been taken to create standards for water quality and implement plans to provide people with clean water. Research has helped governments implement plans using the cheapest most effective methods. Water quality needs to be improved through a system including money, education and policy reforms.

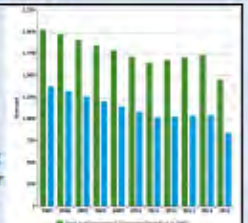


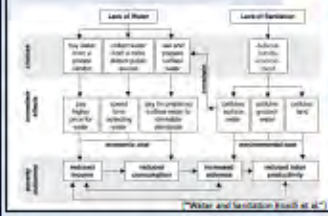
The Effects of Water Deterioration in Third World Countries

Kate Rubin: EVST 100, Charlotte Weseley: EVST 100

Problems and Barriers with Current Water Transportation

- Population increase→ rushed management of rapid urban development
- Inadequate investment in water and sanitation infrastructure
- Old technologies are still being used because they are cheaper and faster, yet not as effective



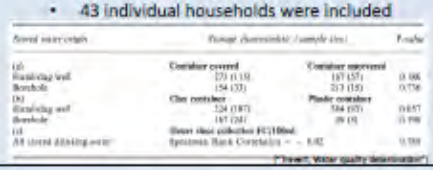


Research Question

At which point during water collection does the most contamination occur and how can new implementations help improve the deterioration?

Case Study

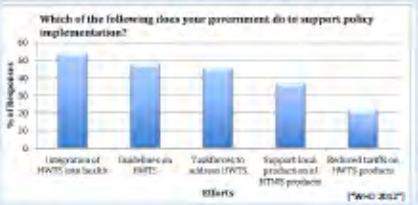
- Three rural villages in southern Honduras were studied from July-March & October-August for two years
  - Visits occurred from 8:00am-12:00pm
  - Three samples were taken from the community well and each of the storage containers from four households
  - 43 individual households were included

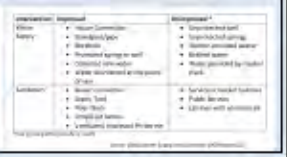


Global Action

unicef + World Health Organization = THE NETWORK

Household Water Treatment and Safe Storage = HWTS





Sense of Urgency for Clean Water

- Almost one million people in rural Honduras lack access to safe drinking water
- Women and girls spend 40 billion hours every year carrying water from sources which are usually far away
  - Girls arrive late to school after completing their chores
  - Reports show that attendance in school rise when communities gain access to water, leading to higher literacy levels

Morbidity and mortality rates for selected water-, sanitation-, and hygiene-related diseases

Disease	Estimated morbidity (episodes per year)	Estimated mortality (deaths per year)	Cause/link: Unsanitary disposal of excreta	Unsafe drinking water	Poor hygiene	Water resources developments*
Diarrhoeal diseases	1 billion	2.2 million	✓	✓	✓	
Intestinal helminths	1.5 billion	100,000	✓	✓	✓	
Schistosomiasis	200 million	200,000	✓			✓
Trachoma	150 million†	—	✓		✓	

("World Health Organization (WHO)")

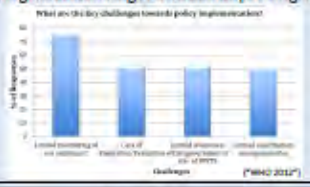
Water Collection

Piping System | Hand-Dug Well | Borehole

Water Storage

Moving Forward

There are still global challenges toward improving water quality



Financially

INTERVENTION	Annual cost per person reached (US$ year 2000): Africa	Asia	LAC
Improved water supply			
Standpost	2.40	4.95	3.17
Borehole	1.70	1.26	4.27
Dug well	1.58	1.85	5.65
Rain water	3.60	2.51	2.86
Disinfected	0.33	0.26	0.59
Regulated piped water in-house (hardware and software)	12.75	9.95	15.29
Regulated piped water in-house (software only)	8.34	5.97	8.90

("Inactive, Water Sanitation and Health")

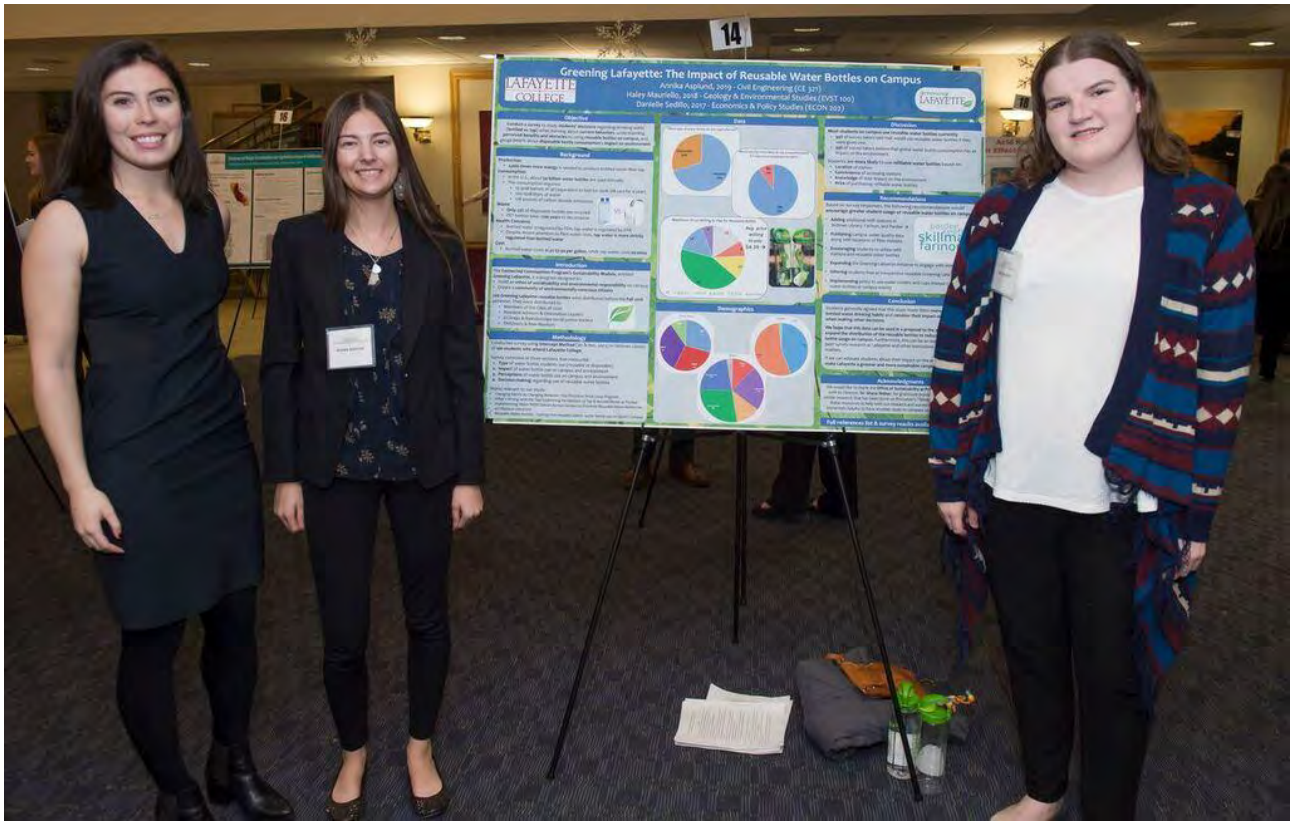
Poster #11

Greening Lafayette: The Impact of Reusable Water Bottles on Campus

Annika Asplund, Haley Mauriello, and Danielle Sedillo

The goal of our project is to study the impact of receiving reusable water bottles on students' decisions regarding drinking water (bottled vs. tap) and assess the effectiveness of the Greening Lafayette sustainability kit distribution as part of the College's Connected Communities Program. The Connected Communities Program is an additional residential structure that aspires to develop unity and identity within the 5 Commons by creating modules that instill common values as pillars of a Lafayette education. The Sustainability Module, entitled Greening Lafayette, is an active educational and engagement opportunity for students to learn about different aspects of the environment and how they impact their surrounding community, both ecological and social.

We conducted our research by distributing surveys to students, based on similar surveys at other institutions of higher education, to gauge current behaviors of students in terms of consuming bottled water and/or tap water and using reusable water bottles, discern important benefits and barriers to students in terms of their type of water consumption, and if the student community believes that various scales of bottled water consumption have an environmental impact. We hope that, as a result of this project, this data will be used in a proposal to administration to expand the distribution of the reusable bottles to students to reduce disposable water bottle usage on campus and be an example for further peer survey research at Lafayette and other institutions about environmental matters.



Greening Lafayette: The Impact of Reusable Water Bottles on Campus

LAFAYETTE COLLEGE

Annika Asplund, 2019 - Civil Engineering (CE 321)
Haley Mauriello, 2018 - Geology & Environmental Studies (EVST 100)
Danielle Sedillo, 2017 - Economics & Policy Studies (ECON 202)

greening LAFAYETTE

Objective

Conduct a survey to study **students' decisions** regarding drinking water **(bottled vs. tap)** while learning about **current behaviors**, understanding **perceived benefits and obstacles** to using **reusable bottles on campus**, and gauge beliefs about **disposable bottle consumption's impact on environment**

Background

Production
- **2,000 times more energy** is needed to produce bottled water than tap

Consumption
- In the U.S., about **50 billion water bottles** are used annually
- This consumption requires:
  - 15-30M barrels of oil (equivalent to fuel for 100K-2M cars for a year)
  - 100-150B liters of water
  - 12B pounds of carbon dioxide emissions

Waste
- **Only 23%** of disposable bottles are recycled
- PET bottles take **~700 years** to decompose

Health Concerns
- Bottled water is regulated by FDA; tap water is regulated by EPA
- Despite recent attention to Flint water crisis, **tap water is more strictly regulated than bottled water**

Cost
- Bottled water costs **$1.22-$7.50 per gallon**, while tap water costs **$0.0004**

Introduction

The **Connected Communities Program's Sustainability Module**, entitled ***Greening Lafayette***, is a program designed to:
- Instill an **ethos of sustainability and environmental responsibility** on campus
- Create a **community of environmentally conscious citizens**

700 *Greening Lafayette* reusable bottles were distributed before the **Fall 2016** semester. They were distributed to:
- Members of the Class of 2020
- Resident Advisors & Orientation Leaders
- ECOreps & Kaleidoscope social justice leaders
- PARDners & Peer Mentors

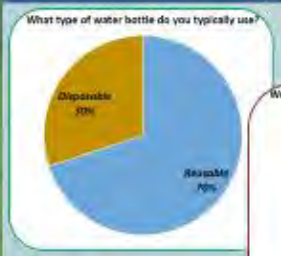
Methodology

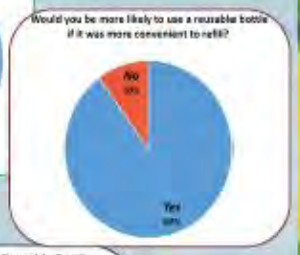
Conducted survey using **Intercept Method** (Jin & Kim, 2003) in Skillman Library of **100 students who attend Lafayette College**

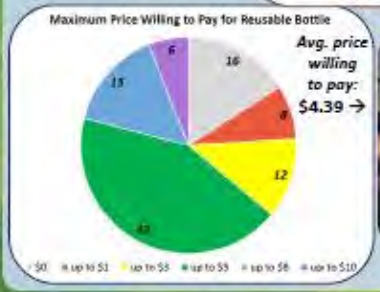
Survey consisted of three sections that measured:
1. **Type** of water bottle students use (reusable or disposable)
2. **Impact** of water bottle use on campus and environment
3. **Perceptions** of water bottle use on campus and environment
4. **Decision-making** regarding use of reusable water bottles

Works relevant to our study:
- *Changing Norms by Changing Behavior: The Princeton Drink Local Program*
- *What's Wrong with the Tap? Examining Perceptions of Tap & Bottled Water at Purdue*
- *Implementing Water Refill Station Across Campus to Promote Reusable Water Bottle Use at Villanova University*
- *Reusable Water Bottles: Curbing Non-reusable plastic water bottle use on Duke's Campus*

Data







Demographics

Discussion

Most students on campus use reusable water bottles currently
- **94%** of survey takers said that would use reusable water bottles if they were given one
- **99%** of survey takers believe that global water bottle consumption has an impact on the environment

Students **are more likely** to use **refillable water bottles** based on:
- **Location** of station
- **Convenience** of accessing stations
- **Knowledge** of their impact on the environment
- **Price** of purchasing refillable water bottles

Recommendations

Based on survey responses, the following recommendations would **encourage greater student usage of reusable water bottles on campus:**

- **Adding** additional refill stations in Skillman Library, Farinon, and Pardee →
- **Publishing** campus water quality data along with locations of filter stations
- **Encouraging** students to utilize refill stations and reusable water bottles
- **Expanding** the Greening *Lafayette* initiative to engage with more students
- **Offering** students free or inexpensive reusable Greening Lafayette bottles
- **Implementing** policy to use water coolers and cups instead of disposable water bottles at campus events

pardee keefe skillman farinon

Conclusion

Students generally agreed that this study made them **more aware of their bottled water drinking habits** and **consider their impact on the environment when making other decisions.**

We hope that this data can be used in a proposal to the administration to expand the distribution of the reusable bottles to reduce disposable water bottle usage on campus. Furthermore, this can be an example for further peer survey research at Lafayette and other institutions about environmental matters.

If we can educate students about their impact on the environment, **we can make Lafayette a greener and more sustainable campus community.**

Acknowledgments

We would like to thank the **Office of Sustainability at Princeton University** along with its Director, **Dr. Shana Weber**, for graciously providing access to results of similar research that has been done on Princeton's "Drink Local Program". We used these resources to help with our research and survey-making process. It was immensely helpful to have another study to compare to throughout this project.

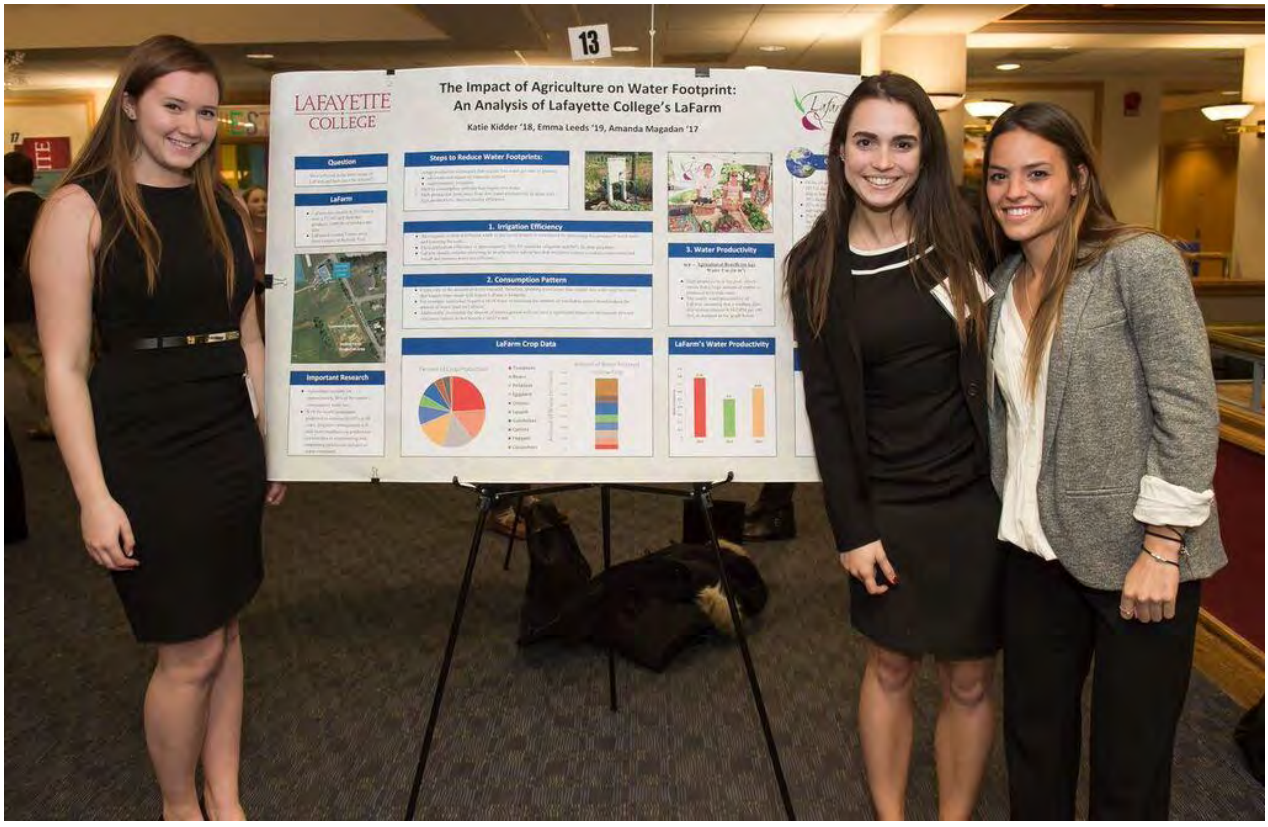
Full references list & survey results available upon request.

Poster #12

The Impact of Agriculture on Water Footprint: An Analysis of Lafayette College's LaFarm

Katie Kidder, Emma Leeds, and Amanda Magadan

With the world population projected to increase by 65% in 50 years and agriculture globally accounting for a majority of water consumption, the necessity of research on effective agricultural water usage grows more imperative every day. Considering that Lafayette College locally grows crops on its own farm, LaFarm, our research choose to examine how LaFarm contributes to the global water footprint. LaFarm was created in 2013 three miles away from campus next to the Metzgar Athletics Complex and serves as a sustainability initiative that incorporates the Lafayette community. The purpose of our research is to investigate the efficiency of LaFarm's water usage and explore the ways it can be reduced through choice of irrigation system, consumptive patterns, and water productivity for LaFarm specifically. Additionally, the study compares how LaFarm's use of water impacts the overall global water footprint. Our findings suggest that LaFarm can further reduce its water footprint by improving irrigation methods and consumptive choices. For example, irrigation could be ameliorated by night irrigation or the plantation of more tree to reduce evaporation. Furthermore, LaFarm could grow more crops that require less water and less crops that require more water. Although these recommendations provide ways for LaFarm to reduce its water footprint, the research found that LaFarm, generally minimizes its water footprint through its choice of irrigation, choice of crops, and water productivity, and is a model example of a small scale farm that utilizes water for agriculture in a sustainable way.



LAFAYETTE COLLEGE

The Impact of Agriculture on Water Footprint: An Analysis of Lafayette College's LaFarm

Katie Kidder '18, Emma Leeds '19, Amanda Magadan '17

Question

How efficient is the water usage of LaFarm and how can it be reduced?

LaFarm

- LaFarm was created in 2013 and is now a 57,000 sq ft farm that produces 5,000 lbs of produce per year.
- LaFarm is located 3 miles away from campus on Sullivan Trail.

Important Research

- Agriculture accounts for approximately 80% of the nation's consumptive water use.
- With the world population projected to increase by 65% in 50 years, irrigation management will shift from emphasizing production per unit area to emphasizing and monitoring production per unit of water consumed.

Steps to Reduce Water Footprints:

1. Adopt production techniques that require less water per unit of product
   - advanced techniques of rainwater harvest
   - supplementary irrigation
2. Shift to consumption patterns that require less water
3. Shift production from areas from low water-productivity to areas with high productivity, thus increasing efficiency

1. Irrigation Efficiency

- An irrigation system is efficient when its net social benefit is maximized by decreasing the amount of water used and lowering the costs.
- Field application efficiency is approximately 70% for sprinkler irrigation and 90% for drip irrigation.
- LaFarm should consider switching to an alternative subsurface drip irrigation system to reduce evaporation and runoff and increase water use efficiency.

2. Consumption Pattern

- Crops vary in the amount of water required, therefore, growing more crops that require less water and less crops that require more water will reduce LaFarm's footprint.
- For example, sunchokes require a lot of water so reducing the number of sunchokes grown would reduce the amount of water used on LaFarm.
- Additionally, increasing the amount of carrots grown will not have a significant impact on the amount of water used since carrots do not require a lot of water.

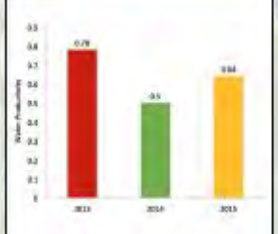
LaFarm Crop Data

3. Water Productivity

$$WP = \frac{\text{Agricultural Benefit (in kg)}}{\text{Water Use (in m}^3\text{)}}$$

- High productivity is the goal, which means that a large amount of output is produced with little input.
- The yearly water productivity of LaFarm, assuming that a medium flow drip system releases 0.34 GPM per 100 feet, is depicted in the graph below.

LaFarm's Water Productivity



Global Impact

- Of the 55 million acres of land irrigated in 2013 in the US, 9% were irrigated using drip or low-flow micro sprinklers. This is a 30% increase from 2008.
- 22% of drip irrigation systems were sub-surface in 2013.
- The Food and Agriculture Organization of the United Nations estimates that about 1.9% of the world's irrigated land is either waterlogged or excessively salty, and another 33% is affected to some degree. Salinization affects 20% of the irrigated land in the United States.

Recommendations & Discussion

- Night irrigation, which reduces evaporation during irrigation, could be implemented to improve water use efficiency by two to three times. Also, planting more trees to serve as shelterbelts reduces evaporation and transpiration by 20%.
- Overall, it is important for LaFarm to maintain sustainable patterns of water management through efficient irrigation, consumption patterns, and water productivity to improve the water footprint on a local and global scale.

Poster #13

Bleaching Away Beauty: Coral Reefs are Disappearing and the Barren Ocean Floor Remains

Kyla Dewey, Jacob Orender, and Danielle Ricciardi

Coral reefs are one of the most biodiverse ecosystems on the planet. In addition to hosting sea life, humans from all over the world travel to see the beauty of these systems. However, coral bleaching is a major problem that is harming the corals and reducing their chances of survival. Coral bleaching is the process by which corals expel symbiotic algae when under duress. Stresses that are currently threatening corals are those that have resulted from human-induced climate change; these include rising sea temperatures, increased oxygen levels, increased carbon dioxide levels, and the increased severity and occurrence of violent storms. Humans more-directly threaten these species through their use of corals to produce pharmaceutical products, tourists harming the corals' chemistry by touching them, over-fishing near coral reefs, and wastes released through other processes, such as the runoff and sedimentation from agriculture. The ability of corals to recover from these stresses depends on the length and severity of the stress. Ultimately, many of these corals end up dying. Now is the time to be concerned for the survival of coral reefs. The loss of this species and habitat will significantly reduce the biodiversity on this planet. Humans, as the most intellectually-developed species, the species inducing the most harm, and the species with a lot to lose, have an ethical and self-interested obligation to ensure the survival of these reefs for years to come.

Bleaching Away Beauty: Coral Reefs are Disappearing and the Barren Ocean Floor Remains

Kyla Dewey – Chem 252, Jacob Orender – EVST 100, Danielle Ricciardi – EVST 100

Research Question: How do humans and changing water conditions harm coral reefs?

What is Coral Bleaching?

- Expulsion of symbiotic zooxanthellae bacteria due to changes in conditions such as light, temperature, and nutrient levels in the water
- Causes the white, or bleached, coloring of coral

Image created by Paul Kane.

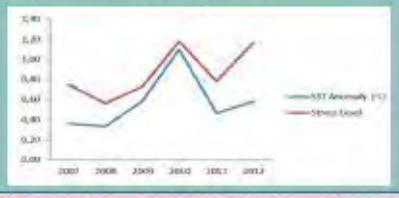
Why are Coral Reefs Important?

- 4000-4500 (>1/4 of all) fish species inhabit coral reefs
- Symbiosis:
  - Zooxanthellae → Live in larger groups in hosts; perform photosynthesis
  - Coral → Get nutrients from zooxanthealle or eat zooplankton

How Does Coral Bleaching Occur?

- Global climate change
- Run-off from fertilizers and waste
- Accidents, such as oil spills
- Overfishing and trolling
- Tourism
- Pollution

Figure 1 (Left). Trolling net. Image taken by Sophia Choi.
Figure 2 (Right): Pollution. Image taken by Secore.



Figures 3. Correlation between deviations in ocean temperatures and stress levels in coral. Graph included in a publication by B. Semedi and F. Rahmawan.

Can Coral Reefs Recover?

- Yes!
  - From minor bleaching
- However:
  - If bleaching is consistent, the coral will inevitably die before the zooxanthellae has the chance to reattach to the coral
- Impact on Humans:
  - Tourism
  - Food Supply
  - Pharmaceuticals
  - Costal damage during storms
  - Air and ocean water quality

Figure 4 (Left): Image of Healthy Coral. Image taken by Michele Westmoreland.
Figure 5 (Right): Image of Bleached Coral. Image taken by Clara Chaisson.

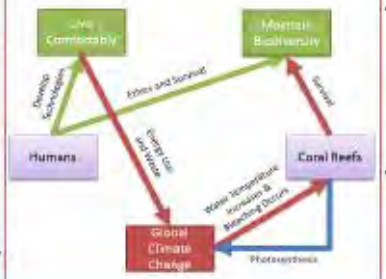
Human and Coral Reef Interactions

Global Climate Change's Impact on Reefs:
- Rising Water Temperatures
  - Coral's survival range: 24-29.5°C
  - Exceeds maximum for >3 weeks → Coral expel zooxanthellae
  - Increases diseases' ability to survive
- Increasing CO_2 Levels
  - CO_2 reacts with water and increases the acidity (decreases the pH) of the water

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow 2H^+ + CO_3^{2-}$$

  - Since the industrial revolution, concentration of CO_2 increased 100 ppm
    - Preceding 8000 years, CO_2 only rose by 20ppm



Global Climate Change's Impact on Reefs:
- Increasing O_2 Levels
  - High light and temperature → More photosynthesis → Zooxanthellae produce toxic oxygen radicals → Corals expel zooxanthellae
    1. Expelling gastrodermal cells
    2. Resorption
    3. Tissue death
- Violent Storms
  - Number of hurricanes are increasing
  - Water temperature increases by 1°C after a storm
    - 17% of reefs are destroyed the year after a hurricane

Conclusions and Future Research

- Global climate change results in coral bleaching
  - **Solution:** Reduce carbon in the atmosphere
- Humans harm coral: agriculture, fishing, tourism, pollution, accidents, exacerbating climate change
  - **Solution:** Reduce and control fertilizers and be more cautious near corals
- If nothing is done: Endangerment or extinction of species
  - **Solution:** Artificially create reefs to save species
- **Future Research:**
  - Improving artificial reefs
  - Artificial regulation of chemistry near reefs

Poster #14

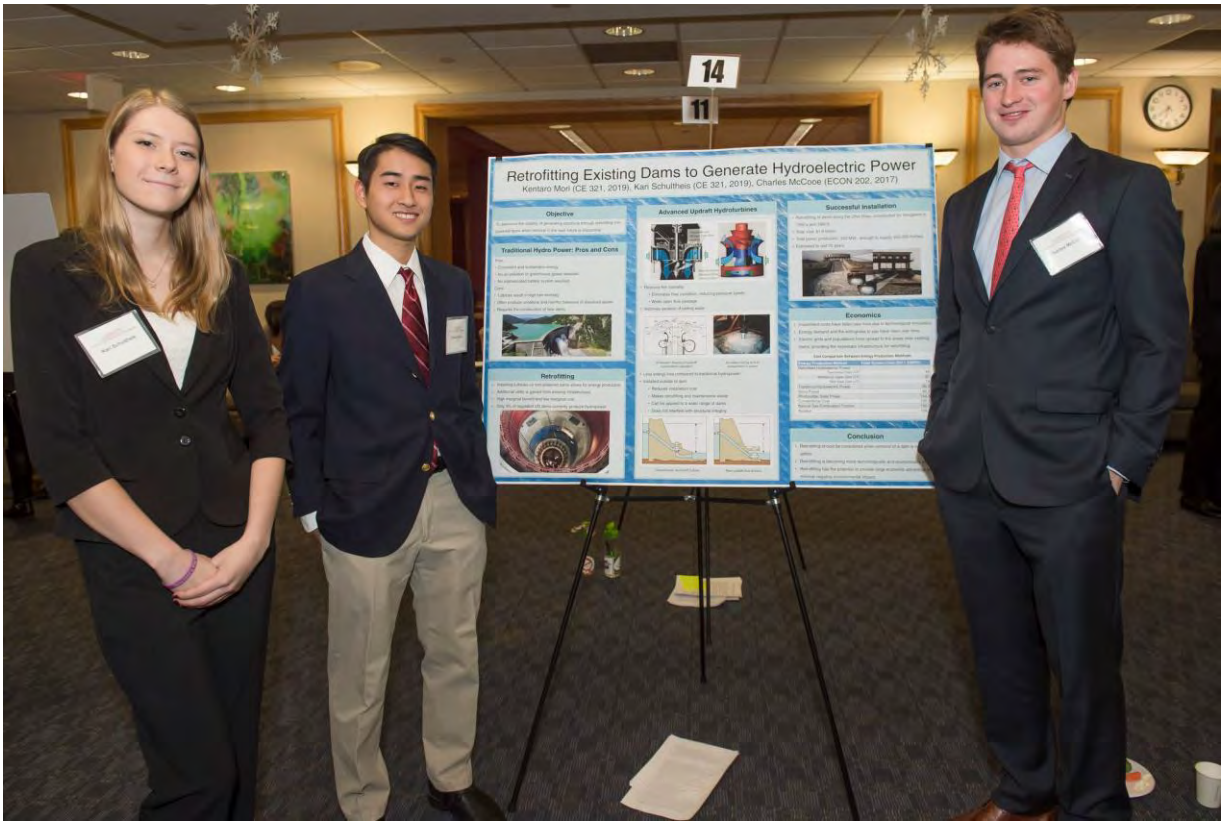
Retrofitting Existing Dams to Generate Hydroelectric Power

Charles McCooe, Kentaro Mori, and Kari Schultheis

Humans have been building dams since nearly 3000 BC, and in 20th century America, their construction began on a large scale. This has left our country with upward of 82,000 dams large enough to be regulated. However, in recent years we have begun to realize the potentially devastating effects these existing dams can have on the environment. Despite this, many existing dams will not be removed in the immediate future, due to the numerous difficulties in removing dams and the myriad of benefits they provide. For these dams, the question becomes, can we gain additional utility from this existing infrastructure without causing further damage to our environment?

One possible way to extract this additional utility with minimal negative impact is to use existing dams to produce hydropower. Only about 3% of regulable dams are used to generate hydropower. With new developments in Advanced Updraft Hydroturbines, retrofitting these existing dams to generate hydropower is quickly becoming an attractive solution. Compared to conventional turbines, Advanced Updraft Hydroturbines feature numerous improvements, such as lower fish mortality rates, better aeration of water, higher energy efficient, and easier installation processes. This new technology has already been implemented to generate electricity for communities along the Ohio River, where dams used for navigating the river are vital to local economies.

Overall, retrofitting existing dams for hydroelectric generation provides an alternative clean energy source and a large economic advantage with minimal additional environmental interference.



Retrofitting Existing Dams to Generate Hydroelectric Power

Kentaro Mori (CE 321, 2019), Kari Schultheis (CE 321, 2019), Charles McCooe (ECON 202, 2017)

Objective

To determine the viability of generating electricity through retrofitting non-powered dams when removal in the near future is impractical

Traditional Hydro Power: Pros and Cons

Pros:

- Consistent and sustainable energy
- No air pollution or greenhouse gases released
- No sophisticated battery system required

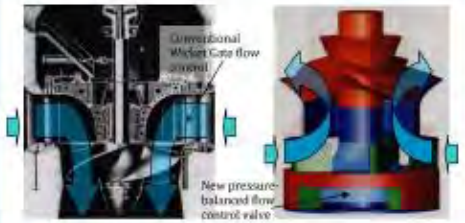
Cons:

- Turbines result in high fish mortality
- Often produce unnatural and harmful balances of dissolved gases
- Requires the construction of new dams

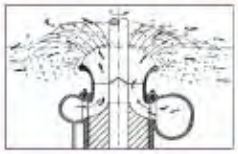
Retrofitting

- Installing turbines on non-powered dams allows for energy production.
- Additional utility is gained from existing infrastructure.
- High marginal benefit and low marginal cost
- Only 3% of regulated US dams currently produce hydropower.

Advanced Updraft Hydroturbines



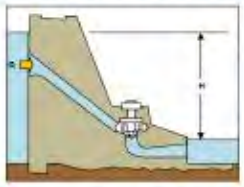
- Reduces fish mortality
  - Eliminates flow cavitation, reducing pressure spikes
  - Wider open flow passage
- Improves aeration of exiting water



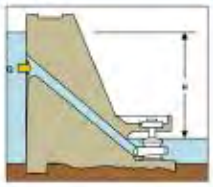
Schematic drawing of updraft hydroturbine operation

Air-water mixing and air entrainment in action

- Less energy loss compared to traditional hydropower
- Installed outside of dam
  - Reduces installation cost
  - Makes retrofitting and maintenance easier
  - Can be applied to a wider range of dams
  - Does not interfere with structural integrity



Conventional downdraft turbine



New updraft flow turbine

Successful Installation

- Retrofitting of dams along the Ohio River, constructed for navigation in 1950's and 1960's
- Total cost: $1.9 billion
- Total power production: 350 MW - enough to supply 350,000 homes
- Estimated to last 70 years

Economics

- Investment costs have fallen over time due to technological innovation.
- Energy demand and the willingness to pay have risen over time.
- Electric grids and populations have spread to the areas near existing dams, providing the necessary infrastructure for retrofitting.

Cost Comparison Between Energy Production Methods

Energy Production Method	Total System Cost (2011 $/MWh)
Retrofitted Hydroelectric Power	
Townshend Dam (VT)	45
Middlebury Upper Dam (VT)	61
Red Rock Dam (VT)	14
Traditional Hydroelectric Power	90.3
Wind Power	86.6
Photovoltaic Solar Power	144.3
Conventional Coal	100.1
Natural Gas Combustion Turbine	130.3
Nuclear	108.4

Conclusion

- Retrofitting should be considered when removal of a dam is not an option.
- Retrofitting is becoming more technologically and economically viable.
- Retrofitting has the potential to provide large economic advantage with minimal negative environmental impact.

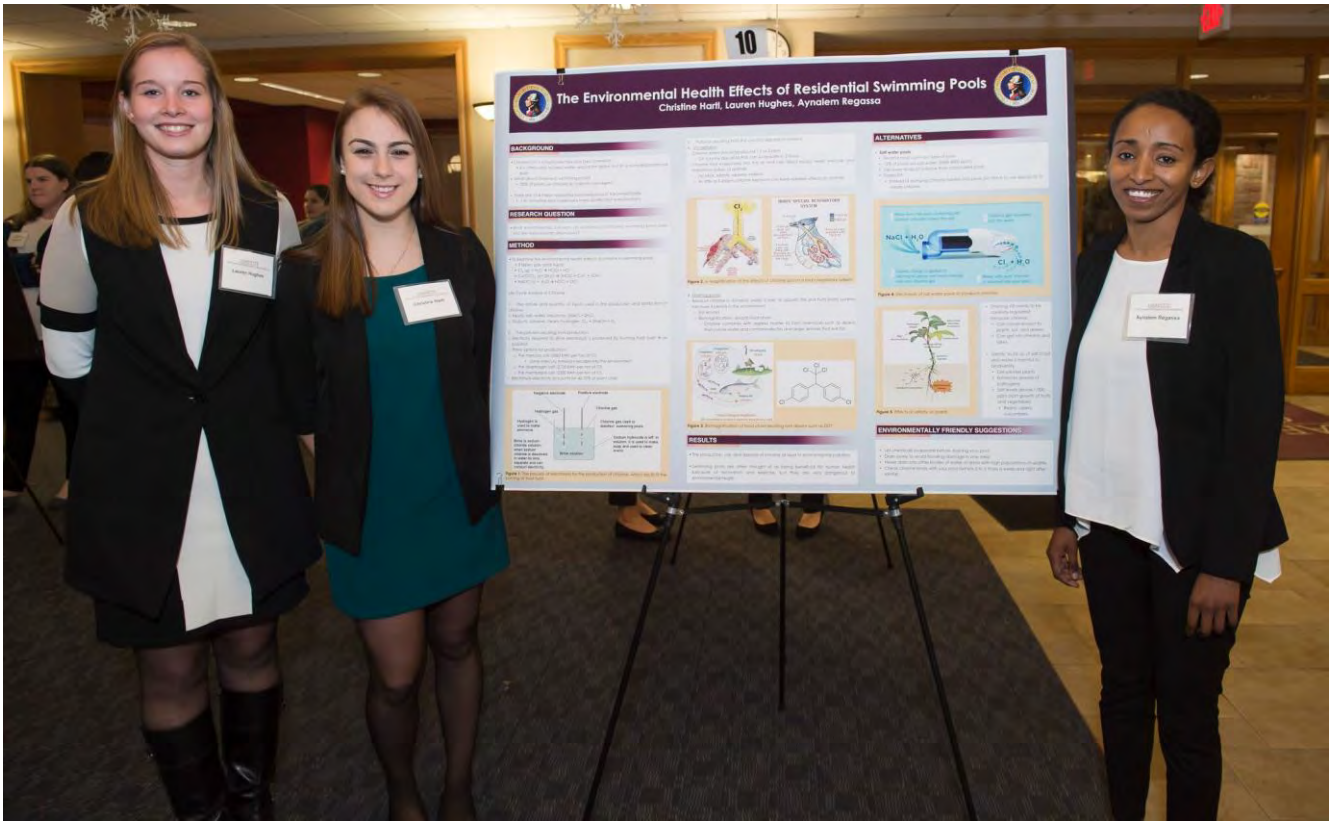
Poster #15

The Environmental Health Effects of Residential Swimming Pools

Christine Hartl, Lauren Hughes, and Aynalem Regassa

Water scarcity is a major challenge facing our world today, which is why it is critical for contemporary society to be cautious of its use and consumption. Chemicals are often used to sanitize contaminated water so that we can efficiently utilize our available water sources and minimize water waste. For example, chlorine is used to clean wastewater and drinking water around the globe, but at a controlled and balanced level. What about chlorine in residential swimming pools though? What effects can this toxic chemical have on the environment when it is not as carefully controlled and regulated as it is in an industrial setting?

This poster examines the environmental effects of chlorine in swimming pools and concludes, through the life cycle analysis of chlorine, that the production, use, and disposal of this chemical is detrimental to the health of the environment. Thus, we examine the second most common sanitation method to chlorinated pools, salt water generators, to determine if they are a cleaner alternative. Based off of our results, we end with suggestions to make residential pools more environmentally friendly.



The Environmental Health Effects of Residential Swimming Pools

Christine Hartl, Lauren Hughes, Aynalem Regassa

BACKGROUND

- Chlorine (Cl) is a highly reactive and toxic chemical
  - It is often used to clean water around the globe, but at a controlled balanced level
- What about chlorine in swimming pools?
  - 85% of pools use chlorine as a disinfectant agent

- There are 10.4 million residential swimming pools in the United States
  - 1 in 10 routine pool inspections have disinfectant level violations

RESEARCH QUESTION

- What environmental concerns do residential chlorinated swimming pools pose and are there cleaner alternatives?

METHOD

- To examine the environmental health effects of chlorine in swimming pools
  - 3 types: gas, solid, liquid
  - Cl_2 (g) + H_2O → HOCl + HCl
  - $Ca(ClO)_2$ (s) + $2H_2O$ → $2HClO + Ca^{2+} + 2OH^-$
  - NaOCl (l) + H_2O → HOCl + OCl

Life Cycle Analysis of Chlorine

1. The nature and quantity of inputs used in the production and distribution of chlorine
   - Inputs: salt, water, electricity: $2NaCl + 2H_2O$
   - Outputs: chlorine, steam, hydrogen: $Cl_2 + 2NaOH + H_2$

2. The pollution resulting from production
   - Electricity required to drive electrolysis is produced by burning fossil fuels → air pollution
   - Three options for production:
     - the mercury cell (3360 kWh per ton of Cl)
       - some mercury emissions escape into the environment
     - the diaphragm cell (2720 kWh per ton of Cl)
     - the membrane cell (2500 kWh per ton of Cl)
   - Electrolysis electricity accounts for 40-70% of plant costs

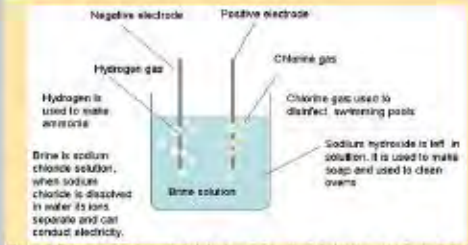


Figure 1. The process of electrolysis for the production of chlorine, which results in the burning of fossil fuels

3. Pollution resulting from the use and disposal of chlorine

A. UV radiation:
- Chlorine levels should be around 1.5 to 3 ppm
  - On a sunny day all of that can evaporate in 2 hours
- Chlorine that evaporates into the air and can affect blood, heart, immune, and respiratory system of animals
  - Ex) birds, rabbits, squirrels, rodents
  - As little as 0.4 ppm chlorine exposure can have adverse effects on animals

Figure 2. A magnification of the effects of chlorine gas on a bird's respiratory system

B. Draining pools:
- Residual chlorine in domestic water is toxic to aquatic life and hurts biotic systems because it persists in the environment
  - Soil erosion
  - Biomagnification: disrupts food chain
    - Chlorine combines with organic matter to form chemicals such as dioxins that pollute water and contaminate fish and larger animals that eat fish

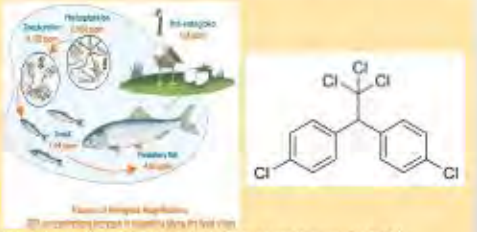


Figure 3. Biomagnification of food chain resulting rom dioxins such as DDT

RESULTS

- The production, use, and disposal of chlorine all lead to environmental pollution

- Swimming pools are often thought of as being beneficial for human health because of recreation and exercise, but they are very dangerous to environmental health

ALTERNATIVES

- **Salt water pools**
  - Second most common type of pool
  - 12% of pools are salt water (2500-4000 ppm)
  - Use lower levels of chlorine than chlorinated pools
  - Tradeoff?
    - Instead of dumping chlorine tablets into pools you have to use electricity to create chlorine

Figure 4. Electrolysis of salt water pools to produce chlorine

Figure 5. Effects of salinity on plants

- Draining still needs to be carefully regulated because chlorine...
  - Can cause erosion to plants, soil, and sewers
  - Can get into streams and lakes

- Salinity, build up of salt in soil and water is harmful to biodiversity
  - Dehydrates plants
  - Enhances spread of pathogens
  - Salt levels above 1,000 ppm stunt growth of fruits and vegetables
    - Beans, celery, cucumbers

ENVIRONMENTALLY FRIENDLY SUGGESTIONS

- Let chemicals evaporate before draining your pool
- Drain slowly to avoid flooding/damage in one area
- Never drain into other bodies of water or areas with high populations of wildlife
- Check chlorine levels with your pool test kits 2 to 3 times a week and right after rainfall

Poster #16

Analysis of Water Desalination for Agricultural use in California

Rojhae Panton, Kate Wickersham, and Kayla Zola

As water scarcity becomes increasingly pressing in California and other drought ridden areas, innovative means of supplying water are necessary. A proposed solution is water desalination. Research was conducted to analyze whether or not desalinated water can be used to ameliorate the effects of the drought on agriculture in California. The analysis included an in-depth evaluation of desalination technologies, use of desalinated water for agricultural production, and a Spanish case study. Economic and environmental factors were also considered. It was found that safe levels of salinity are not consistent across all crop types, and that some key cash crops in California are exceptionally sensitive to even small levels of salinity. It was also determined that reverse osmosis is the most viable desalination method due to the potential for decreased energy costs with improvements in technology and flexibility in the composition of water output. Since crops have a varying sensitivity to salinity, the ability to efficiently control salinity of water output is critical. In assessing the success of desalination in Spain, the reverse osmosis process was proven to be efficient and economically successful. Challenges will arise from brine disposal, emission control, and economic viable of desalination plants. Investments should be allocated toward research and development rather than providing subsidies.

Analysis of Water Desalination for Agricultural use in California

Rojhae Panton, Kate Wickersham, Kayla Zola | 8 December, 2016

Can water desalination mitigate the effect of the drought on agriculture in California?

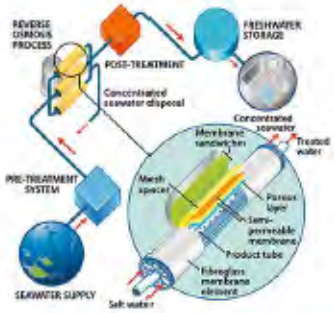
Drought Effects

- Losses: $2.7 billion in revenue, 21,000 jobs
- Increased pumping costs
- Land fallowing
- Losses in the livestock and dairy sectors

Desalination Technologies

- Initially, desalination technology was very expensive
- Primarily used domestically, not for commercial agriculture
- Desalination technologies: Reverse Osmosis (RO), Electro-dialysis Reversal, Distillation
- RO is the best treatment option for agriculture
  - Flexible technology
  - Huge cost reduction potential from improved energy efficiency
  - New developments will use fewer materials and chemicals
  - Technologically feasible, but economic and environmental limitations

Reverse Osmosis Process



Spanish Case Study

- Tedagua: World leader in water desalination technology, engineers RO plants
  - Recovery rate for desalination: 35% to 51%
  - Cost range: $0.59/m³ to $0.77/m³ (depending on unit and operating conditions)
  - Plant production capacity: 10,000 m³/day
- Modular units privately owned with some contribution from regional governments
- Differences in water standards for agricultural and domestic use
  - Boron Sensitive Crops: Safe level for agriculture is half that of drinking water standards
- Proven benefits of RO: water use reduction, increased yield, reduce fertilizer use
- Farmers pay less than 1% of total costs due to government subsidies

Spain and California have similar climates, yield comparable crops, and face similar issues

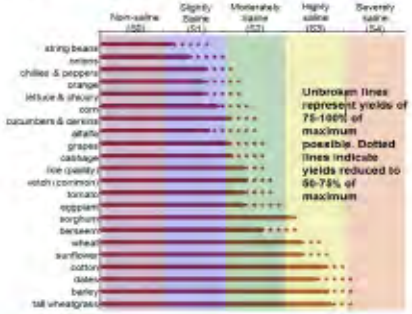
Chemical Content of Water

- RO reduces water salinity but also takes out other chemicals
- Chemicals naturally in freshwater removed during RO: Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Sulfates (SO_4^{-2})
  - Nutrient levels higher in irrigation water than desalinated water
- Boron (B): can pass through RO membrane
  - Not an issue for domestic use but can harm crops in excess

Crop Use

- Grapes and oranges: yield reduction at moderate salinity
  - CA grows 90% of USA's grapes, second only to Florida in orange production
- Tomatoes, wheat, and corn: moderate to high tolerance
- Oranges and tomatoes are especially sensitive to Boron
- Mg^{2+} deficiencies cause harm to basil, tomatoes, flowers

Grape leaf damage from highly saline water

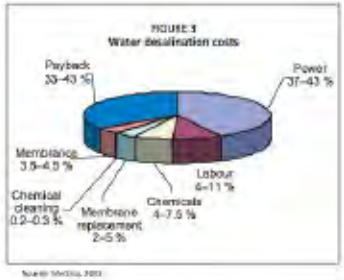


Social and Political Considerations

- Implications associated with public and private ownership
- Government investment in research and development instead of subsidies
- Job creation from construction and operation of plants
- Plant contributions to air, water, and noise pollution
- Environmental injustice caused by location of desalination plant
- Adjustment of water quality standards depending on intended use
- Undefined ocean property rights

Economic Costs

- Main costs of desalination: energy and initial investments
- Cost of desalination has decreased: $4/m³ to less than $1/m³
- Improving RO membranes has lead to 80% reduction in energy consumption, reducing overall cost
- Water transportation increases costs to the consumer
- Lower economic costs by increasing economies of scale



Environmental Costs

- Brine Disposal: Brine is discharged back into the ocean, potentially harming marine habitats
- Contamination of surface water and aquifers due to incorrect chemical disposal and leakage
- Greenhouse gas emissions from desalination plants
- Habitat destruction from plants construction
- Subsurface intake of salt water inadvertently kills fish species, microbial organisms, and other marine life

Poster #17

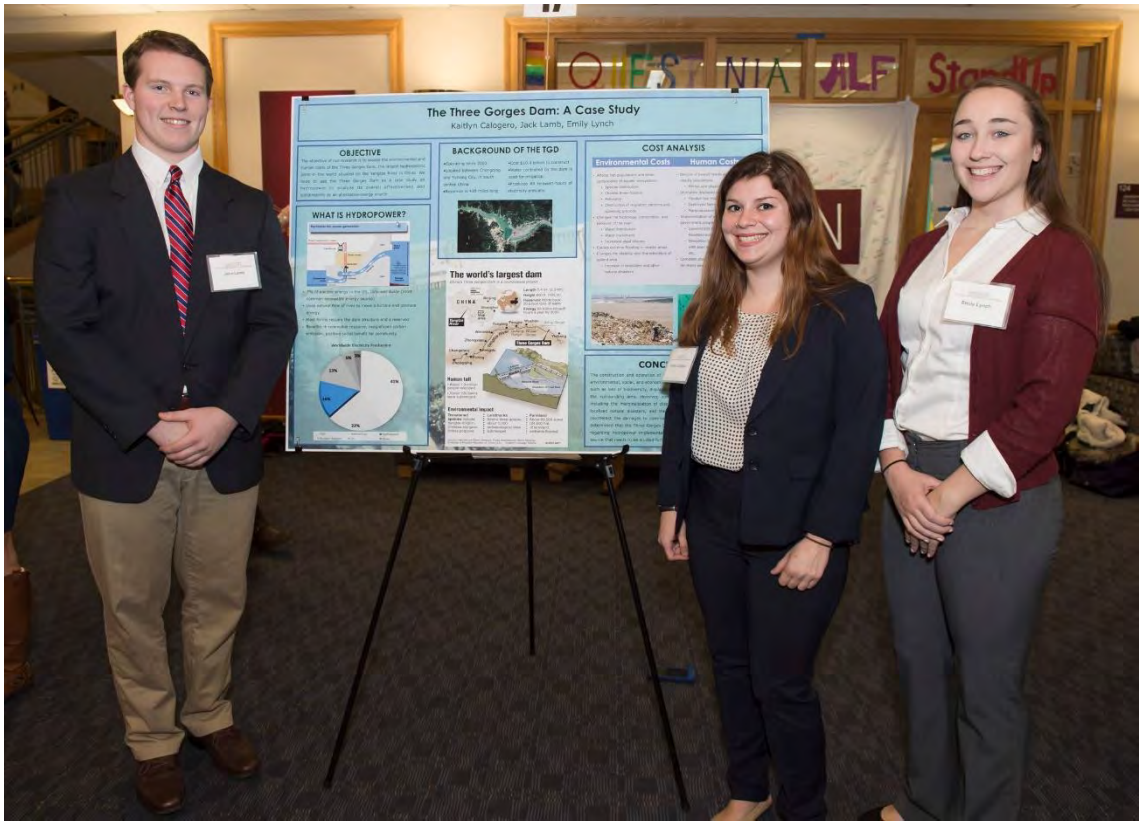
The Three Gorges Dam: A Case Study

Kaitlyn Calogero, Jack Lamb, and Emily Lynch

In the wake of global climate change, hydroelectric power is currently the leading source of renewable energy, contributing 16% of the world's electric energy. However, there are a number of externalities associated with the implementation of hydroelectric plants. The goal of our project is to examine the costs associated with hydroelectric power through a case study of the Three Gorges Dam-- the largest hydroelectric plant project in the world, located on the Yangtze River in China.

The types of costs that we wish to focus on include general environmental costs and human costs. Human costs include social and economic costs, as well as damages to the overall quality of life of the people located near the Three Gorges Dam. These costs arise from changes in landscape and societal structure due to the creation of this dam. Environmental costs arise from the consequent interruption of river flow and drastic changes in the aquatic and terrestrial ecosystems both at the site of the dam and downstream.

Our examination of the Three Gorges Dam is intended to show the overall costs and damages of hydroelectric power on the aggregate level. By examining the serious issues associated with what is considered to be the most famous example of hydroelectric power, we hope to prove that this energy source needs to be further analyzed before being considered a sustainable alternative to fossil fuels.



The Three Gorges Dam: A Case Study

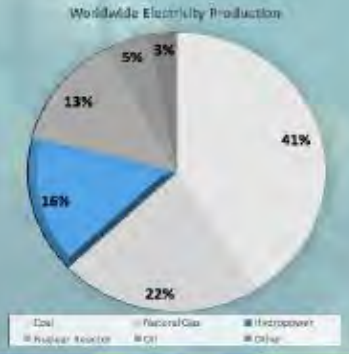
Kaitlyn Calogero, Jack Lamb, Emily Lynch

OBJECTIVE

The objective of our research is to assess the environmental and human costs of the Three Gorges Dam, the largest hydroelectric plant in the world situated on the Yangtze River in China. We hope to use the Three Gorges Dam as a case study on hydropower to analyze its overall effectiveness and sustainability as an alternative energy source.

WHAT IS HYDROPOWER?

- 7% of electric energy in the US, 16% worldwide (most common renewable energy source)
- Uses natural flow of river to move a turbine and produce energy
- Most forms require the dam structure and a reservoir
- Benefits → renewable resource, insignificant carbon emission, positive social benefit for community

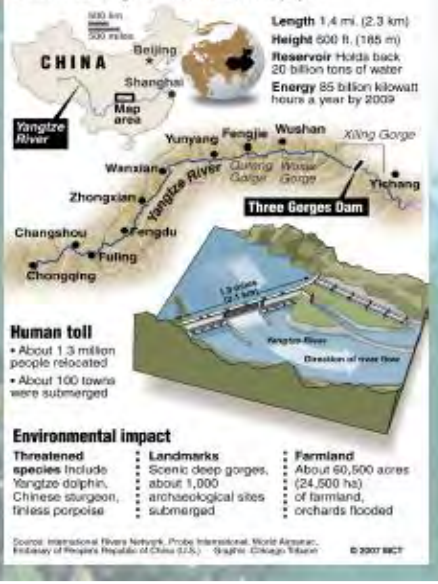


BACKGROUND OF THE TGD

- Operating since 2003
- Located between Chongqing and Yichang City, in south-central China
- Reservoir is 410 miles long
- Cost $10.4 billion to construct
- Water controlled by the dam is used for irrigation
- Produces 84 terawatt-hours of electricity annually

The world's largest dam

China's Three Gorges Dam is a controversial project.



COST ANALYSIS

Environmental Costs	Human Costs

• Affects fish populations and other components of aquatic ecosystems
  ◦ Species distribution
  ◦ Chinese River Dolphin
  ◦ Pollutants
  ◦ Obstruction of migration patterns and spawning grounds
• Changes the hydrology, composition, and behavior of the river
  ◦ Water distribution
  ◦ Water movement
  ◦ Increased algal blooms
• Causes extreme flooding in nearby areas
• Changes the stability and characteristics of upland area
  ◦ Increase in landslides and other natural disasters
	• Decline of overall health and well-being of nearby populations
	  ◦ Mental and physical health
	• Ultimately displaced millions of people
	  ◦ Flooded two major cities
	  ◦ Destroyed farmland
	  ◦ Marginalization of displaced groups
	• Implementation of costly, yet ineffective government programs
	  ◦ Government-Organized Distant Resettlement Program
	  ◦ Relocation to less desirable locations with poor access to education, jobs, etc.
	• Complete change in way and quality of life for many people

CONCLUSIONS

The construction and operation of the Three Gorges Dam has caused numerous environmental, social, and economic damages. These include more obvious effects such as loss of biodiversity, displacement of human populations, and flooding of the surrounding area. However, some less noticeable changes also occurred including the marginalization of displaced farmers, the potential for increased localized natural disasters, and the resulting government spending needed to counteract the damages to communities and landscapes in the area. We have determined that the Three Gorges Dam should serve mainly as a cautionary tale regarding hydropower implementation, and that this is an alternative energy source that needs to be studied further before being implemented worldwide.

Poster #18

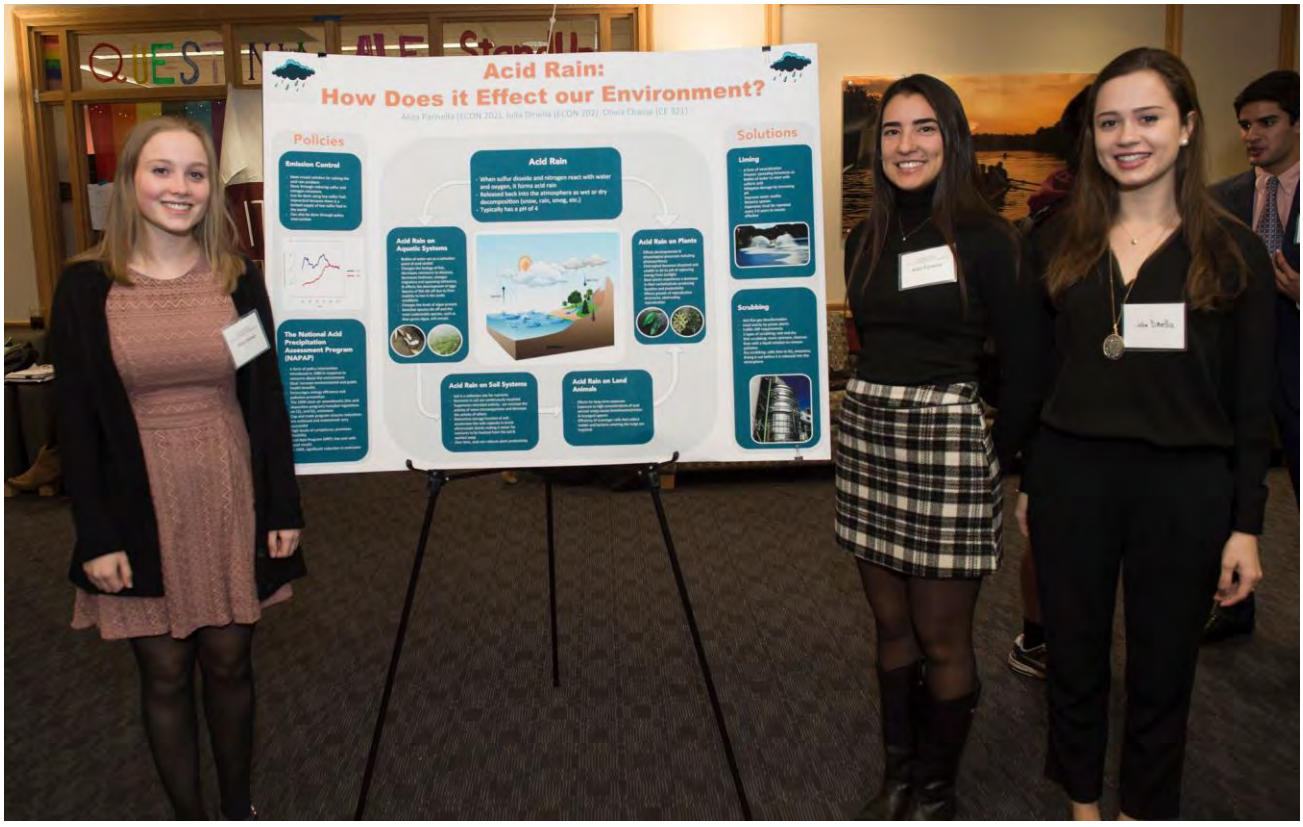
Acid Rain: How Does it Effect our Environment?

Olivia Chassé, Julia Dinella, and Aliza Parisella

Acid rain is developed when Sulfur Dioxide and Nitrogen Oxide are mixed with water and oxygen in our atmosphere. Bodies of water, animals, soil, and plants are all impacted by the acidity in the rain. Acid rain has a domino effect on our ecosystem. Disturbing the natural process of one system or species can lead to complications in another, such as acidity in the soil leading to a reduction of plant productivity. Most noticeably, acid rain affects our aquatic systems by changing the biology of fish as well as controlling the living species of algae.

Some of the main forms of control for acid rain are neutralization and scrubbing. Neutralization (aka liming) is a relatively expensive process that entails spreading limestone on large bodies of water for counteracting the acidity. Scrubbing is a more common abatement method that involves cleaning power plant flues with lime solution to prevent SO2 emissions from entering the atmosphere.

Policy intervention in the form of emission control has been the most effective way of monitoring the effects of acid rain. The National Acid Precipitation Assessment Program (NAPAP) was introduced in 1980 and regulations on carbon and sulfur emissions were included in the 1990 clean air amendments. This cap and trade program has encouraged energy efficiency and pollution prevention and ensures reductions in emissions are achieved and maintained. These policies have been very successful because the system promotes flexibility and high levels of compliance. It is a low cost system, with very good results.



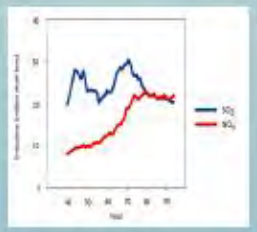
Acid Rain: How Does it Effect our Environment?

Aliza Parisella (ECON 202), Julia Dinella (ECON 202), Olivia Chassé (CE 321)

Policies

Emission Control

- Most crucial solution for solving the acid rain problem
- Done through reducing sulfur and nitrogen emissions
- Can be done using low sulfur fuel; impractical because there is a limited supply of low sulfur fuel in the world
- Can also be done through policy intervention



The National Acid Precipitation Assessment Program (NAPAP)

- A form of policy intervention
- Introduced in 1980 in response to concerns about the environment
- Goal: Increase environmental and public health benefits
- Encourages energy efficiency and pollution prevention
- The 1990 clean air amendments (the acid deposition program) included regulations on CO_2 and SO_2 emissions
- Cap and trade program ensures reductions are achieved and maintained; very successful
- High levels of compliance; promotes flexibility
- Acid Rain Program (ARP): low cost with good results
- In 2008, significant reduction in emissions

Acid Rain

- When sulfur dioxide and nitrogen react with water and oxygen, it forms acid rain
- Released back into the atmosphere as wet or dry decomposition (snow, rain, smog, etc.)
- Typically has a pH of 4

Acid Rain on Aquatic Systems

- Bodies of water act as a collection point of acid rainfall
- Changes the biology of fish, decreases resistance to diseases, decreases liveliness, changes migratory and spawning behaviors, & effects the development of eggs
- Species of fish die off due to their inability to live in the acidic conditions
- Changes the kinds of algae present
- Sensitive species die off and the most undesirable species, such as blue-green algae, will remain

Acid Rain on Plants

- Effects developmental & physiological processes including photosynthesis
- Chlorophyll becomes bleached and unable to do its job of capturing energy from sunlight
- Bean plants experience a decrease in their carbohydrate-producing function and productivity
- Effects growth of reproductive structures, obstructing reproduction

Acid Rain on Soil Systems

- Soil is a collection site for nutrients
- Nutrients in soil are continuously recycled
- Suppresses microbial activity; can increase the activity of some microorganisms and decrease the activity of others
- Diminishes storage function of soil; accelerates the soils capacity to break electrostatic bonds making it easier for nutrients to be leached from the soil & washed away
- Over time, acid rain reduces plant productivity

Acid Rain on Land Animals

- Effects for long-term exposure
- Exposure to high concentrations of acid aerosol smog causes bronchoconstriction & laryngeal spasms
- Efficiency of scavenger cells that collect matter and bacteria entering the lungs are impaired

Solutions

Liming

- A form of neutralization
- Process: spreading limestone on bodies of water to react with sulfuric acid
- Mitigates damage by increasing pH
- Improves water quality
- Restores species
- Expensive; must be repeated every 3-5 years to remain effective

Scrubbing

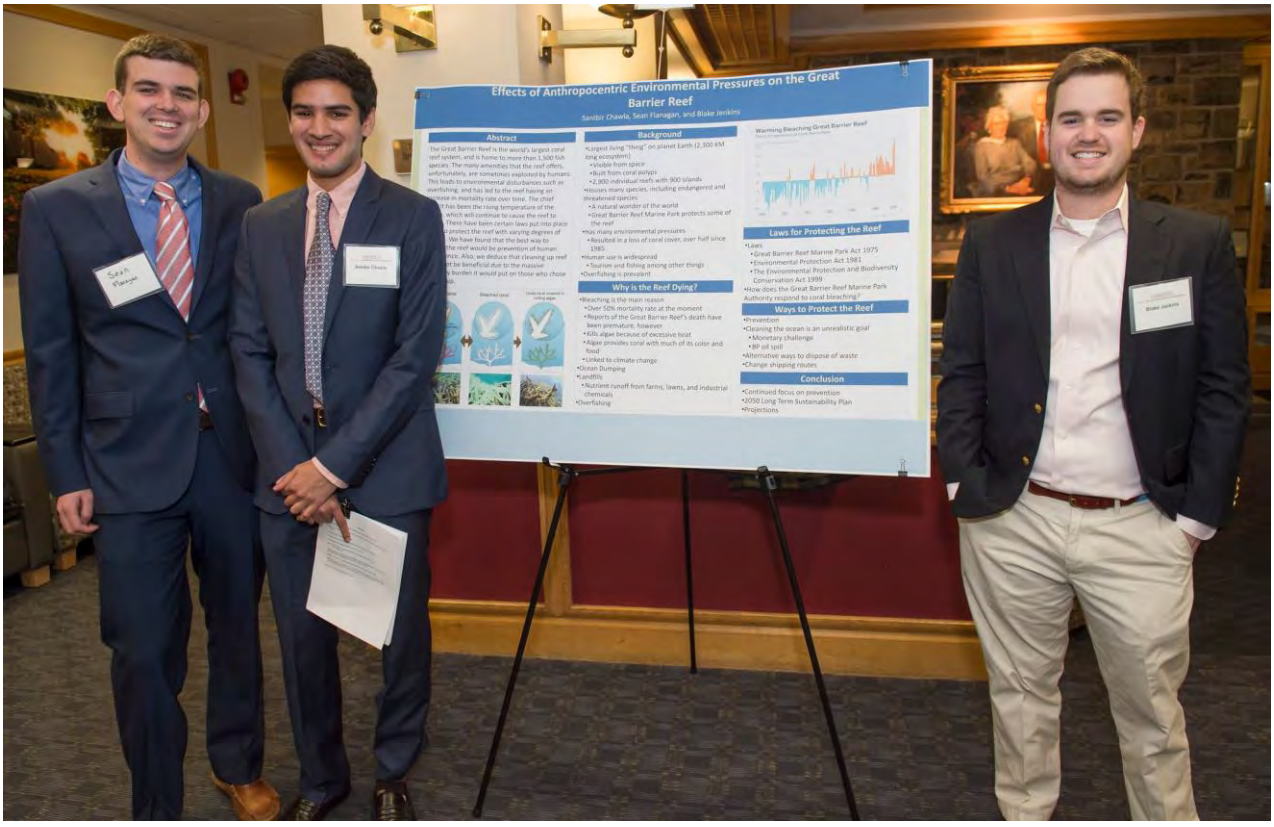
- AKA flue gas desulfurization
- Used mainly by power plants
- Fulfills ARP requirements
- 2 types of scrubbing: wet and dry
- Wet scrubbing: more common, cleanses flues with a liquid solution to remove pollution
- Dry scrubbing: adds lime to SO_2 emissions, drying it out before it is released into the atmosphere

Poster #19

Effects of Anthropocentric Environmental Pressures on the Great Barrier Reef

Santbir Chawla, Sean Flanagan, and Blake Jenkins

The main focus of the poster will be the effect of ocean dumping on the Great Barrier Reef. The Great Barrier Reef, located off the coast of Queensland, Australia, is the world's largest coral reef system. Unfortunately, the Great Barrier Reef is dying at a rapid rate, which is estimated to be around 50%. A main reason why the Great Barrier Reef is dying is because of ocean bleaching and ocean dumping, which disturbs the life cycle and marine ecosystems. The increased temperature of the ocean is causing the corals to expel algae that are supposed to remain within their tissues. These algae, called zooxanthellae, give the coral much of its color and food. If bleaching continues, the organisms will continue to die off. We will try to analyze what laws have been put into place to try and prevent ocean dumping to protect the marine life. Furthermore, we will try to see if there are any alternatives to ocean dumping, such as landfills and incineration of waste. Also, it is too expensive and inefficient to clean up; as a result, cleaning up the ocean and the Great Barrier Reef is an unrealistic goal. As an example of the massive cost to clean oceans, it is estimated that it would take $489 million a year to clean up just 1% of the North Pacific Ocean. We will propose that the main focus should be preventing ocean dumping.



Effects of Anthropocentric Environmental Pressures on the Great Barrier Reef

Santbir Chawla, Sean Flanagan, and Blake Jenkins

Abstract

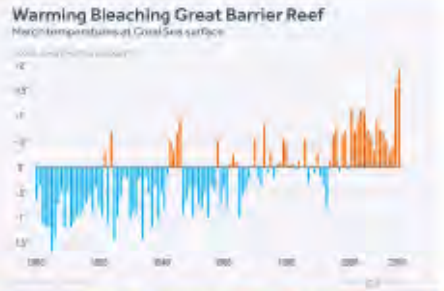
The Great Barrier Reef is the world's largest coral reef system, and is home to more than 1,500 fish species. The many amenities that the reef offers, unfortunately, are sometimes exploited by humans. This leads to environmental disturbances such as overfishing, and has led to the reef having an increase in mortality rate over time. The chief culprit has been the rising temperature of the ocean, which will continue to cause the reef to perish. There have been certain laws put into place to try to protect the reef with varying degrees of success. We have found that the best way to protect the reef would be prevention of human interference. Also, we deduce that cleaning up reef would not be beneficial due to the massive monetary burden it would put on those who chose to clean up.

Background

- Largest living "thing" on planet Earth (2,300 KM long ecosystem)
  - Visible from space
  - Built from coral polyps
  - 2,900 individual reefs with 900 islands
- Houses many species, including endangered and threatened species
  - A natural wonder of the world
  - Great Barrier Reef Marine Park protects some of the reef
- Has many environmental pressures
  - Resulted in a loss of coral cover, over half since 1985
- Human use is widespread
  - Tourism and fishing among other things
- Overfishing is prevalent

Why is the Reef Dying?

- Bleaching is the main reason
  - Over 50% mortality rate at the moment
  - Reports of the Great Barrier Reef's death have been premature, however
  - Kills algae because of excessive heat
  - Algae provides coral with much of its color and food
  - Linked to climate change
- Ocean Dumping
- Landfills
  - Nutrient runoff from farms, lawns, and industrial chemicals
- Overfishing



Laws for Protecting the Reef

- Laws
  - Great Barrier Reef Marine Park Act 1975
  - Environmental Protection Act 1981
  - The Environmental Protection and Biodiversity Conservation Act 1999
- How does the Great Barrier Reef Marine Park Authority respond to coral bleaching?

Ways to Protect the Reef

- Prevention
- Cleaning the ocean is an unrealistic goal
  - Monetary challenge
  - BP oil spill
- Alternative ways to dispose of waste
- Change shipping routes

Conclusion

- Continued focus on prevention
- 2050 Long Term Sustainability Plan
- Projections

Posters #20

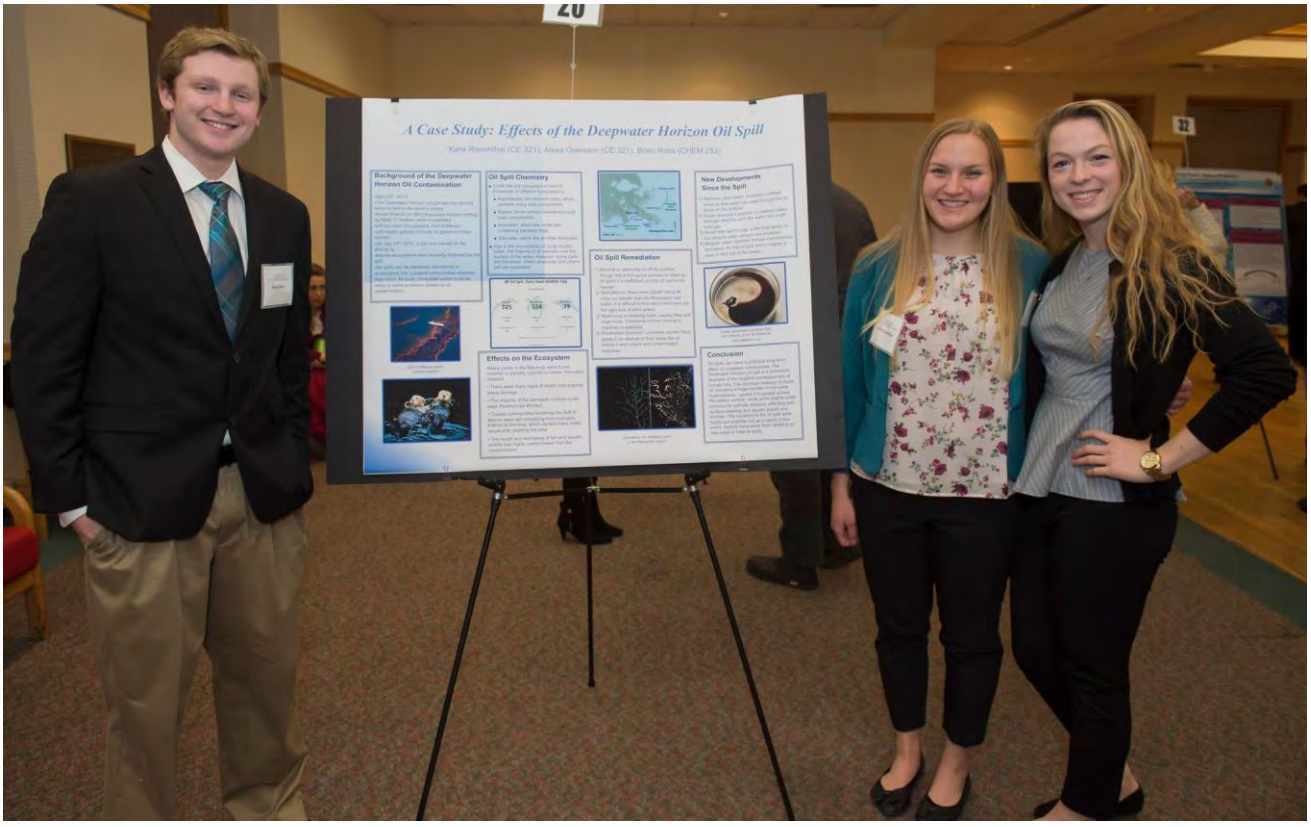
A Case Study: Effects of the Deepwater Horizon Oil Spill

Alexa Overeem, Kara Rosenthal, and Brian Ross

Oil spills tend to receive a large amount of media coverage because they are quite catastrophic, and this was true for the Deepwater Horizon Oil Spill. Our group focused on the chemistry, effects on ecosystems, remediation efforts, and the impacts of this oil spill on researchers and how new methods of cleaning up oil spills were developed.

From a chemical perspective, oil spills have a profound effect on the environment. The variety of hydrocarbons that make up crude oil lead to a large variety of possible chemical reactions when they come to mix with ocean water. For instance, some will form stable emulsions when mixed with water, while others will sink in water, and others still will be so light that they float on the surface of the water and evaporate due to relatively low intermolecular forces. Despite this, large oil spills have direct effects on the environment and living things. For instance, the most profoundly affected groups are those found regularly on the surface of the water, where the majority of the hydrocarbons settle, such as sea otters and seabirds. Corals are also influenced from the oil and many acquired tissue damage from this spill.

In our project, we will also discuss the remediation attempted to cease and clean up the spill. The Deepwater Horizon Oil Spill was mitigated by the construction of barrier sand berms, the restriction or blocking of inlets, and the diversion of freshwater from rivers into oceans.



A Case Study: Effects of the Deepwater Horizon Oil Spill

Kara Rosenthal (CE 321), Alexa Overeem (CE 321), Brian Ross (CHEM 252)

Background of the Deepwater Horizon Oil Contamination

- April 20th, 2010
- The Deepwater Horizon oil spill was the second worst oil spill in the world's history
- British Petroleum (BP) Deepwater Horizon drilling rig killed 11 workers when it exploded
- Off the coast of Louisiana, Gulf of Mexico
- 200 million gallons of crude oil spilled for three months
- On July 15th, 2010, a cap was placed on the drilling rig
- Marine ecosystems were severely impacted by the spill
- Oil spills can be extremely detrimental to ecosystems and coastline communities wherever they occur. As such, immediate action must be taken to solve problems related to oil contamination.

Gulf of Mexico post-contamination

Oil Spill Chemistry

- Crude oils are composed of tens of thousands of different hydrocarbons.
  - Asphaltenes, the heaviest class, which contains many solid components
  - Resins, which contain several acid and base components
  - Aromatics, which are molecules containing benzene rings
  - Saturates, which are all other molecules
- Due to the immiscibility of crude oil and water, the majority of oil spreads over the surface of the water. However, some parts are dissolved, others evaporate and others still are emulsified

Effects on the Ecosystem

- Many corals in the Macando were found covered or partially covered in brown, flocculent material
- There were many signs of recent and ongoing tissue damage
- The majority of the damaged colonial corals were *Paramuricea Biscaya*
- Coastal communities bordering the Gulf of Mexico were still recovering from hurricane Katrina at this time, which caused many more issues with cleaning the area
- The health and well-being of fish and aquatic wildlife was highly compromised from the contamination

Oil Spill Remediation

1) Burning or skimming oil off the surface; though this is the typical process to clean up oil spills it is inefficient and the oil cannot be reused
2) Sand Berms; these were placed along 46 miles on islands near the Mississippi river outlet. It is difficult to find sand inland and use the right size of sand grains
3) Restricting or blocking inlets; usually filled with large rocks, it prevents oil from moving to marshes or wetlands
4) Freshwater diversion; Louisiana opened flood gates in an attempt to flush away the oil before it went inland and contaminated estuaries

Unhealthy Vs. Healthy coral in the Macando region

New Developments Since the Spill

1) Stainless steel mesh: scientists modified mesh so that water can pass through but oil stays on the surface
2) Super absorbent polymer: a material called petrogel absorbs oil in the water into a soft solid gel
3) Smart filter technology: a film that repels oil but attracts water using a nanomaterial
4) Magnet: water repellent ferrous nanoparticles are mixed into the oil spill and a magnet is used to lift it out of the ocean

Super absorbent polymer that can absorb up to 40 times its own weight in oil

Conclusion

Oil spills can have a profound long term effect on coastline communities. The Deepwater Horizon oil spill is a prominent example of the negative consequences of human folly. The chemical makeup of crude oil, involving a huge number of non-polar hydrocarbons, causes it to spread across the waters surface, while some slightly polar compounds partially dissolve, effecting both surface-dwelling and aquatic plants and animals. The solutions to the oil spill were hastily put together but as a result of this event, experts have since been working on new ways to treat oil spills.

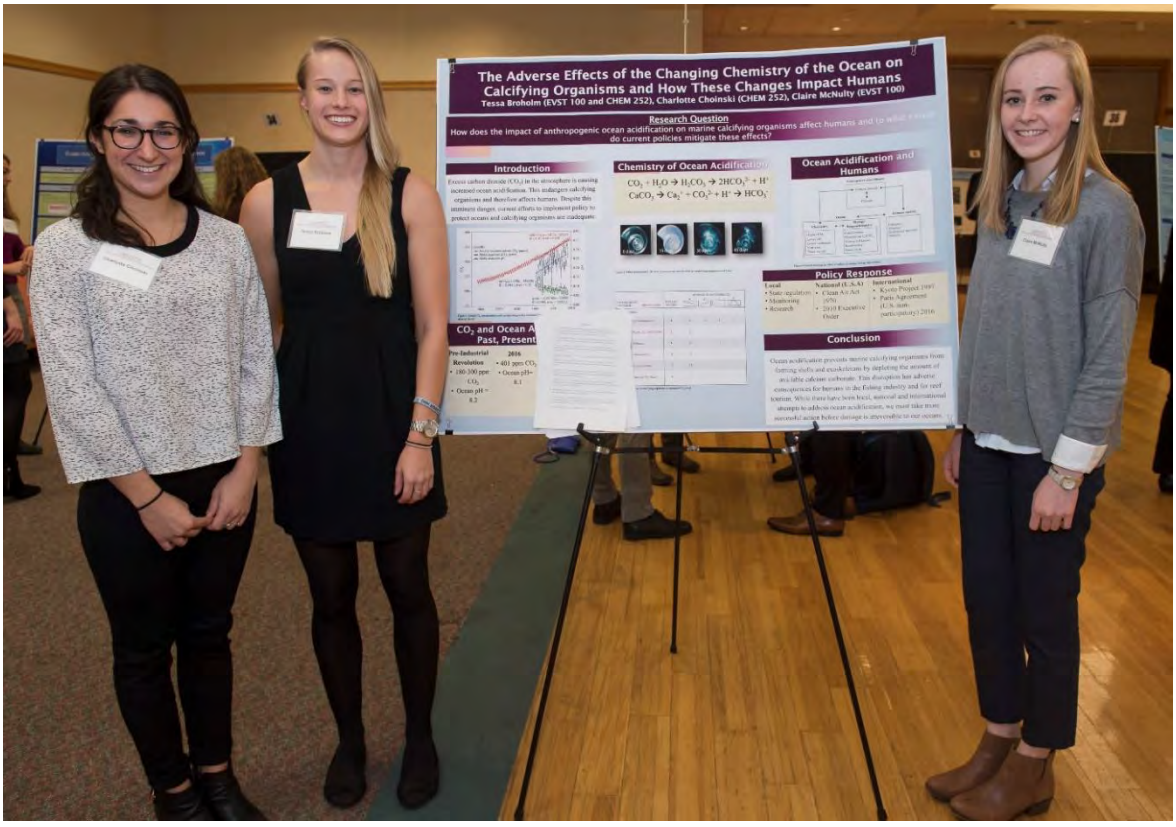
Poster #21

The Adverse Effects of the Changing Chemistry of the Ocean on Calcifying Organisms and How These Changes Impact Humans

Tessa Broholm, Charlotte Choinski, and Claire McNulty

Carbon dioxide levels are at the highest atmospheric concentration that have been recorded in the past 65,000 years and are increasing at an astounding rate. The ocean is the largest natural sink for carbon dioxide, but as CO2 dissolves in water, it dissociates into ions that lower the acidity of the ocean. As the acidity of the oceans changes, certain marine organisms, ranging from mollusks to calcifying plankton, have showed distinct losses in their calcifying ability. Calcification offers protection against predation as well as skeletal structure. Because of their inability to calcify, the species that are unable to adapt to the changing pH levels are suffering.

Calcifying organisms not only represent important parts of marine ecosystems, but they are also culturally, economically and nutritionally important to humans. Loss of these organisms could lead to the loss of human dependence on fish as a food source, marine ecosystems for ecotourism and loss of biodiversity in the oceans. The consequences for these losses could be catastrophic, yet there are no effective policies currently in place that specifically protect these organisms from ocean acidification. We must implement comprehensive policies quickly to save these organisms and preserve the wellbeing of these ecosystems—for their intrinsic value and humans' dependence on them—before it is too late.



The Adverse Effects of the Changing Chemistry of the Ocean on Calcifying Organisms and How These Changes Impact Humans

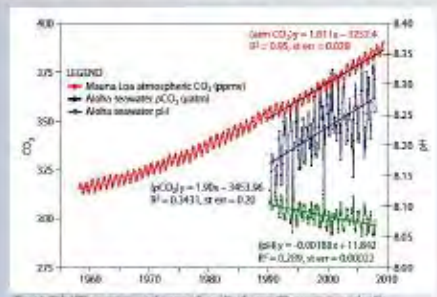
Tessa Broholm (EVST 100 and CHEM 252), Charlotte Choinski (CHEM 252), Claire McNulty (EVST 100)

Research Question

How does the impact of anthropogenic ocean acidification on marine calcifying organisms affect humans and to what extent do current policies mitigate these effects?

Introduction

Excess carbon dioxide (CO_2) in the atmosphere is causing increased ocean acidification. This endangers calcifying organisms and therefore affects humans. Despite this imminent danger, current efforts to implement policy to protect oceans and calcifying organisms are inadequate.



CO_2 and Ocean Acidification: Past, Present, Future

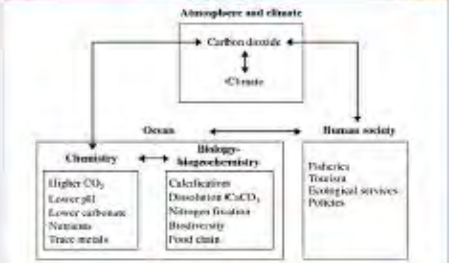
Pre-Industrial Revolution	2016	2100 Projections
• 180-300 ppm CO_2 • Ocean pH = 8.2	• 401 ppm CO_2 • Ocean pH= 8.1	• >500 ppm CO_2 • pH expected to drop 0.3-0.4 more units by the end of the century

Chemistry of Ocean Acidification

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow 2HCO_3^{2-} + H^+$$

$$CaCO_3 \rightarrow Ca_2^+ + CO_3^{2-} + H^+ \rightarrow HCO_3^-$$

Ocean Acidification and Humans



Policy Response

Local	National (U.S.A)	International
• State regulation • Monitoring • Research	• Clean Air Act 1970 • 2010 Executive Order	• Kyoto Project 1997 • Paris Agreement (U.S. non-participatory) 2016

Conclusion

Ocean acidification prevents marine calcifying organisms from forming shells and exoskeletons by depleting the amount of available calcium carbonate. This disruption has adverse consequences for humans in the fishing industry and for reef tourism. While there have been local, national and international attempts to address ocean acidification, we must take more successful action before damage is irreversible to our oceans.

Poster #22

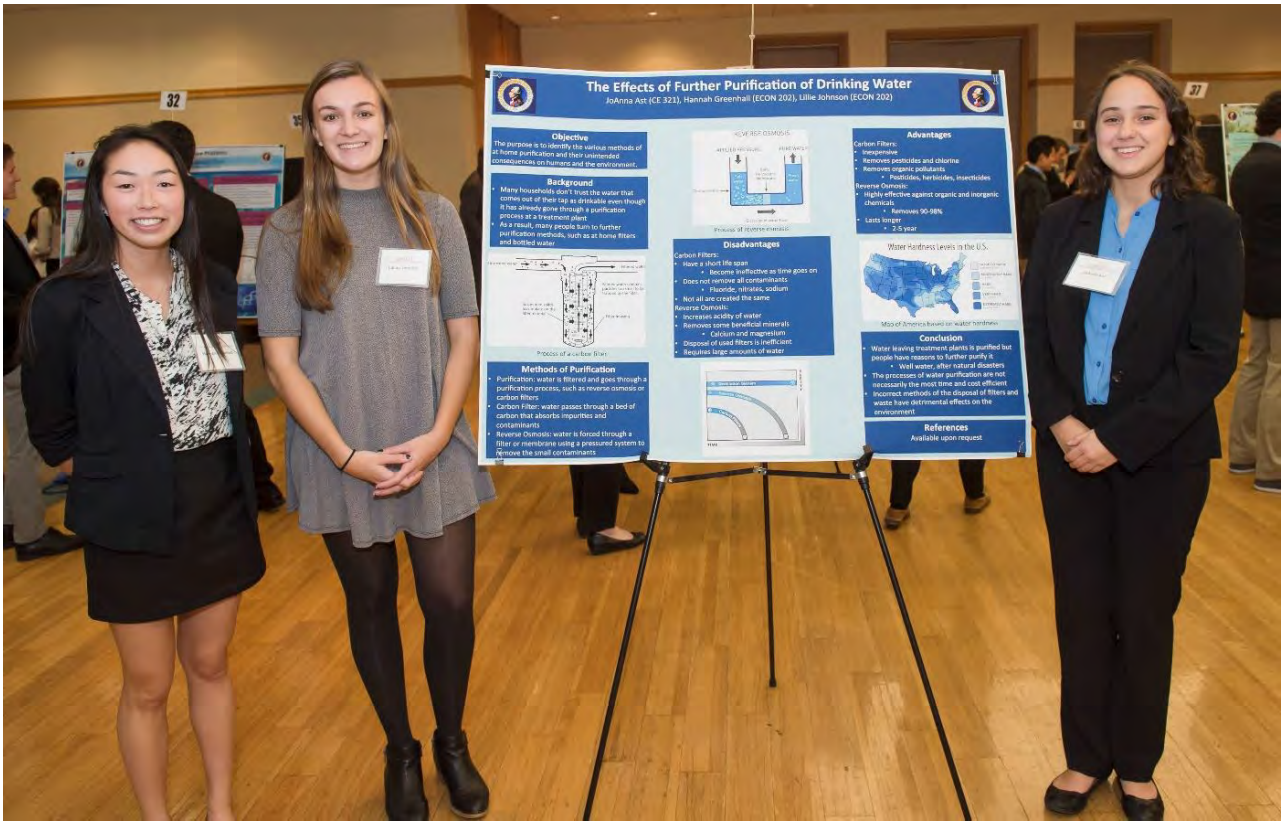
The Effects of Further Purification of Drinking Water

JoAnna Ast, Hannah Greenhall, and Lillie Johnson

In our poster, we answer the question, "Why do people decide to further purify their water?" We wanted to explore this topic due to our curiosity towards the purity of tap water and why people feel like their water is not necessarily "clean enough" and why they would need to take further action. To answer our question, we investigate small-scale techniques and determine if the benefits truly outweigh the costs.

As a basic human need, everyone should have access to safe drinking water. Although the water leaving the treatment plants goes through a vigorous purification process, many people still decide to take an extra precaution by conducting their own purification. People make this choice mainly due to their desire to eliminate the added chemicals from the treatment process but there also is a personal preference based on smell and taste. The main goal of water treatment is to remove the unwanted contaminants and pathogens but to do so, other chemicals, such as chlorine, are added as a preventative measure.

After leaving the treatment plant, continued purification can actually have adverse health effects because of the removal of possible beneficial minerals that are present in tap water. Along with this, the additional costs associated with further purification and the disposal methods lead us to the conclusion that at home remedies of purification is not necessarily cost or time efficient.



The Effects of Further Purification of Drinking Water

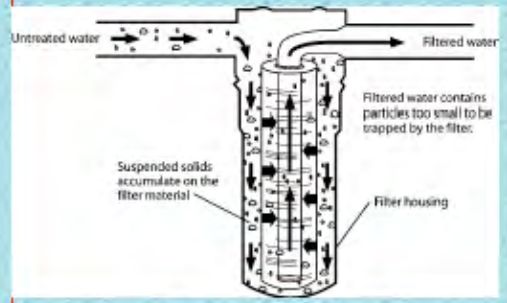
JoAnna Ast (CE 321), Hannah Greenhall (ECON 202), Lillie Johnson (ECON 202)

Objective

The purpose is to identify the various methods of at home purification and their unintended consequences on humans and the environment.

Background

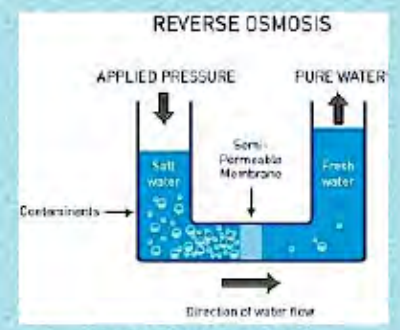
- Many households don't trust the water that comes out of their tap as drinkable even though it has already gone through a purification process at a treatment plant
- As a result, many people turn to further purification methods, such as at home filters and bottled water



Process of a carbon filter

Methods of Purification

- Purification: water is filtered and goes through a purification process, such as reverse osmosis or carbon filters
- Carbon Filter: water passes through a bed of carbon that absorbs impurities and contaminants
- Reverse Osmosis: water is forced through a filter or membrane using a pressured system to remove the small contaminants



Process of reverse osmosis

Disadvantages

Carbon Filters:

- Have a short life span
  - Become ineffective as time goes on
- Does not remove all contaminants
  - Fluoride, nitrates, sodium
- Not all are created the same

Reverse Osmosis:

- Increases acidity of water
- Removes some beneficial minerals
  - Calcium and magnesium
- Disposal of used filters is inefficient
- Requires large amounts of water

Advantages

Carbon Filters:

- Inexpensive
- Removes pesticides and chlorine
- Removes organic pollutants
  - Pesticides, herbicides, insecticides

Reverse Osmosis:

- Highly effective against organic and inorganic chemicals
  - Removes 90-98%
- Lasts longer
  - 2-5 year

Map of America based on water hardness

Conclusion

- Water leaving treatment plants is purified but people have reasons to further purify it
  - Well water, after natural disasters
- The processes of water purification are not necessarily the most time and cost efficient
- Incorrect methods of the disposal of filters and waste have detrimental effects on the environment

References

Available upon request

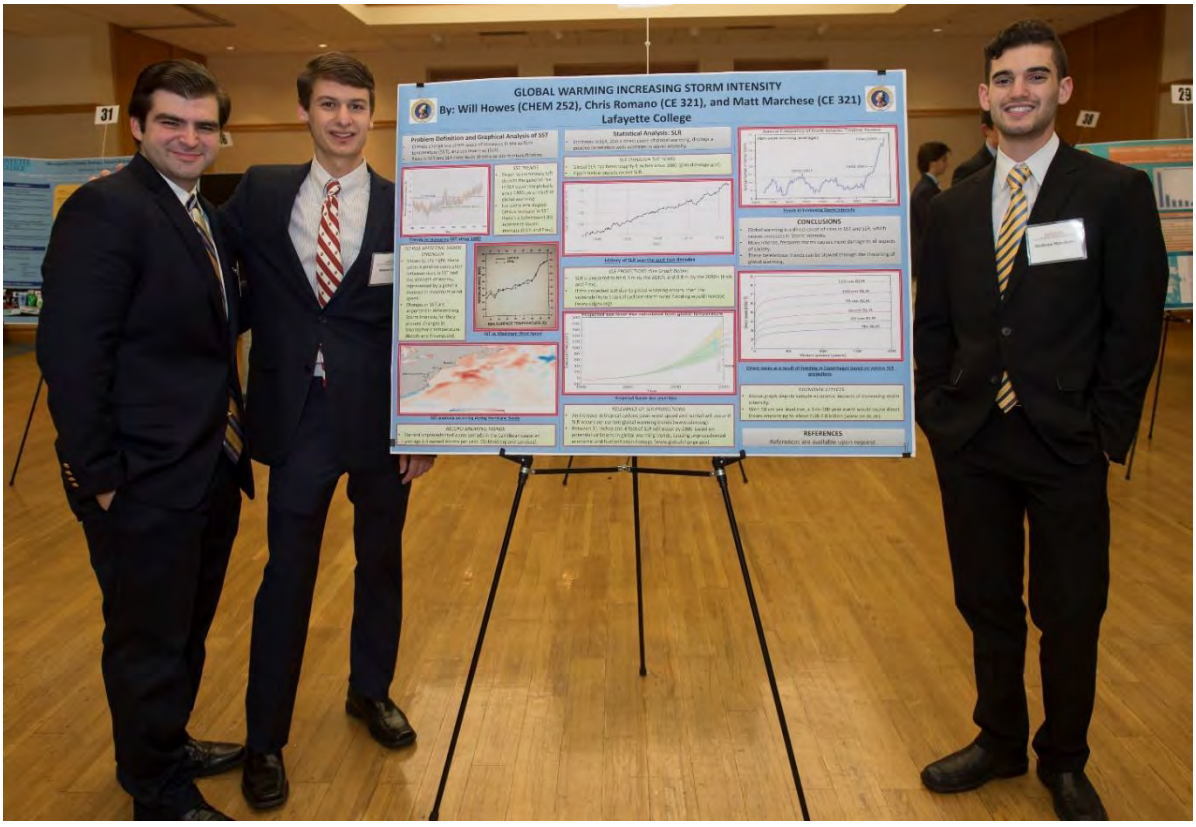
Poster #23

Global Warming Increasing Storm Intensity

Will Howes, Matt Marchese, and Chris Romano

Even though there is a futile debate regarding its existence, it is no secret among environmentalists that climate change is a global force that is severely affecting the way in which society deals with water-associated issues. Therefore, this poster examines one of the main water-associated problems that arises as a direct result of climate change. Specifically, it analyzes the effects that trends in climate change - or more accurately, global warming – have on the process of storm intensification. With named storms occurring on a regular basis for the last several years, including storms like Hurricanes Irene, Sandy, and Matthew, this problem is an extremely relevant, contemporary issue deserving of increased attention.

Henceforth, through the graphical and statistical analysis of mediums such as rises in sea surface temperature (SST) and sea level rise (SLR) – trends that exist because of global warming – this poster quantifies and examines the significance of this problem on a global scale. Finally, the magnitude of this problem of storm intensification is examined through the lens of societal impact, being that more frequent, more intense storms causes a direct increase in economic and infrastructural problems in developments across the globe. Placed in this context, the poster then comes to conclusions regarding potential solutions for storm intensification, which all relate back to slowing its biggest catalyst in global warming.

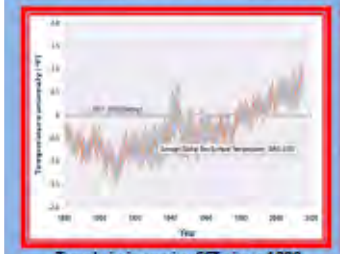


GLOBAL WARMING INCREASING STORM INTENSITY

By: Will Howes (CHEM 252), Chris Romano (CE 321), and Matt Marchese (CE 321)
Lafayette College

Problem Definition and Graphical Analysis of SST

- Climate change is a direct cause of increases in sea surface temperature (SST), and sea level rise (SLR).
- Rises in SST and SLR contribute directly to storm intensification.



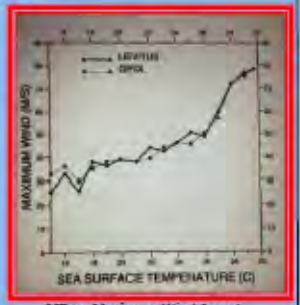
Trends in increasing SST since 1880

SST TRENDS

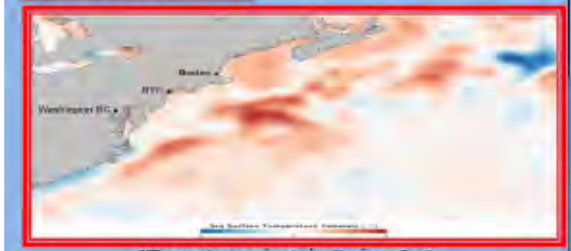
- Graph to immediate left depicts the general rise in SST occurring globally since 1880, as a result of global warming.
- For every one degree Celsius increase in SST there's a subsequent 8% increase in Storm Intensity (Irish and Frey).

SST RISE AFFECTING STORM STRENGTH

- Shown to the right, there exists a positive correlation between rises in SST and the strength of storms, represented by a general increase in maximum wind speed.
- Changes in SST are important in determining Storm Intensity for they present changes in tropospheric temperature (Booth and Thompson).



SST vs. Maximum Wind Speed



SST anomaly occurring during Hurricane Sandy

RECORD-BREAKING TRENDS

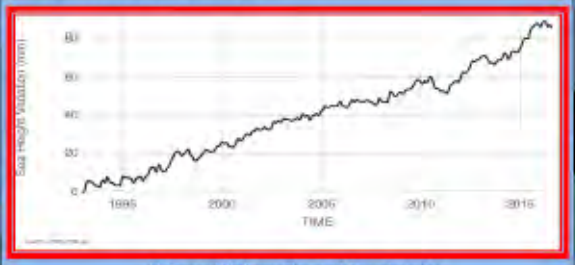
- Current unprecedented warm periods in the Caribbean cause an average 2.5 named storms per year. (Goldenberg and Landsea).

Statistical Analysis: SLR

- Increases in SLR, also a direct cause of global warming, displays a positive correlation with increases in storm intensity.

SLR THROUGH THE YEARS

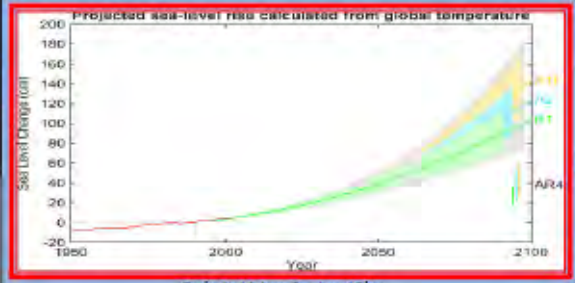
- Global SLR has been roughly 8 inches since 1880 (globalchange.gov).
- Figure below depicts recent SLR.



History of SLR over the past two decades

SLR PROJECTIONS (See Graph Below)

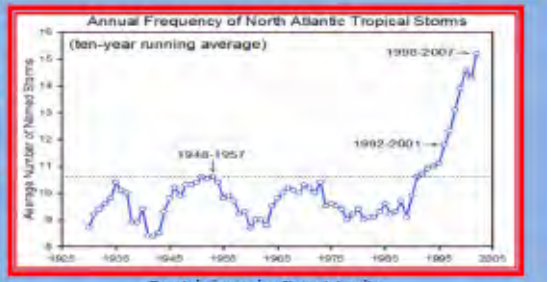
- SLR is projected to be 0.3 m by the 2030's and 0.8 m by the 2080's (Irish and Frey).
- If the projected SLR due to global warming occurs, then the vulnerability to tropical cyclone storm surge flooding would increase (www.cdgev.org).



Projected future Sea Level Rise

RELEVANCE OF SLR PROJECTIONS

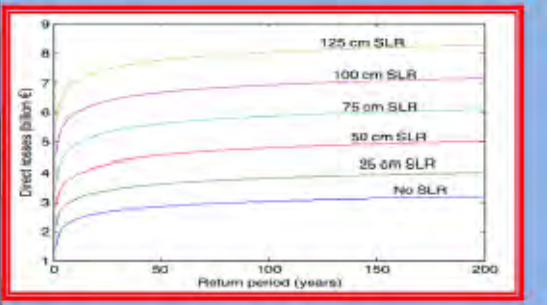
- An increase in tropical cyclone peak wind-speed and rainfall will occur if SLR occurs per current global warming trends (www.cdev.org).
- Between 11 inches and 4 feet of SLR will occur by 2100 based on potential variations in global warming trends, causing unprecedented economic and humanitarian damage (www.globalchange.gov).



Trends in increasing Storm Intensity

CONCLUSIONS

- Global warming is a direct cause of rises in SST and SLR, which causes increases in Storm Intensity.
- More intense, frequent storms causes more damage to all aspects of society.
- These deleterious trends can be slowed through the thwarting of global warming.



Direct losses as a result of flooding in Copenhagen based on various SLR projections

ECONOMIC EFFECTS

- Above graph depicts sample economic impacts of increasing storm intensity.
- With 50 cm sea level rise, a 1-in-100 year event would cause direct losses amounting to about EUR 4.8 billion (www.ise.ac.uk)

REFERENCES

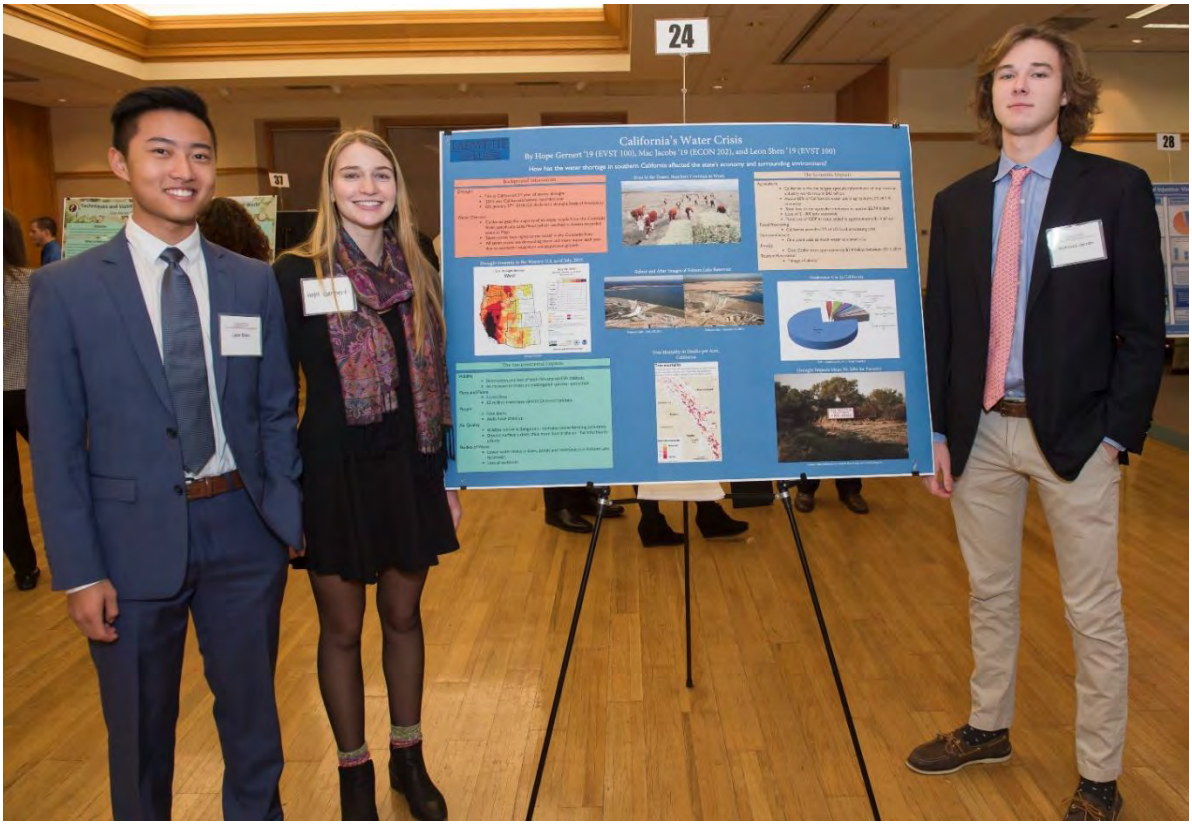
References are available upon request.

Poster #24

California's Water Crisis

Hope Gernert, Mac Jacobs, and Leon Shen

Lack of precipitation on top of exponential economic growth has led to a water shortage in Southern California. Our research question is "how has the water shortage in Southern California affected the state's economy and surrounding environment?". Our research led us to five major industries directly affected by the drought: agriculture, food processing, semiconductor production, energy and tourism and recreation. 80% of California's water usage goes to the agriculture industry, which only makes up 2% of the state's economy. It is the most affected industry due to an overall loss of $1.3 billion in GDP and 21,000 jobs, from agriculture alone. However, because the industry makes up so little of the state's economy, the state did not suffer very much overall. Our research also helped us find the major ways in which the environment has been impacted by the shortage of water. We found that wildlife, bodies of water, air quality, flora and fauna, and people are affected by the drought in Southern California. Southern California's largest reservoir, the Folsom Lake Reservoir, reached its lowest point in 2015. Additionally, there have been 12 million tree deaths as a result of the current drought in Southern California. This has damaged the livelihood of small animals that depend on trees for both food (acorns) and shelter.



LAFAYETTE COLLEGE

California's Water Crisis

By Hope Gernert '19 (EVST 100), Mac Jacobs '19 (ECON 202), and Leon Shen '19 (EVST 100)

How has the water shortage in southern California affected the state's economy and surrounding environment?

Background Information

Drought

- This is California's 5th year of severe drought
- 2015 was California's hottest recorded year
- On January 17th, 2014, CA declared a drought State of Emergency

Water Overuse

- California gets the majority of its water supply from the Colorado River, specifically Lake Mead (which reached its lowest recorded point in May)
- Seven states have rights to the water in the Colorado River
- All seven states are demanding more and more water each year due to economic expansion and population growth

Even in the Desert, Ranchers Continue to Work

The Economic Impacts

Agriculture

- California is the the largest agricultural producer of any state, an industry worth around $45 billion
- About 80% of California's water use is agricultural, 2% of CA economy
- Total loss to the agriculture industry is approx. $2.74 billion
- Loss of 21,000 jobs statewide
- Total loss of GDP in value added is approximately $1.3 billion

Food Processing

- California provides 11% of US food processing jobs

Semiconductors

- One plant uses as much water as a small city

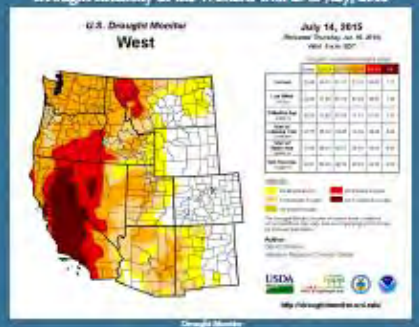
Energy

- Cost Californians approximately $1.4 billion between 2011-2014

Tourism/Recreation

- "Image of plenty"

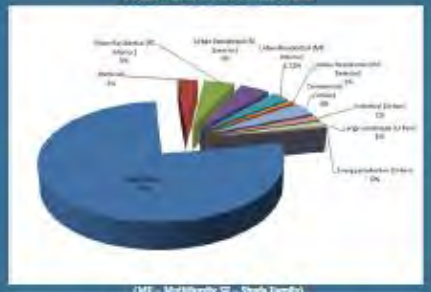
Drought Intensity in the Western U.S. as of July, 2015



Before and After Images of Folsom Lake Reservoir

Folsom Lake – July 20, 2011 | Folsom lake – January 16, 2014

Freshwater Use in California



The Environmental Impacts

Wildlife

- Destruction and loss of both fish and wildlife habitats
- An increase in stress on endangered species - extinction

Flora and Fauna

- Forest fires
- 12 million trees have died in CA forest habitats

People

- Fake lawns
- Wells have dried up

Air Quality

- Wildfire smoke is dangerous - contains ozone-forming pollutants
- Ground surface is drier, thus more dust in the air - harmful health effects

Bodies of Water

- Lower water levels in lakes, ponds and reservoirs (i.e. Folsom Lake Reservoir)
- Loss of wetlands

Tree Mortality in Deaths per Acre, California

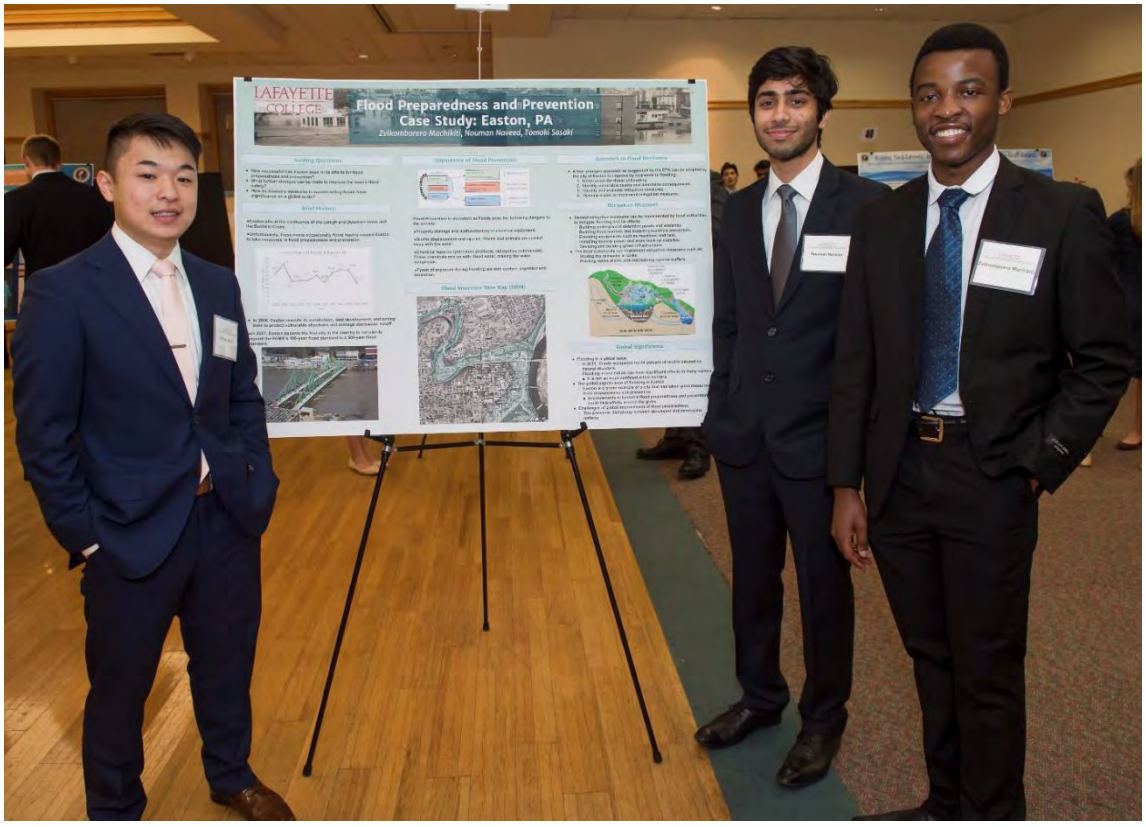
Drought Impacts Mean No Jobs for Farmers

Poster #25

Flood Preparedness and Prevention
Case Study: Easton, PA

Zvikomborero Machikiti, Nouman Naveed, and Tomoki Sasaki

Easton sits at the confluence of the Lehigh and Delaware rivers and the Bushkill Creek. Due to this location, the town has had a history of numerous small to large floods. Easton has made various efforts to prevent flooding and mitigate the resulting damages. How successful has Easton been in its efforts for flood preparedness and prevention? What further changes can be made to improve the town's flood safety? How do Easton's measures in counteracting floods have significance on a global scale? We attempt to answer these questions by: looking at the political measures taken in flood safety, studying the hazards associated with flooding, analyzing the approaches Easton can adopt to build flood resilience, and considering the global significance of this local issue. Through the interdisciplinary approach which includes chemistry, engineering, and politics, a more holistic understanding of this issue can be achieved.



Flood Preparedness and Prevention Case Study: Easton, PA

Zvikomborero Machikiti, Nouman Naveed, Tomoki Sasaki

Guiding Questions

- How successful has Easton been in its efforts for flood preparedness and prevention?
- What further changes can be made to improve the town's flood safety?
- How do Easton's measures in counteracting floods have significance on a global scale?

Brief History

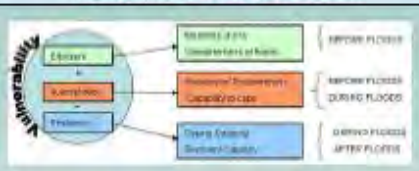
•Easton sits at the confluence of the Lehigh and Delaware rivers and the Bushkill Creek.

•Unfortunately, these rivers occasionally flood, having caused Easton to take measures in flood preparedness and prevention.

- In 2006, Easton rewrote its subdivision, land development, and zoning laws to protect vulnerable structures and manage stormwater runoff.

•In 2007, Easton became the first city in the country to voluntarily expand the FEMA's 100-year flood standard to a 500-year flood standard.

Importance of Flood Prevention



Flood Prevention is important as floods pose the following dangers to the society:

•Property damage and malfunctioning of electrical equipment.

•Biolife displacement and injuries. Plants and animals are carried away with the water.

•Chemical hazards (petroleum products, radioactive substances). These chemicals mix up with flood water, making the water dangerous.

•Types of exposure during flooding are skin contact, ingestion and inhalation.

Flood Insurance Rate Map (FIRM)

Approach to Flood Resilience

- A four pronged approach as suggested by the EPA can be adopted by the city of Easton to improve its resilience to flooding:
  1. Understand the threat of flooding.
  2. Identify vulnerable assets and determine consequences.
  3. Identify and evaluate mitigation measures.
  4. Develop a plan to implement mitigation measures.

Mitigation Measures

- Several mitigation measures can be implemented by local authorities to mitigate flooding and its effects:
  - Building underground detention ponds and wetlands.
  - Building flood barriers and installing backflow preventers.
  - Elevating equipments such as machines and tank.
  - Installing backup power and store back up supplies.
  - Devising and building green infrastructure.
- The local community can implement mitigation measures such as:
  - Storing the rainwater in tanks.
  - Planting native plants and maintaining riparian buffers.

Global Significance

- Flooding is a global issue
  - In 2013, floods accounted for 44 percent of deaths caused by natural disasters.
  - Flooding in one nation can have significant effects in many nations.
    - It is not an issue confined within borders.
- The global significance of flooding in Easton
  - Easton is a prime example of a city that has taken great measures in flood preparedness and prevention.
    - Improvements in Easton's flood preparedness and prevention could help efforts around the globe.
- Challenges of global improvement of flood preparedness
  - The economic dichotomy between developed and developing nations.

Poster #26

Are Gray Water Systems Feasible for Domestic Use?

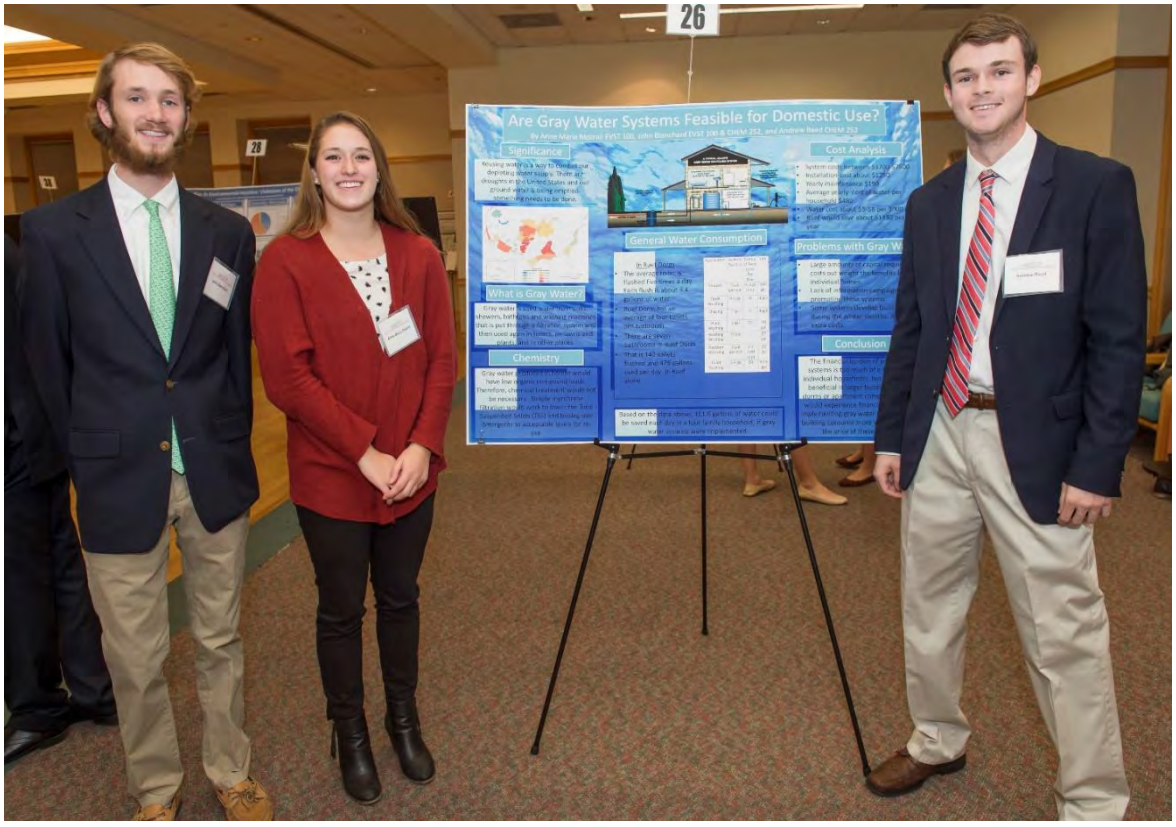
John Blanchard, Anne Marie Mozrall, and Andrew Reed

We decided to explore the domestic feasibility of gray water systems. The significance of this is to combat water shortages in the United States and the rest of the world. We knew that this technology has been around and wondered why it was not a widely used practice.

Gray water is used water from sinks, showers, bathtubs and washing machines that is put through a filtration system and then used again in toilets, on lawns and plants, and in other places. Domestically, gray water would have low organic compound loads. Therefore, chemical treatment would not be necessary. Simple membrane filtration would work to lower the Total Suspended Solids (TSS) and biodegrade detergents to acceptable levels for re-use.

We conducted research on general household water use to see how much water could actually be saved. Our findings propose that a family of four could save more than 100 gallons of water each day.

While these processes have the potential to save water and money, there are some problems associated with gray water systems. These issues include implementation and maintenance costs, and the potential for the filters to freeze during the winter. We determined that gray water systems would not be cost effective for individual homes. However, we did conclude that buildings such as dorms and apartment complexes would prosper greatly.

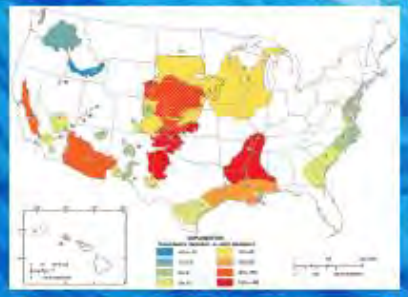


Are Gray Water Systems Feasible for Domestic Use?

By Anne Marie Mozrall EVST 100, John Blanchard EVST 100 & CHEM 252, and Andrew Reed CHEM 252

Significance

Reusing water is a way to combat our depleting water supply. There are droughts in the United States and our ground water is being emptied- something needs to be done.



What is Gray Water?

Gray water is used water from sinks, showers, bathtubs and washing machines that is put through a filtration system and then used again in toilets, on lawns and plants, and in other places.

Chemistry

Gray water produced in homes would have low organic compound loads. Therefore, chemical treatment would not be necessary. Simple membrane filtration would work to lower the Total Suspended Solids (TSS) and biodegrade detergents to acceptable levels for re-use.

General Water Consumption

In Ruef Dorm

- The average toilet is flushed five times a day. Each flush is about 3.4 gallons of water
- Ruef Dorm has an average of four toilets per bathroom
- There are seven bathrooms in Ruef Dorm
- That is 140 toilets flushed and 476 gallons used per day in Ruef alone

Application	Gallons Per Use	Family of Four Uses Per Day	Total
Shower	5 gal per min	4 (x10 min)	200 gal
Teeth Brushing	0.5 gal	8	4 gal
Shaving	1 gal	4	4 gal
Hand Washing	1 gal	20	20 gal
Washing Machine	27 gal	1	27 gal
Outdoor Watering	2 gal per min	0.5 (x30 min)	30 gal
Toilet flushing	3.4 gal	24	81.6 gal

Based on the data above, 111.6 gallons of water could be saved each day in a four family household, if gray water systems were implemented.

Cost Analysis

- System costs between $3700-$7500
- Installation cost about $1250
- Yearly maintenance $190
- Average yearly cost of water per household $480
- Water cost about $5-$8 per 1000 gal
- Ruef would save about $1130 per year

Problems with Gray Water

- Large amounts of capital required, costs out weight the benefits for individual homes.
- Lack of information campaigns promoting these systems
- Some systems develop build up during the winter months. Adding extra costs.

Conclusion

The financial burden of gray water systems is too much of a burden for individual households, but remain very beneficial in larger buildings such as dorms or apartment complexes. Homes would experience financial losses from implementing gray water systems. Larger building consume more water, offsetting the price of these systems.

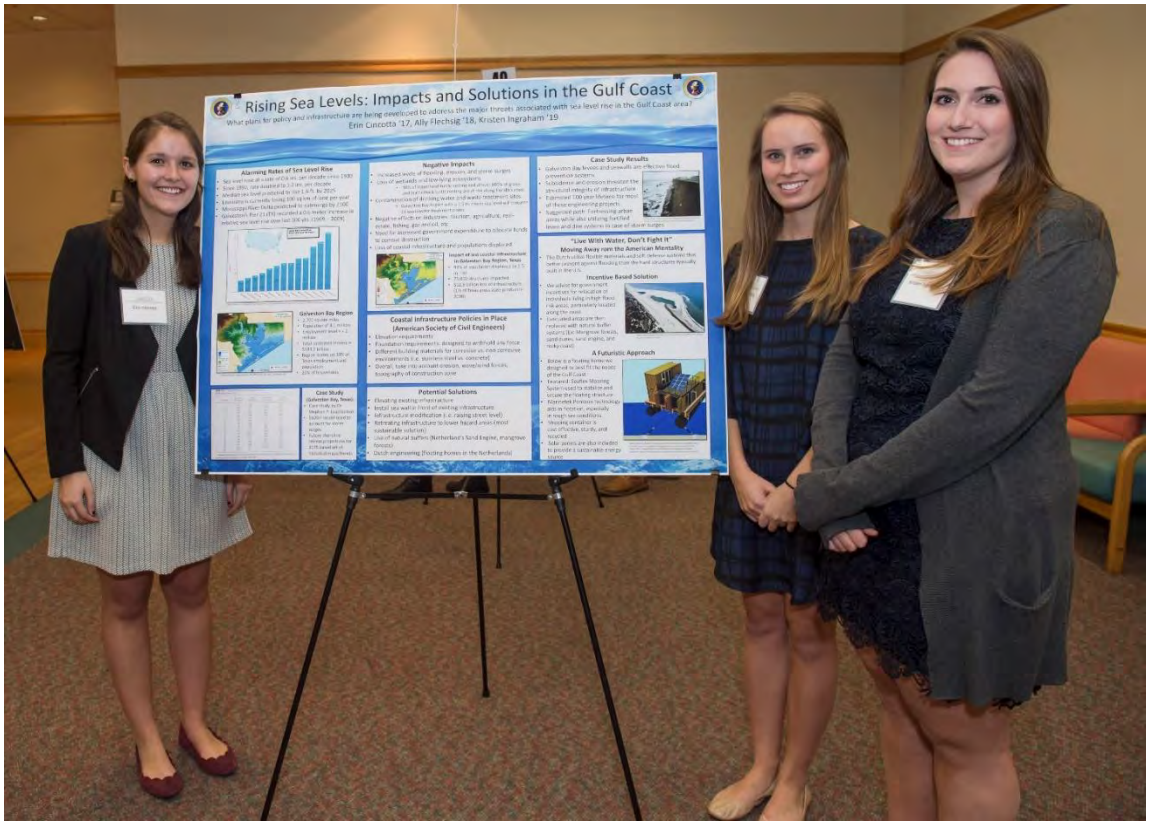
Poster #27

Rising Sea Levels: Impact and Solutions in the Gulf Coast

Erin Cincotta, Ally Flechsig, and Kristen Ingraham

Our project focuses on the potential economic and environmental impacts that threaten coasts as sea levels rise globally. Our research centers on the Gulf Coast area, looking closely at forecasts predicting future trends of rising sea levels. These predictions reiterate the importance and necessity of implementation of economic policy and flood prevention systems in order to protect cities and residents along with habitat. Leatherman's case study on Galveston Bay, Texas discusses the strengths and weaknesses of various forms of infrastructure developed in order to address increased storm surges and flooding.

We evaluate the environmental casualties of rising sea levels, such as loss of wetlands and devastation of both aquatic and terrestrial ecosystems that have led to economic problems throughout the Gulf. Future projections indicate severely high levels of sea rise that would further devastate and endanger life on the coast. As a result, policy makers and engineers alike have come up with certain preventative measures and creative solutions in an effort to combat impending sea level rise. Several areas have implemented policies that regulate building codes, elevation requirements, and encouraged use of non-corrosive materials that can withstand potential erosion. We then look to the Netherlands, one of the leaders in innovative solutions to sea level rise, as a source for potential solutions that could be incorporated in the Gulf area. We propose the use of Dutch designs, tailored specifically to meet the needs and limitations of the Gulf coast.



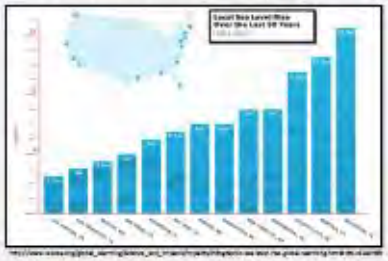
Rising Sea Levels: Impacts and Solutions in the Gulf Coast

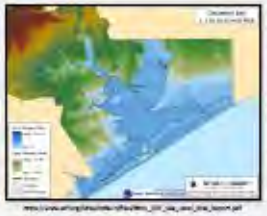
What plans for policy and infrastructure are being developed to address the major threats associated with sea level rise in the Gulf Coast area?

Erin Cincotta '17, Ally Flechsig '18, Kristen Ingraham '19

Alarming Rates of Sea Level Rise

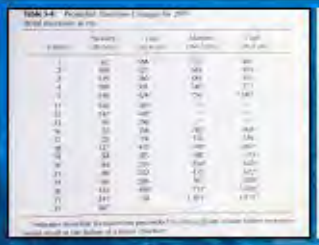
- Sea level rose at a rate of 0.6 ins. per decade since 1900
- Since 1992, rate doubled to 1.2 ins. per decade
- Median sea level predicted to rise 1.6 ft. by 2025
- Louisiana is currently losing 100 sq km of land per year
- Mississippi River Delta predicted to submerge by 2100
- Galveston's Pier 21 (TX) recorded a 0.6 meter increase in relative sea level rise over last 100 yrs. (1909 – 2009)





Galveston Bay Region

- 2,700 square miles
- Population of 4.1 million
- Employment level = + 2 million
- Total combined income = $183.2 billion
- Region makes up 18% of Texas employment and population
- 20% of households

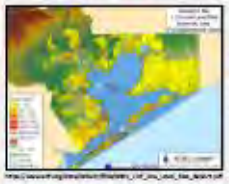


Case Study (Galveston Bay, Texas)

- Case study by Dr. Stephen P. Leatherman
- SLOSH model used to account for storm surges
- Future shoreline retreat projections for 2075 based off of historical maps/trends

Negative Impacts

- Increased levels of flooding, erosion, and storm surges
- Loss of wetlands and low-lying ecosystems
  - 90% of loggerhead turtle nesting and almost 100% of green and leatherback turtle nesting are at risk along Florida's coast
- Contamination of drinking water and waste treatment sites
  - Galveston Bay Region with a 1.5 m. rise in sea level will threaten 16 wastewater treatment plants
- Negative effects on industries: tourism, agriculture, real-estate, fishing, gas and oil, etc.
- Need for increased government expenditure to allocate funds to combat destruction
- Loss of coastal infrastructure and populations displaced



Impact of lost coastal infrastructure in Galveston Bay Region, Texas

- 93% of population displaced by 1.5 m. rise
- 75,000 structures impacted
- $12.5 billion loss of infrastructure (1% of Texas gross state product in 2008)

Coastal Infrastructure Policies in Place (American Society of Civil Engineers)

- Elevation requirements
- Foundation requirements: designed to withhold any force
- Different building materials for corrosive vs. non corrosive environments (i.e. stainless steel vs. concrete)
- Overall, take into account erosion, wave/wind forces, topography of construction zone

Potential Solutions

- Elevating existing infrastructure
- Install sea wall in front of existing infrastructure
- Infrastructure modification (i.e. raising street level)
- Retreating infrastructure to lower hazard areas (most sustainable solution)
- Use of natural buffers (Netherland's Sand Engine, mangrove forests)
- Dutch engineering (floating homes in the Netherlands)

Case Study Results

- Galveston Bay levees and seawalls are effective flood prevention systems
- Subsidence and erosion threaten the structural integrity of infrastructure
- Estimated 100 year lifetime for most of these engineering projects
- Suggested path: Fortressing urban areas while also utilizing fortified levee and dike systems in case of storm surges

"Live With Water, Don't Fight It" Moving Away rom the American Mentality

- The Dutch utilize flexible materials and soft defense systems that better prevent against flooding than the hard structures typically built in the U.S.

Incentive Based Solution

- We advise for government incentives for relocation of individuals living in high flood risk areas, particularly located along the coast
- Evacuated areas are then replaced with natural buffer systems (Ex: Mangrove forests, sand dunes, sand engine, and rocky coast)

A Futuristic Approach

- Below is a floating home we designed to best fit the needs of the Gulf Coast
- Featured: Seaflex Mooring System used to stabilize and secure the floating structure
- Marinetek Pontoon technology aids in flotation, especially in rough sea conditions
- Shipping container is cost effective, sturdy, and recycled
- Solar panels are also included to provide a sustainable energy source

Poster #28

Case Studies in Environmental Justice: Violations of the Clean Water Act

Casey Banta-Ryan, Grace Housman, and Chris Melka

Access to clean water is a privilege that can be easily be taken for granted, but the unfortunate reality of the matter is that in present day United States, there are many people who lack that privilege. Not just due to circumstances, but often because of some very specific decisions made by companies and local governments for the sake of saving money and time at the expense of human livelihoods. Low-income households and racial minorities are disproportionately affected by these decisions by a significant margin in the USA, a matter that has been excellently captured in the stories of three different cities: Flint MI, Greenville MS, and Chester PA. All three of these municipalities have stories of environmental injustice to tell and in all three of them, the Clean Water Act was violated, with the water that was publicly available to citizens not meeting minimum health standards.

Although these are all American cities, make no mistake: similar cases of injustice have occurred all across the world. Many cities across the globe have had their water contaminated as a result of intentional choices being made about the placement of water treatment plants and the treatment process itself. This is dangerous for both humans and the environment, and it is important to examine these case studies in order to gain a better understanding of the dangers all too many people are facing and the injustice that needs to be addressed.

Case Studies in Environmental Injustice: Violations of the Clean Water Act

Casey Banta-Ryan (EVST 100) Chris Melka (GOVT 231) Grace Housman (EVST 100)

Objective:
To examine the correlation between infractions of EPA standards and areas with a low income population

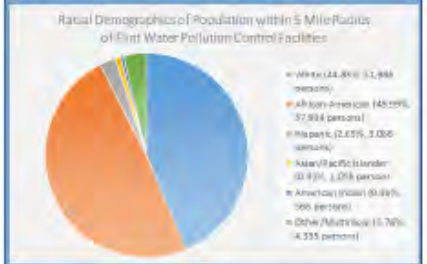
Environmental justice is the fair treatment of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

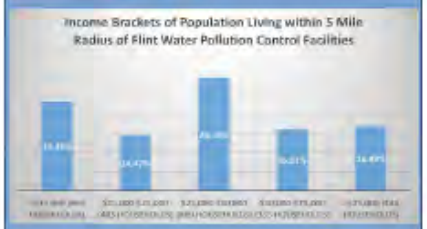
Connections Between Cases

- Water color/taste/odor noticed by residents
- Whistleblower largely ignored
- Effort to cover up violations by local authorities
- Lack of funding leading to incident
- Lack of lasting policy response

Globally, one in ten people lack access to potable water

Flint, Michigan



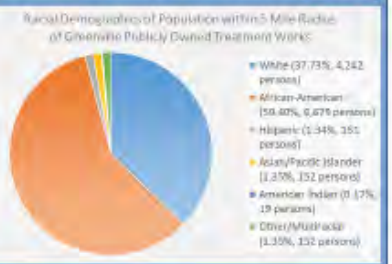


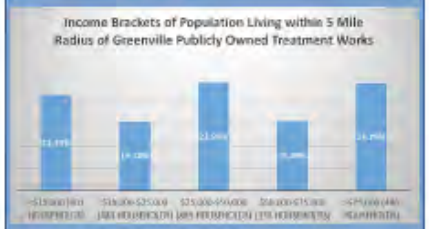
Violations
- Violated Safe Drinking Water Act
- THMs (trihalomethanes) in water, as a byproduct of chlorine disinfection result from chlorine reacting with organic matter in water, cancer causing in large doses
- Failed to add corrosion inhibitors that prevent leaching

"It started innocently when someone forgot to follow the law."- Marc Edwards, Virginia Tech professor working in Flint

Flint Policy Results
Bill will be introduced in Michigan House of Representatives to make it a felony for state officials to manipulate or falsify information in official reports
Class action lawsuit from four families filed November 2015

Greenville, Mississippi





Violations
- Unauthorized discharges into navigable waters
- Failure to comply with NPDES permit conditions for operation and maintenance of its sanitary sewer system,
- Exceeded effluent discharge limitations
- Failure to comply with NPDES permit conditions regarding timely reporting noncompliance.

"We plan to totally comply with it," ... "And if we run out of money – I don't know. But we certainly would not intentionally fail to comply."- Andy Alexander, attorney for the city of Greenville

Greenville Policy Results
Civil Penalty, city fined
6 years to implement plans for prevention

Chester, Pennsylvania

Violations
- Failure to comply with limits on the maximum volume of a single pollutant a plant can discharge
- Discharge of untreated sewage into water sources
- Failure to develop and implement a long term control plan meeting the standards of water quality control established by the combined sewer overflow Control Policy
- Unauthorized dry-weather sewage overflows

"Agreements like this one are a victory for environmental justice."-Assistant Attorney General John C. Cruden

Chester Policy Results
DELCORA pays $1,375,000
Made a long term control plan for facility

Conclusion

In cases of environmental injustice, legislative response is lacking and does little to ensure repeated violations do not occur.

Poster #29

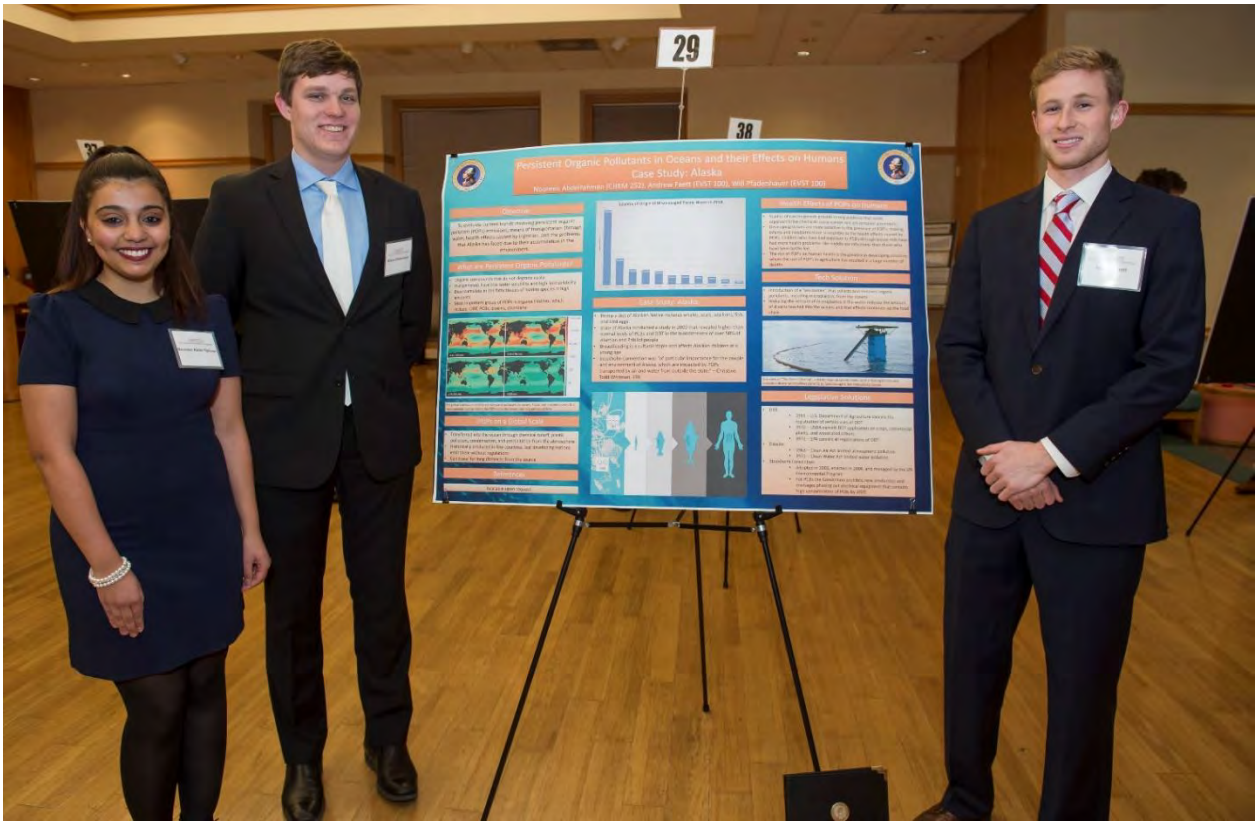
Persistent Organic Pollutants in Oceans and their Effects on Humans
Case Study: Alaska

Noureen Abdelrahman, Andrew Faett, and Will Pfadenhauer

Persistent Organic Pollutants, or POPs for short, are organic compounds that readily persist in the environment, even taking up to a century to degrade. POPs are capable of traveling long distances from their place of origin through water runoff, wind, and ocean currents. POPs are halogenated, have low water solubility and high lipid solubility which make them bioaccumulate in the fatty tissues of marine species causing these animals to carry dangerous amounts of them, which can in turn affect human health when consumed. Of the halogenated hydrocarbons, the most important group of POPs is organochlorines, which include: DDT, PCBs and dioxins.

POPs can damage the endocrine, reproductive and immune systems of humans as well as affect the brain and nervous system. Some POPs have been proven to be carcinogens and cause other deadly diseases such as obesity and diabetes. POPs also pose a serious threat to Alaskan Native populations. This is because the main method of gathering food in Alaska is through hunting whales, seals, fish, and bird eggs, in which POPs readily bioaccumulate.

One proposed technical solution involves the design and implementation of a sea barrier that collects microplastics containing POPs to reduce their involvement within the food chain. Historically the United States and other nations have passed laws to reduce POP emissions, but many undeveloped nations still use them readily, and the United States has yet to sign the most important piece of current legislation; the Stockholm Convention.



Persistent Organic Pollutants in Oceans and their Effects on Humans
Case Study: Alaska

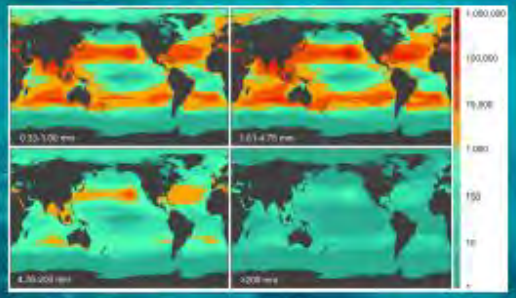
Noureen Abdelrahman (CHEM 252), Andrew Faett (EVST 100), Will Pfadenhauer (EVST 100)

Objective

To evaluate current trends involving persistent organic pollutant (POPs) emissions, means of transportation through water, health effects caused by ingestion, and the problems that Alaska has faced due to their accumulation in the environment.

What are Persistent Organic Pollutants?

- Organic compounds that do not degrade easily
- Halogenated, have low water solubility and high lipid solubility
- Bioaccumulate in the fatty tissues of marine species in high amounts
- Most important group of POPs is organochlorines, which include: DDT, PCBs, dioxins, chlordane



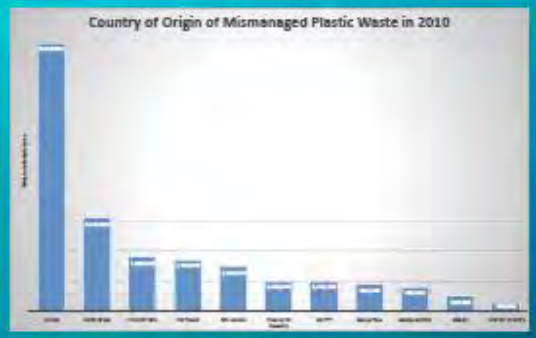
The global distribution of different size plastic pollutants in oceans. Plastic trash leaches dioxins (the most common and harmful of the POP's) into the oceans over long periods of time.

POPs on a Global Scale

- Transferred into the ocean through chemical runoff, plastic pollution, condensation, and precipitation from the atmosphere
- Historically produced in few countries, but developing nations emit them without regulations
- Can travel for long distances from the source

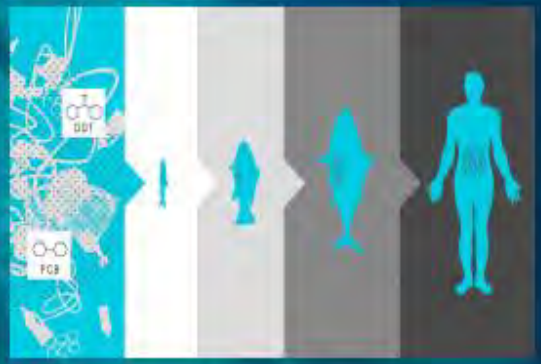
References

Available upon request.



Case Study: Alaska

- Primary diet of Alaskan Native includes whales, seals, sea lions, fish, and bird eggs
- State of Alaska conducted a study in 2000 that revealed higher than normal levels of PCBs and DDT in the bloodstreams of over 50% of Aluetian and Pribilof people
- Breastfeeding is a cultural staple and affects Alaskan children at a young age
- Stockholm Convention was "of particular importance for the people and environment of Alaska, which are impacted by POPs transported by air and water from outside the state." – Christine Todd Whitman, EPA



Health Effects of POPs on Humans

- Studies of carcinogenesis provide strong evidence that some organochlorine chemicals cause cancer and act as tumor promoters
- Developing tissues are more sensitive to the presence of POP's, making infants and newborns more susceptible to the health effects caused by POPs. Children who have had exposure to PCB's through breast milk have had more health problems- like middle ear infections- than those who have been bottle fed
- The risk of POP's on human health is the greatest in developing countries where the use of POP's in agriculture has resulted in a large number of deaths

Tech Solution

- Introduction of a "sea barrier" that collects and removes organic pollutants, including microplastics, from the oceans
- Reducing the amount of microplastics in the water reduces the amount of dioxins leached into the oceans and that effects continues up the food chain

One view of "The Ocean Cleanup", a plastic cleanup system made up of a floating barrier and collection device which allows currents to flow through it but stops plastic pieces

Legislative Solutions

- DDT
  - 1969 – U.S. Department of Agriculture cancels the registration of certain uses of DDT
  - 1970 – USDA cancels DDT application on crops, commercial plants, and wood productions
  - 1972 – EPA cancels all registrations of DDT
- Dioxins
  - 1963 – Clean Air Act limited atmospheric pollution
  - 1972 – Clean Water Act limited water pollution
- Stockholm Convention
  - Adopted in 2001, enacted in 2004, and managed by the UN Environmental Program
  - For PCBs the Convention prohibits new production and envisages phasing out electrical equipment that contains high concentration of PCBs by 2025

Poster #30

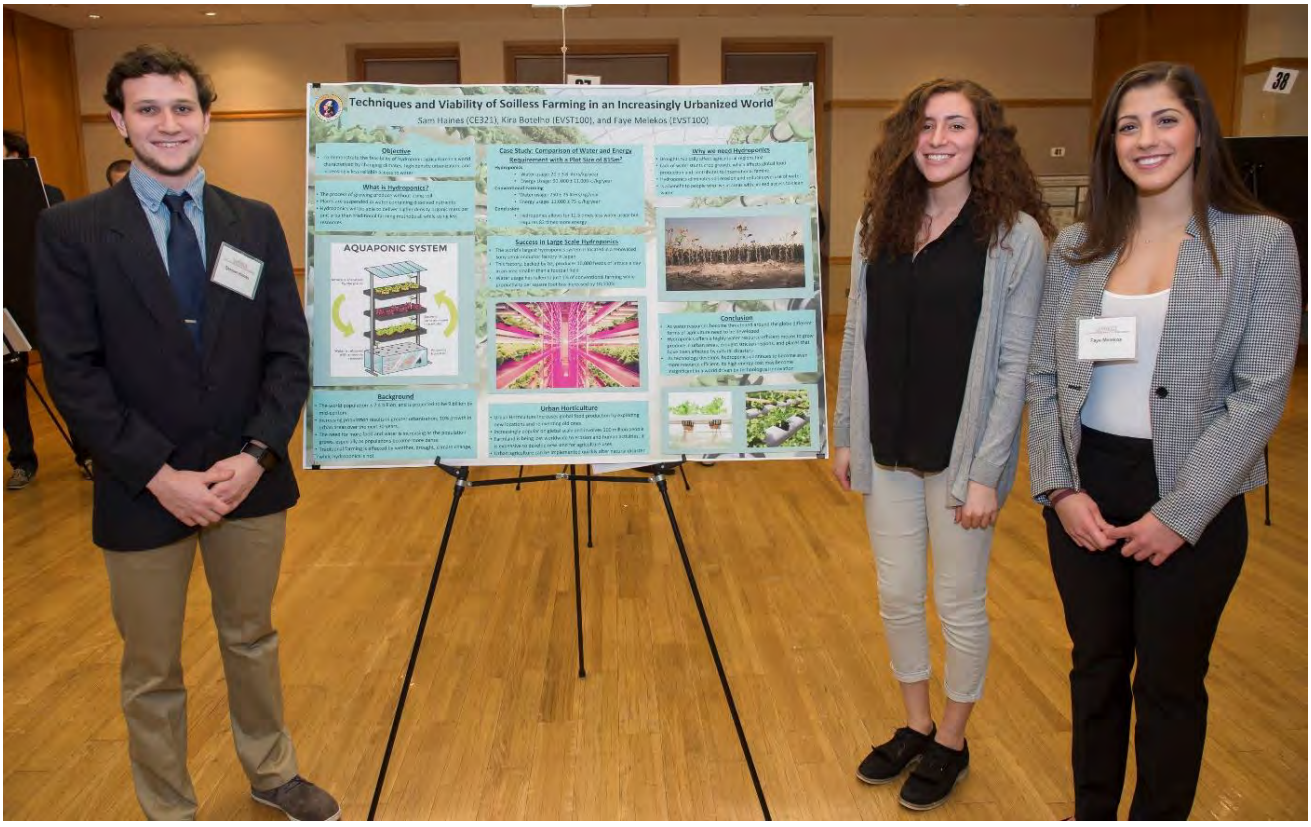
Techniques and Viability of Soilless Farming in an Increasingly Urbanized World

Kira Botelho, Sam Haines, and Faye Melekos

Water resources are increasingly threatened worldwide by climate change, drought, and irresponsible management practices. Traditional farming methods continue to overuse this valuable resource in threatened regions like the western United States. Soilless farming offers an environmentally friendly alternative to these agricultural practices through techniques like hydroponics and aquaponics. As the world's population continues to grow and migrate to urban areas, the ways in which we get our food and water will need to be rethought.

Hydroponics is an agricultural technique in which plants are grown without soil but instead are suspended in water or another soilless medium. Nutrients are dissolved into the water to allow for high density planting and harvesting. This practice uses less water than traditional agriculture because water entering and leaving the system is tightly controlled and recycled. Our poster explores the ways in which hydroponics may become a superior alternative to traditional agriculture in a world that is faced with more severe water shortages and less access to clean fresh water.

Along with using less water, hydroponics is an effective way to bring farming into urban areas. Hydroponic systems allow for expansion upwards instead of outwards in population and infrastructure dense cities. These systems can bring a new purpose to old buildings in urban areas. As populations grow the demand for water and food security will increase. Hydroponics will save water and provide an additional food source.



Techniques and Viability of Soilless Farming in an Increasingly Urbanized World

Sam Haines (CE321), Kira Botelho (EVST100), and Faye Melekos (EVST100)

Objective

- To demonstrate the feasibility of hydroponic agriculture in a world characterized by changing climates, high density urbanization, and increasingly less reliable access to water

What is Hydroponics?

- The process of growing produce without using soil
- Plants are suspended in water containing dissolved nutrients
- Hydroponics will be able to deliver higher density organic mass per unit area than traditional farming methods all while using less resources

Background

- The world population is 7.4 billion, and is projected to be 9 billion by mid-century.
- Increasing population results in greater urbanization; 10% growth in urban areas over the next 30 years.
- The need for more food and water is increasing as the population grows, especially as populations become more dense
- Traditional farming is effected by weather, drought, climate change, while hydroponics is not

Case Study: Comparison of Water and Energy Requirement with a Plot Size of 815m²

Hydroponics

- Water usage: 20 ± 3.8 liters/kg/year
- Energy Usage: 90, 000 ± 11,000 kJ/kg/year

Conventional Farming

- Water usage: 250 ± 25 liters/kg/year
- Energy usage: 11,000 ± 75 kJ/kg/year

Conclusion

- Hydroponics allows for 12.5 times less water usage but requires 82 times more energy

Success in Large Scale Hydroponics

- The world's largest hydroponics system is located in a renovated Sony semiconductor factory in Japan
- This factory, backed by GE, produces 10,000 heads of lettuce a day in an area smaller than a football field
- Water usage has fallen to just 1% of conventional farming while productivity per square foot has increased by 10,000%

Urban Horticulture

- Urban Horticulture increases global food production by exploiting new locations and reinventing old ones
- Increasingly popular on global scale and involves 100 million people
- Farmland is being lost worldwide to erosion and human activities. It is expensive to develop new land for agriculture uses
- Urban agriculture can be implemented quickly after natural disaster

Why we need Hydroponics

- Droughts typically affect agricultural regions first
- Lack of water stunts crop growth, which affects global food production and contributes to international famine
- Hydroponics eliminates soil erosion and reduces overuse of water
- Is a benefit to people who live in areas with limited access to clean water

Conclusion

- As water resources become threatened around the globe different forms of agriculture need to be developed
- Hydroponics offers a highly water resource efficient means to grow produce in urban areas, drought stricken regions, and places that have been affected by natural disasters
- As technology develops, hydroponics continues to become even more resource efficient. Its high energy cost may become insignificant in a world driven by technological innovation

Poster #31

Microplastics: Oceanic Damage, Industrial Resistance, and Political Solutions

Bianca Buecklers, Brynn Fuller-Becker, and Sarah Heins

Microplastics are small pieces of plastic whose length ranges from one nanometer to less than five millimeters. They can be found in cosmetics, can be used for industrial processes, or resultant of breakdowns of larger plastics. Microplastics enter the aquatic food chain through the consumption by small organisms, and carry pollutants and impurities from initial ingestion. In addition, larger organisms (including humans) are put to risk due to the negative health implications of ingesting microplastics or the pollutants they contain. However, microplastics are crucial to the profit of businesses worldwide. With the banning of microplastics, many companies would be at risk of bankruptcy or significant financial deficits. The effects of microplastic use from an environmental perspective have been identified but not fully addressed from a policy perspective. While bans have been implemented, they are narrowly focused in region and in types of microplastics. A solution has not yet been devised which will null the environmental effects of microplastics without putting businesses at risk. A pressure-state response system can be used to address this issue. In the system, businesses inflict a pressure on the environment for their personal gain. The pressure negatively impacts an ecosystem, and this manipulation can best be relieved through a policy response. What solutions can be created to fight against the negative consequences of microplastic pollution that will be followed by all nations, while still refraining from causing major risks to businesses?

LAFAYETTE COLLEGE

Microplastics: Oceanic Damage, Industrial Resistance, and Political Solutions

Sarah Heins, Bianca Buecklers, Brynn Fuller-Becker

What regulations/ solutions can be created to fight against the negative consequences of microplastic pollution, that will be followed by all nations, while still refraining from causing major risks to businesses?

Introduction

- Recent technological innovations have led to the increased production and use of microplastics.
  - cosmetic industries to industrial processes
- Companies worldwide now depend on microplastics for their products and services
- Microplastics have adverse effects on our environment and specifically in aquatic systems
- Multidisciplinary - environmentalists, businesspeople, and policymakers
- Must work together to establish sustainable policy:
  - retract the negative impacts of microplastics on our environment
  - without jeopardizing the businesses that use them
- People are working on cleaning up plastic that can be seen, *but the majority of environmental damage comes from those that can't be seen*

What are Microplastics?

- Size ranges from one nanometer to less than five millimeters.
- Have been used for four decades

Primary:
- Cosmetics
- Industrial scrubbers
- Microfibers

Secondary:
- Larger Pieces broken down (via weathering, sunlight, etc.)

Sources of Microplastics:

Economic Pressure (Business)

Cosmetics
- Used as exfoliates in products

Industrial Use:
- Waste material from milling and grinding
- Loss of raw materials, such as prefabricated plastic pellets fro creating plastic goods
  - Shot-blasting of ship hulls and industrial cleaning supplies
- Alternatives for these methods need to undergo testing and experimentation for hazards to people and the environment
- This testing makes it difficult for companies to make these changes without suffering from economic consequences

Ecosystem State (effect on oceans)

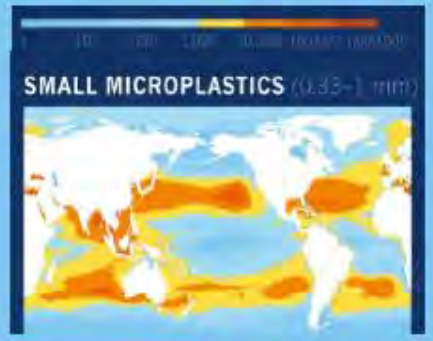
Organism Consumption:
- Small enough to be ingested by low-trophic organisms, like plankton
- This allows entrance into food chain
- Larger organisms consume as well causing digestive issues

Microplastic Contamination:
- Large surface area to volume ratio causes susceptibility of transference of pollutants
- Polluted microplastics can be transported into otherwise unpolluted waters

Policy Responses

Actions Taken
- The United Nations' "Beat the Microbead"
- United States, Canada, and the European Union have made regulations for microplastics
- Canada: Canadian Environmental Protection Act
- United States: Microbead Free Waters Act of 2015
- European Union: Marine Strategy Framework Directive

Actions that Need to be Taken
- United Nations: Direct state regulation, uniform policy required via United Nations Convention on the Law of the Seas
- Voluntary Corporate Codes of Conduct
- *Pharmaceutical Microbead Pollution Regulation*



Conclusion:

- Effects of microplastics can be nulled
- Restrain from economic losses
- Benefits to marine ecosystems and transnational coropations.
- Global policy must take action
- Uniform regulation by the United Nations
- Tradable tax permits, sanctions, or taxes on microplastic production

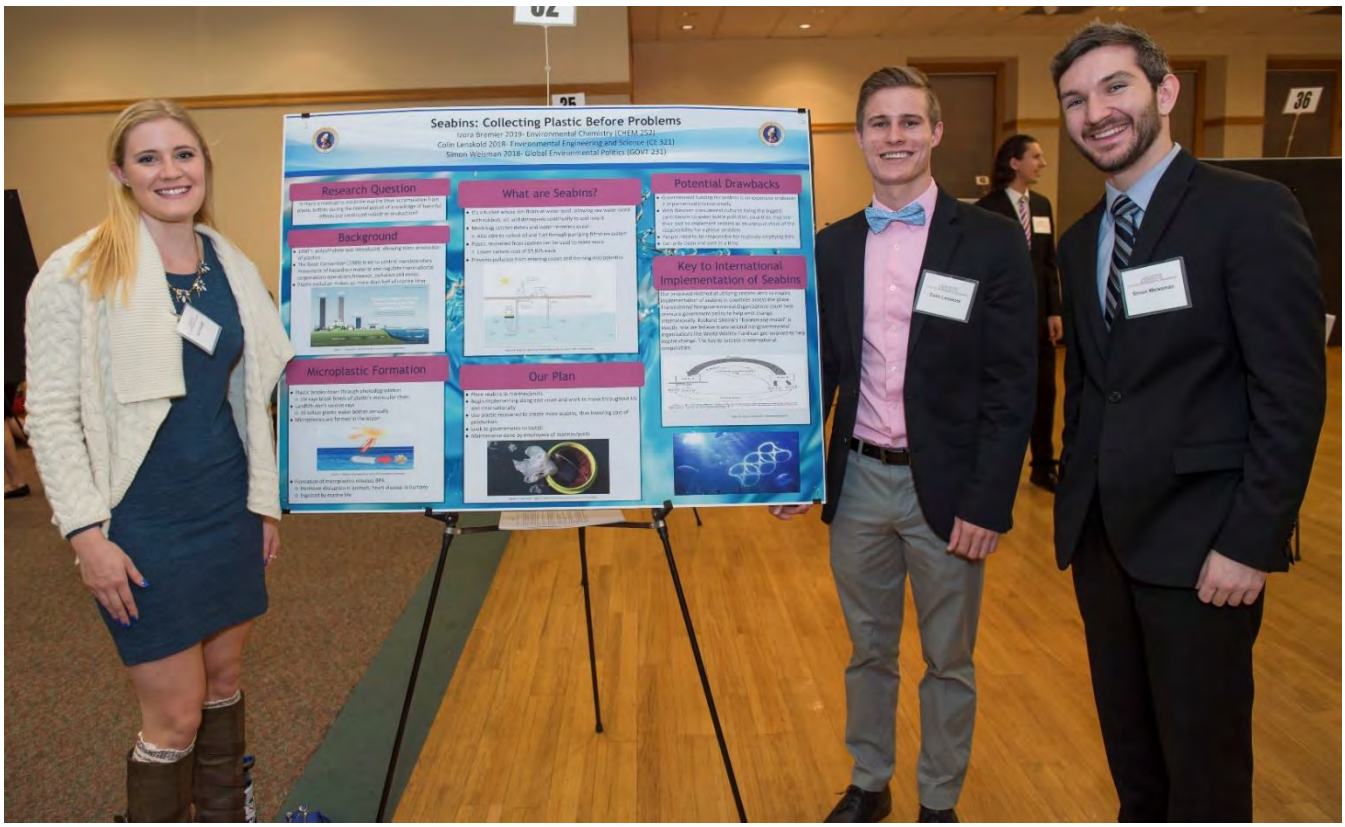
Poster #32

Seabins: Collecting Plastic Before Problems

Izora Bremier, Colin Lenskold, and Simon Weissman

Since the 1960's and the introduction of polyethylene, mass production of water bottles has been exploited by large corporations. With the high demand from consumerist cultures, there has been a shocking impact on the environment. A study at UC Santa Barbara's National Center for Ecological Analysis and Synthesis found that every year, 8 million metric tons of plastic waste enters the ocean. The toxic plastics are easily digested by marine life and when they degrade, the plastic releases bisphenol A (BPA) and PS oligomer toxins into the water.

Searching for an alternative to water bottles is by no means a new endeavor and many options exist that avoid some of the harmful impacts. Our solution to resolving the water bottle issue is that we need to educate people about the current situation. We will do so by analyzing existing strategies to see what is working and what simply isn't. We plan to do so by deciphering the chemical damage to the environment, analyzing alternatives that already exist and establishing a political conscience through pressuring international non-governmental organizations. In doing so, we can only hope to inspire change that could impact the direction of our environmental policies and practices. Through an educational, vivid, and thorough poster, we anticipate displaying the negative effects of water bottles and what continued efforts can be made to ensure their decreased production.



Seabins: Collecting Plastic Before Problems

Izora Bremier 2019- Environmental Chemistry (CHEM 252)
Colin Lenskold 2018- Environmental Engineering and Science (CE 321)
Simon Weisman 2018- Global Environmental Politics (GOVT 231)

Research Question

Is there a method to minimize marine litter accumulation from plastic bottles during the liminal period of knowledge of harmful effects but continued industrial production?

Background

- 1960's polyethylene was introduced, allowing mass production of plastics
- The Basel Convention (1989) tried to control transboundary movement of hazardous material and regulate transnational corporations operations however, pollution still exists
- Plastic pollution makes up more than half of marine litter

Microplastic Formation

- Plastic breaks down through photodegradation
  - UV rays break bonds of plastic's molecular chain
- Landfills don't receive rays
  - 35 billion plastic water bottles annually
- Microplastics are formed in the ocean

- Formation of microplastics releases BPA
  - Hormone disruption in animals, heart disease in humans
  - Ingested by marine life

What are Seabins?

- It's a bucket whose rim floats at water level, allowing sea water laced with rubbish, oil, and detergents continually to spill into it
- Mesh bag catches debris and water re-enters ocean
  - Also able to collect oil and fuel through pumping filtration system
- Plastic recovered from seabins can be used to make more
  - Lower current cost of $3,825 each
- Prevents pollution from entering ocean and forming microplastics

Our Plan

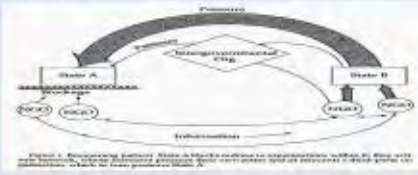
- Place seabins in marinas/ports
- Begin implementing along east coast and work to move throughout US and internationally
- Use plastic recovered to create more seabins, thus lowering cost of production
- Look to governments to install
- Maintenance done by employees of marinas/ports

Potential Drawbacks

- Governmental funding for seabins is an expensive endeavor if implemented internationally
- With Western consumerist cultures being the biggest contributors to water bottle pollution, countries may see their cost to implement seabins as an unequal share of the responsibility for a global problem
- People need to be responsible for routinely emptying bins
- Can only clean one port at a time

Key to International Implementation of Seabins

Our proposed method of utilizing seabins aims to inspire implementation of seabins in countries across the globe. Transnational Nongovernmental Organizations could help pressure government policy to help emit change internationally. Keckand Sikkink's "boomerang model" is exactly how we believe transnational nongovernmental organizations like World Wildlife Fund can get involved to help inspire change. The key to success is international cooperation.



Poster #33

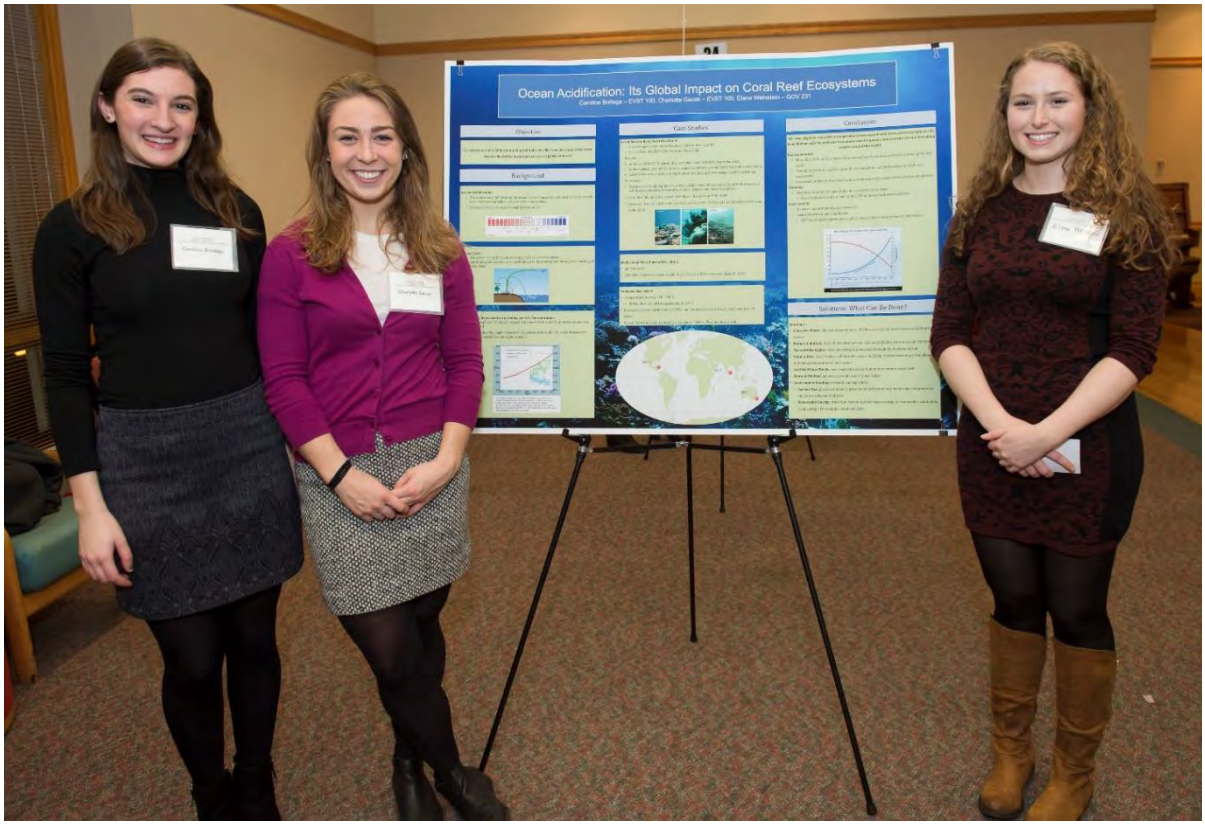
Ocean Acidification: Its Global Impact on Coral Reef Ecosystems

Caroline Bottega, Charlotte Gacek, and Elana Weinstein

Ocean acidification has become a growing concern over the last several decades due to the negative impacts that have been recorded on vulnerable ecosystems, such as coral reef systems. Of these negative impacts, the most prominent and disturbing are the bleaching, dissolving, and reduced productivity of hard coral in reef systems. Ocean acidification has been commonly associated with an overall rise in CO2 levels in these environments. However, this occurrence has been recorded across the globe. In our research, we focus on three specific case studies: Great Barrier Reef, Media Luna Reef, and the reef in Andaman Sea.

Anthropogenic factors are the main cause to the increase in acidity of coastal ocean systems, primarily due to an increase in CO2 emissions into the atmosphere. This takes a local problem and sets it on a global stage. Although the human population is collectively affecting local sites, these localized sites are being negatively affected through their economies specifically regarding coral reef tourism. The question is raised as to whether we are, as humans, equally responsible for coral reef ecosystems. We explore this answer and recognize that there is a problem of unequal responsibility and differential resource use. There are many different aspects that contribute to ocean acidification, yet can also help solve this problem such as policy, economy, science & research, and ideology.

Throughout the project, in addition to educating ourselves on this problem, we hope to find viable solutions to slow the negative effects on global coral ecosystems.



Ocean Acidification: Its Global Impact on Coral Reef Ecosystems

Caroline Bottega – EVST 100, Charlotte Gacek – EVST 100, Elana Weinstein – GOV 231

Objective

To analyze ocean acidification and specifically, its effects on the coral in the Great Barrier Reef off of Australia's coast; is it global or local?

Background

Ocean Acidification:

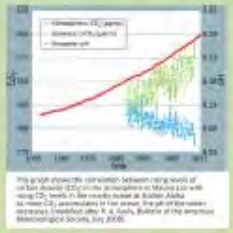
- The reduction of pH levels in the ocean over a long period of time primarily caused by an increased uptake in CO_2 from the atmosphere
- Average surface ocean pH is slightly basic at 8.1

Carbon Cycle:

- The ocean is a carbon sink, meaning it takes in excess carbon
- Anthropogenic carbon is primarily added to the atmosphere through the burning of fossil fuels

Relationship Between Ocean Acidity and CO_2 Concentration

- As atmospheric CO_2 has increased, the concentration of CO_2 in seawater has also increased
- As a result of the higher seawater CO_2 concentration, the pH levels of seawater have decreased, becoming more acidic



Case Studies

Great Barrier Reef, Australia: Site 1

- 8 week experiment on the Southern Barrier Reef in 2007
- Focused on the calcification rate and bleaching

Results:

- At the control CO2 (highest pH), warming led to 45% drop in productivity
- At the highest dose of CO2 in warm water conditions, productivity was reduced by 160%
- Calcification was sensitive to the highest CO2 dosing & was exaggerated by warming.

Conclusion:

- Sensitive reef-building species will be pushed beyond thresholds for growth & survival within a few decades, but coral will show delayed and mixed responses.
- Coral Reef Building Decreased in 6% Reefs (42%) from 1990-2005
- Decrease in Coral Calcification (21%), Coral Growth (16%) and Coral Density (6%) from 1988-2003

Media Luna Reef, Puerto Rico: Site 2

- pH: 7.89-8.17
- Extended exposure to even slight CO_2 increases will decrease calcification rates

Andaman Sea: Site 3

- Temperature Average: 20 – 30° C
  - El Nino Event in 2010 raised temp to 34° C
- Decrease in Coral Calcification (23.5%) and Coral Growth (19.4%-23.4%) over past 15 years
- Loss in Native Species: Damsel fish, Longnose Filefish, Pipe and Razor Fish

Conclusion

The rise of global sea surface temperatures associated with increased atmospheric CO_2 from human activity will lead to an increased frequency and severity of coral bleaching events around the world.

Environmental

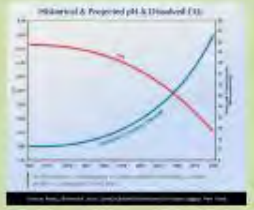
- More than 30% of CO_2 emitted into atmosphere by human activities is taken up by the ocean
- Overall decrease in survival, growth, reproduction, and biodiversity of coral reef ecosystems
- Decreased pH levels of surface waters compromise/prevent calcium carbonate growth

Economy

- Decline in economies, specifically in coral reef eco-tourism
  - Coral reefs contribute to half of the GDP in many Caribbean countries

Government

- No government-funded aid or research
- Lack of international compliance
  - UN Paris Climate Agreement in place, but no clear enforcement or incentives



Solutions: What Can Be Done?

Solutions :

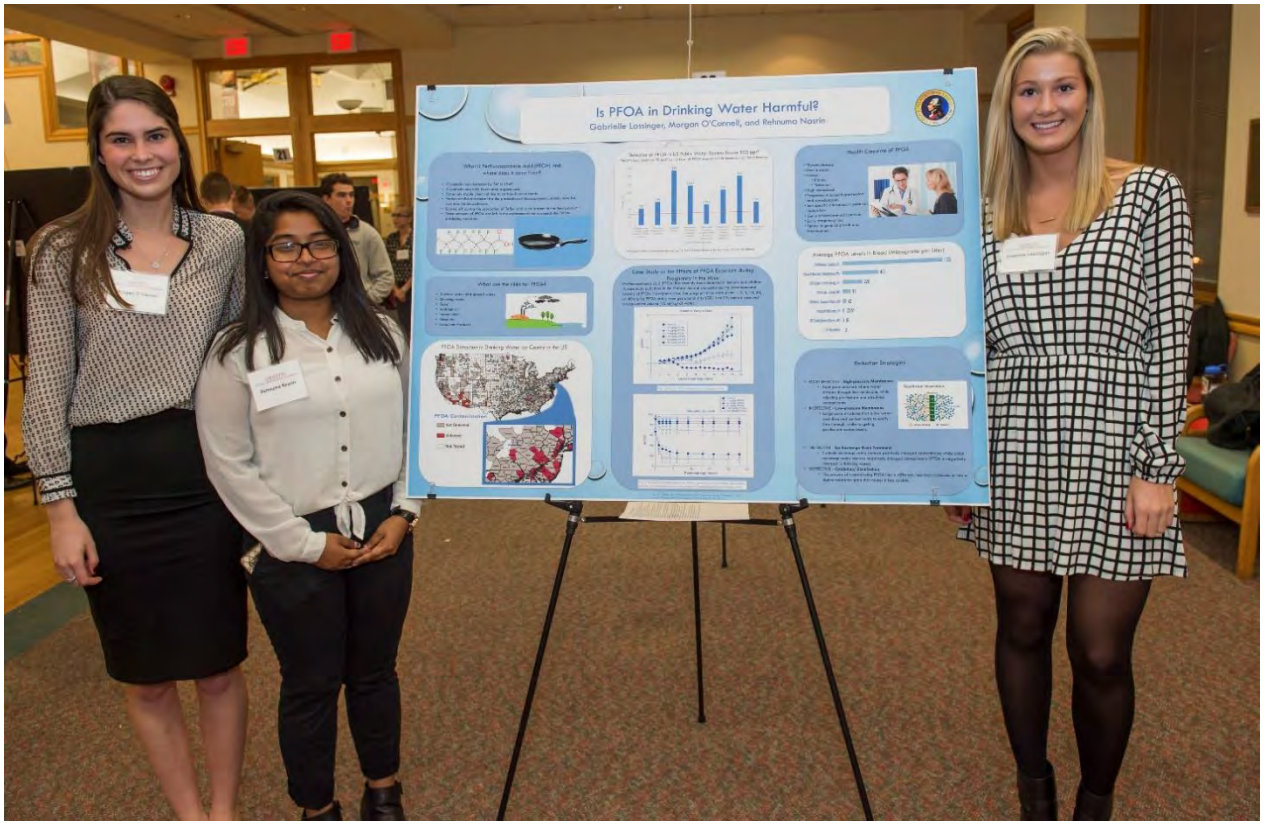
- **Conserve Water**: the less water you use, the less run off and waste water will pollute our oceans
- **Reduce Pollution**: Fossil fuel emission from cars and industry leads to ocean warming
- **Turn Off the Lights**: most electricity is generated through the burning of coal
- **Plant a Tree**: trees reduce runf into the oceans and help reverse warming of the planet and rising temperature of our oceans
- **Artificial Coral Reefs**: man-made structures that imitate natural coral reefs
- **Biorock Method**: achieves growth rates 5 times faster
- **Government funding**: research and legislation
  - **Carbon Tax:** places a monetary price on pollution and may encourage companies to function on cleaner methods
  - **Renewable Energy**: transition from fossil fuel based energy to renewable, sustainable, clean energy; for example: wind and solar

Poster #34

Is PFOA in Drinking Water Harmful?

Gabrielle Lassinger, Rehnuma Nasrin, and Morgan O'Connell

Perfluorooctanoic Acid (PFOA) is a synthetic and fully fluorinated organic acid that was originally manufactured by 3M in 1947. It is an extremely stable chemical due to carbon-fluorine bonds and does not react with other chemicals. The frictionless surface that PFOA produces makes it the perfect artificial chemical for the production of Teflon, a tough synthetic resin mainly used to coat non-stick cooking utensils. Teflon factories burn off trace amounts of PFOA during the production process, spreading the acid into local air and water. For this poster project, we explored the effects that PFOA has on the environment, specifically our drinking water, and the health effects that can be caused by exposure to PFOA. The Environmental Protection Agency and Lifetime Health Advisory claim that any concentration of PFOA above 70 ppt is harmful for humans to drink; however, we found that there are many public water systems in the United States that have recorded concentrations up to 330 ppt. Studies done on pregnant mice have shown that PFOA exposure leads to compromised prenatal survival, early pregnancy loss, and delays in developmental growth. Other health effects of human exposure to PFOA include thyroid disease, liver disease, cancer, and more. To combat the newfound dangers of PFOA, scientists have proposed reduction strategies, most of which have proved to be ineffective, even in a lab setting. We hope our project sheds light on the dangers of PFOA in our drinking water and will promote exploration in new and more effective reduction strategies.



Is PFOA in Drinking Water Harmful?

Gabrielle Lassinger, Morgan O'Connell, and Rehnuma Nasrin

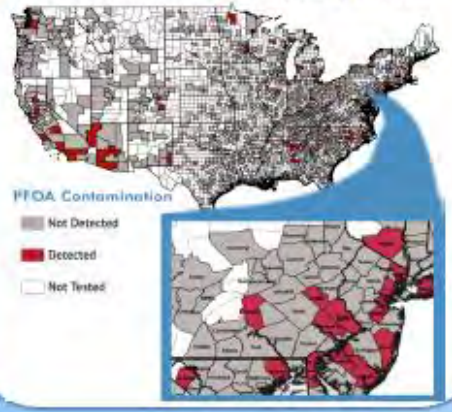
What is Perfluorooctanoic Acid (PFOA) and where does it come from?

- Originally manufactured by 3M in 1947
- A synthetic and fully fluorinated organic acid
- Extremely stable chemical due to carbon-fluorine bonds
- Perfect artificial chemical for the production of fluoropolymers, mainly used for non-stick Teflon cookware
- Burned off during the production of Teflon and is not present in the final product
- Trace amounts of PFOA are left in the environment that surrounds the Teflon-producing factories.

What are the sinks for PFOA?

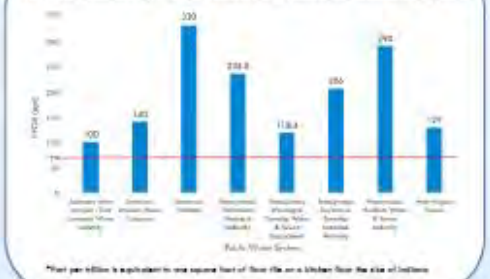
- Surface water and ground water
- Drinking water
- Food
- Ambient air
- Indoor dust
- Biosolids
- Consumer Products

PFOA Detection in Drinking Water by County in the US



Detection of PFOA in US Public Water System Above 100 ppt*

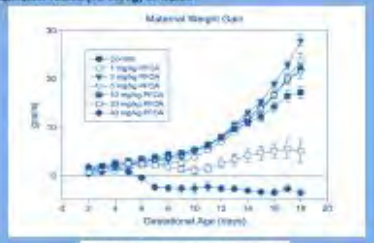
The EPA has identified 70 ppt* as the level of PFOA exposure that becomes harmful to humans

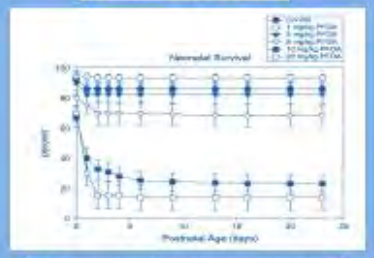


*Part per billion is equivalent to one square foot of water the size of a kitchen floor the size of indiana

Case Study on the Effects of PFOA Exposure during Pregnancy in the Mice

Perfluorooctanoic acid (PFOA) has recently been detected in humans and wildlife. A case study published in the Oxford Journal characterizes the developmental toxicity of PFOA in pregnant mice. The pregnant mice were given 1, 3, 5, 10, 20, or 40 mg/kg PFOA orally from gestational day (GD) 1 to 17; controls received an equivalent volume (10 ml/kg) of water.





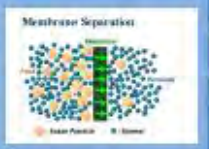
Health Concerns of PFOA

- Thyroid disease
- Liver disease
- Cancer
  - Kidney
  - Testicular
- High cholesterol
- Pregnancy-induced hypertension and preeclampsia
- Sex-specific alterations in pubertal maturation
- Compromised prenatal survival
- Early pregnancy loss
- Delays in general growth and development

Average PFOA Levels in Blood (Micrograms per Liter)

Reduction Strategies

- MOST EFFECTIVE - **High-pressure Membranes**
  - Tight pore structure where water diffuses through the membrane, while rejecting particulate and dissolved contaminants.
- INEFFECTIVE - **Low-pressure Membranes**
  - Large pore structures that allow water and dissolved contaminants to easily flow through, while targeting particulate contaminants.



- INEFFECTIVE - **Ion Exchange Resin Treatment**
  - Cationic exchange resins remove positively charged contaminants while anion exchange resins remove negatively charged contaminants (PFOA is negatively charged in drinking water).
- INEFFECTIVE - **Oxidation/ Disinfection**
  - The process of transforming PFOA into a different, less-toxic molecule or into a higher oxidation state that makes it less soluble.

Poster #35

Dam Removal on the Bushkill Creek

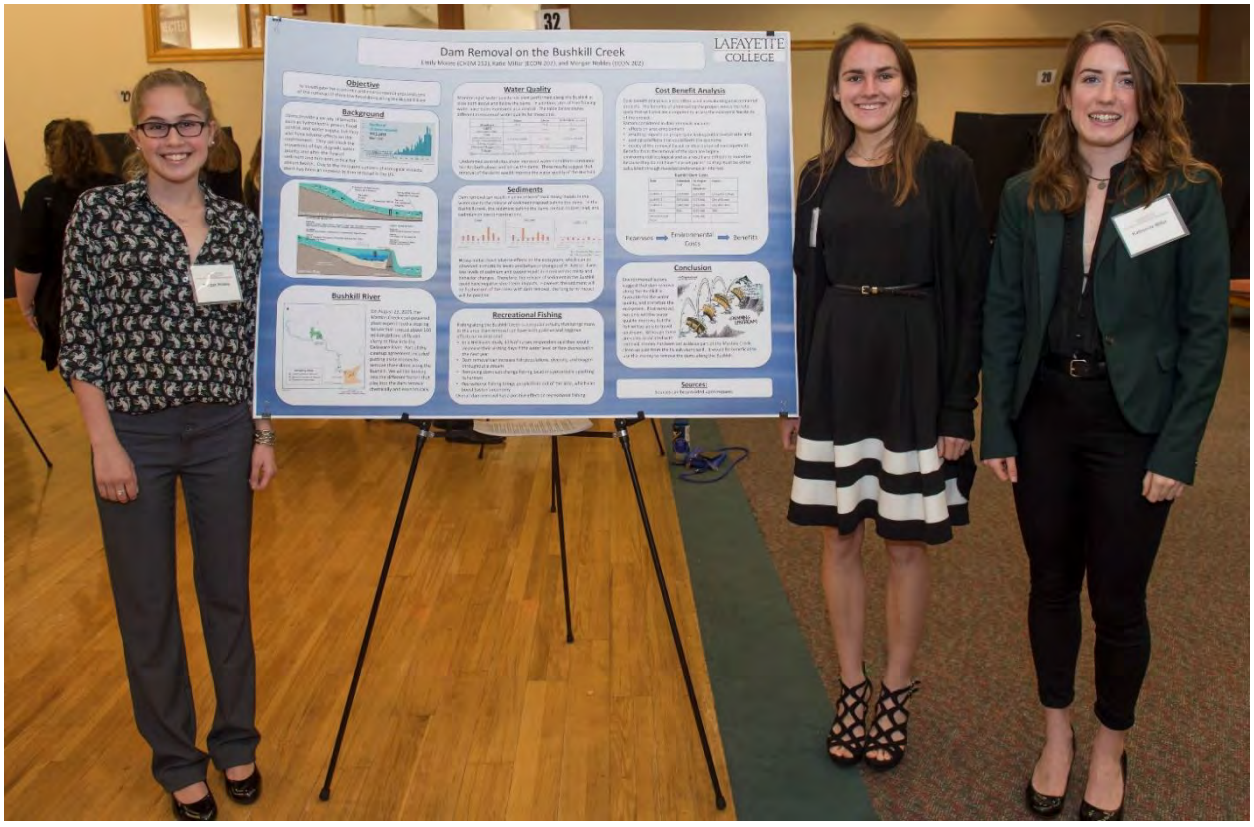
Katie Millar, Emily Moore, and Morgan Nobles

In August 2005 the Martins Creek PPL experienced a fly ash spill due to a wooden stop log failure. Tons of gallons of fly ash slurry spilled into the Delaware River and other surrounding rivers. Clean up began immediately, but by November 2005 PADEP filed a complaint for an incomplete clean up of the spill. Part of the complete cleanup includes the removal of three low head dams along the Bushkill Creek. We have decided to look into the economic and ecological factors of low head dam removal.

Removal of these dams will result in a change in the water quality and composition of the Bushkill Creek. The impact of the sediments released from the dam removal is one important factor to consider during the removal process. In addition, the dams impede water flow which results in different water composition than a free flowing river.

On the economical side, the removal of dams could change the influx of people that visit Easton. The area where the dams are is a popular fishing location. Removal of the dams would increase the diversity and populations of fish, but it could also change the popular fishing areas.

Another aspect of dam removal is the cost-benefit analysis of the project. While it is easy to identify the costs associated, the benefits usually do not have a monetary value. Therefore, it is important to consider many factors, including environmental and economic impacts, when proposing a dam removal.



Dam Removal on the Bushkill Creek

Emily Moore (CHEM 252), Katie Millar (ECON 202), and Morgan Nobles (ECON 202)

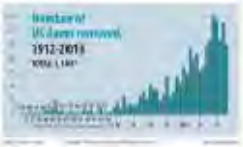
LAFAYETTE COLLEGE

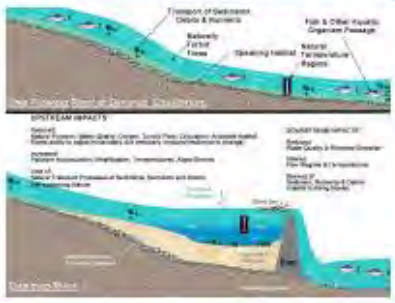
Objective

To investigate the economic and environmental pros and cons of the removal of three low head dams along the Bushkill River

Background

Dams provide a variety of benefits such as hydroelectric power, flood control, and water supply, but they also have adverse effects on the environment. They can block the movement of fish, degrade water quality, and alter the flow of sediment and nutrients critical for stream health. Due to the increased concern of ecological impacts, there has been an increase in dam removal in the US.





Bushkill River

On August 23, 2005, the Martins Creek coal-powered plant experienced a stop log failure that caused about 100 million gallons of fly ash slurry to flow into the Delaware River. Part of the cleanup agreement included putting aside money to remove three dams along the Bushkill. We will be looking into the different factors that play into the dam removal chemically and economically.

Water Quality

Monitoring of water quality has been performed along the Bushkill at sites both above and below the dams. In addition, sites of free flowing water have been monitored as a control. The table below shows different measures of water quality for these sites.

	Below	Above	CONTROL
Abundance	98.4	74.4	111
%EPT	73%	1.8%	83%
HBI	4.3 (Very Good)	7.1 (Fair)	3.5 (Very Good)
Dissolved Oxygen (%sat)	111.6%	112.1%	108.3%
Velocity	0.4	0.5	0.4

Undammed control sites show improved water conditions compared to sites both above and below the dams. These results suggest that removal of the dams would improve the water quality of the Bushkill.

Sediments

Dam removal can result in an increase of toxic heavy metals in the water due to the release of sediment trapped behind the dams. In the Bushkill creek, the sediment behind the dams contain copper, lead, and cadmium in low concentrations.

Heavy metals have adverse effects on the ecosystem, which can be observed in mortality levels and behavior changes of H. Azteca. Even low levels of cadmium and copper result in increased mortality and behavior changes. Therefore, the release of sediment in the Bushkill could have negative short term impacts. However, the sediment will be flushed out of the creek with dam removal, the long term impact will be positive.

Recreational Fishing

Fishing along the Bushkill Creek is a popular activity that brings many to the area. Dam removal can have both positive and negative effects on recreational:

- In a NH Rivers study, 43% of survey responders said they would decrease their visiting days if the water level or flow decreased in the next year
- Dam removal can increase fish populations, diversity, and oxygen throughout a stream
- Removing dams can change fishing locations potentially upsetting fishermen
- Recreational fishing brings people from out of the area, which can boost Easton's economy

Overall dam removal has a positive effect on recreational fishing.

Cost Benefit Analysis

Cost-benefit analysis is a tool often used in evaluating environmental projects. The benefits of undertaking the project versus the total costs that will arise are computed to assess the economic feasibility of the project.

Factors considered in dam removals include:

- effects on area employment
- resulting impacts on property including public and private land
- ecological effects that could harm the economy
- equity of the removal based on distribution of consequences.

Benefits from the removal of the dam are largely environmental/ecological and as a result are difficult to monetize because they do not have "market prices" so they must be either calculated through revealed preference or inferred.

Bushkill Dam Costs

Dam	Estimated Cost	PA Project Funds Allocation	Owner
Bushkill 1	$217,000	$217,000	Lafayette College
Bushkill 2	$175,000	$175,000	City of Easton
Bushkill 3	$142,900	$142,900	City of Easton
TBD	TBD	$467,000	TBD
Dam Removal Total		$743,900	

Expenses → Environmental Costs → Benefits

Conclusion

Environmental factors suggest that dam removal along the Bushkill is favorable for the water quality, and therefore the ecosystem. Post removal, not only will the water quality improve, but the fish will be able to travel upstream. Although there are costs associated with removal, money has been set aside as part of the Martins Creek clean up plan from the fly ash slurry spill. It would be beneficial to use this money to remove the dams along the Bushkill.

Sources:

Sources can be provided upon request.

Poster #36

Green Space: The Best Solution to Stormwater Runoff

Luke Fonteyne, Kyle Rafferty, and Timothy Vangelas

Today's modern stormwater systems, while effective, cause problems for the natural environment. These problems mainly include damage brought on by stormwater runoff, which occurs when there is rain and melting snow on roads, buildings and parking lots that is not able to be infiltrated into the ground. This runoff, which carries harmful pollutants, is directed back into streams and rivers where it damages the natural ecosystem of that body of water. Another issue with that arises from the lack of natural infiltration is that groundwater is being depleted fast. Natural stores of fresh water in the earth are being used up faster than they are being replenished. Today's stormwater system has also been shown to overburden wastewater treatment plants. To combat these effects, governments have implemented legislations that aim at reducing areas where water can runoff directly into natural bodies of water, and expand grassy areas (green space) where wastewater and stormwater can be dealt with more naturally. This also can alleviate some of the stress on municipal water treatment facilities, as well as restore groundwater. Increasing green space is an approach that can help a city's ecosystem sustain itself more readily, and provide more economic growth as water becomes a more abundant and reusable resource.

Green Space: The Best Solution to Stormwater Runoff

Kyle Rafferty, Luke Fonteyne, Tim Vangelas

Introduction

- Problems with Today's Stormwater Infrastructure Include:
  - -Damage Brought on by Runoff
  - -Pollution Brought on by Runoff
  - -Lack of Natural Infiltration
  - -Groundwater Depletion
  - -Overburdening of Wastewater Treatment Plants
- In Order to Combat These Effects,
  - -Governments have implemented legislations that aim at reducing areas where water can runoff directly into natural bodies of water, and expanding grassy areas (green space) where wastewater and stormwater can be dealt with more naturally.
  - -This also can alleviate some of the stress on municipal water treatment facilities, as well as restore groundwater.

Grey Infrastructure

- In urban areas, the connection of impervious surfaces (i.e. roads, parking lots and roofs) to traditional grey infrastructure (i.e. storm drains, storm sewers and combined sewer systems) was originally intended to convey stormwater runoff and reduce flooding.
- These traditional stormwater systems are known to result in: the erosion of waterways, water pollution, degradation of downstream ecosystems during wet weather events, localized flooding, pollutants and nutrients that deposit on surfaces, and combined sewer overflows.

Portland, Oregon

- The Largest Mature Green Stormwater System in the United States
- Rain Gardens, Eco-Roofs at Household Scales, Bio-Retention and Dentention Facilities at Neighborhood Scales, and Increase in the Urban Tree Canaopy at Regional Scales
- Tabor to Riber (T2R) Program—500 Vegetated Stormwater Facilities, >100 Private Stormwater Facilities, the Planting of 3,500 Trees, the Repair or Replacement of 266 km of Sewer Pipe, Delivering Educational Materials, and Soliciting input through Workshops

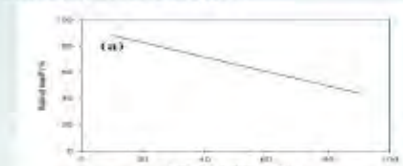
Stormwater Runoff Damages

Economic Effects

- Before Green Stormwater Infrastructure
  - -Stormwater Primarily Stored in Tanks
  - -Very Expensive
- After Green Stormwater Infrastructure
  - -Integrated of Green Stormwater Infrastructure with Engineering Systems
  - -Cost Drop from $144 Million to $63 Million
- Benefits of Green Stormwater Infrastructure
  - -Cost-Effective
  - -Lowers Capital Costs for Developers
  - -More Innovative
  - -Promotes Economic Growth
  - -Increases Property Values

Conclusion

- Fig. A illustrates the diminishing trend of stormwater runoff volume with increasing pervious area percentage.
- When pervious area percentage is increased from 10% to 90%, the ratio of runoff to rainfall significantly decreased from 88.05% to 43.85%.
- Increased green cover by 10% in the residential land reduces runoff by 4.9%, and increased tree cover by the same amount reduces the runoff by 5.7%.
- Doubling impervious cover from 30% to 60%, by replacing bare soil and short vegetation classes with impervious cover, increased total runoff by 33%, and reduced pervious runoff by 53%.



Picture Sources

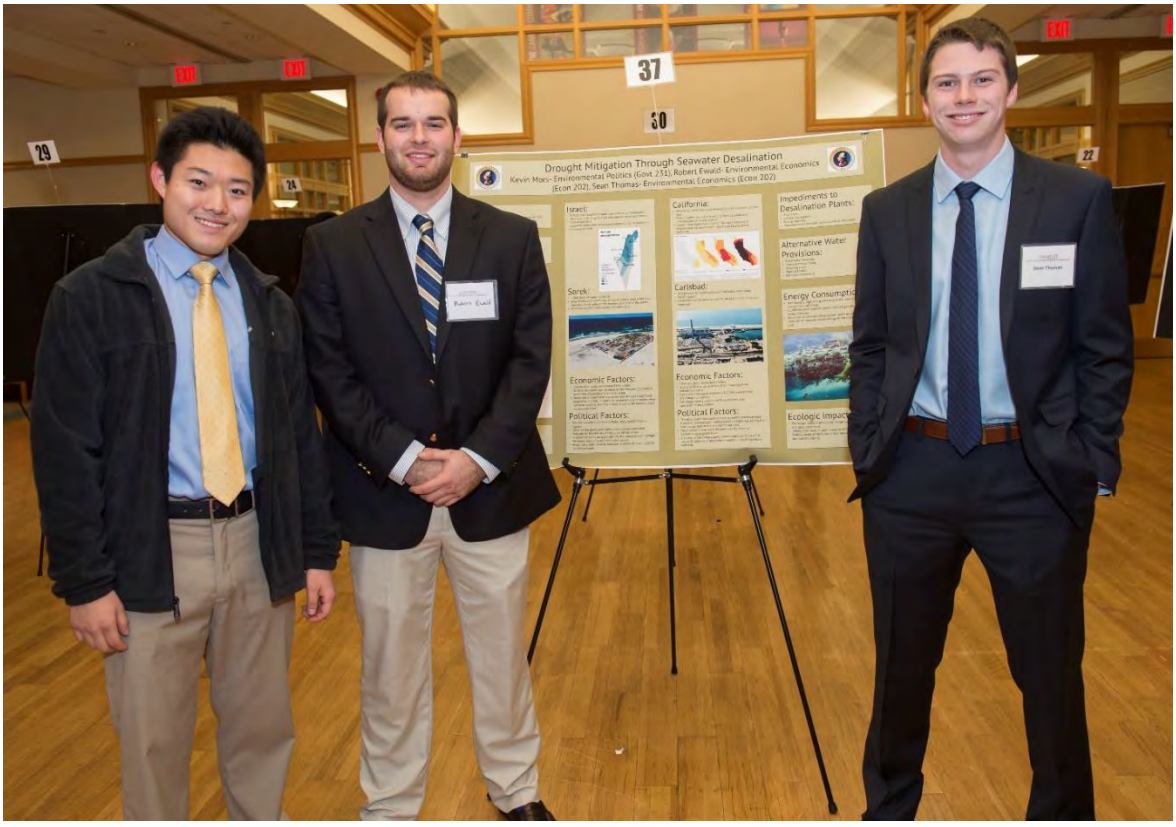
Poster #37

Drought Mitigation Through Seawater Desalination

Robert Ewald, Kevin Mors, and Sean Thomas

Over 40 million people in California are in the middle of the state's worst drought since the late 1970s. Compared to the millions of dollars that have been lost to, and spent on solving the drought, the cost of desalination plants no longer seems as prohibitive as it once did. California has been heavily invested in water recycling, but the extent of the drought has rendered these unable to help mitigate the problem. Desalination plants in Israel show possible opportunities that California can apply. Israel's advancements in membrane technology have reduced the geographic and environmental footprints as well as maintenance costs of the desalination plants. Sea water desalination has emerged as a reliable, and long term economically viable solution to California's current, and likely future water issues.

However, political opposition to sea water desalination plants has been strong in California. The Carlsbad, California sea water desalination plant is set to open this year, but it has been delayed due to 14 environmental lawsuits. But this does not change the fact that particularly arid regions, including those in the United States, have been, and need to, examine solutions to long term droughts. New technologies are available that further reduce the environmental impact of desalination, but these options increase the price of water greatly. Desalination plants emerge out of necessity and they address the limitations of water recycling in drought prone areas.



Drought Mitigation Through Seawater Desalination

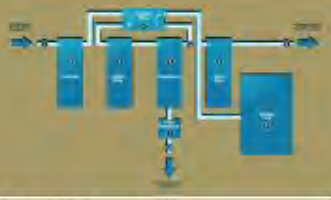
Kevin Mors- Environmental Politics (Govt 231), Robert Ewald- Environmental Economics (Econ 202), Sean Thomas- Environmental Economics (Econ 202)

Objective:

- Address how Israel's new developments in reverse osmosis desalination could be applied to California as a way to mitigate the effects of long term drought

Innovations:

- New vertical membrane technology
- Reduction in pressure tube size
- Reduction in energy inputs
- Increase in membrane size



Significance:

- End of freezing and melting water
- Plants require smaller geographic footprint
- Less energy input means cheaper water
- Ends California's dependence on water recycling plants

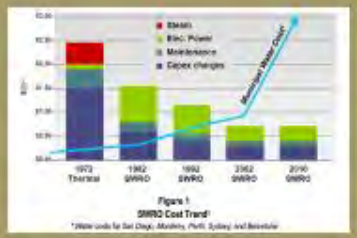


Figure 1
SWRO Cost Trend[1]

[1] Water costs for San Diego, Monterey, Perth, Sydney and Barcelona

Implications:

- Worldwide there are nearly 700 million people who lack access to clean water. This number is expected to reach 1.8 billion by 2050.

Israel:

- 20% of total household water use comes from desalination
- More than 50% of agriculture and industry water use comes from desalination
- Israel has three other desalination plants similar to Sorek, but on a smaller scale

Sorek:

- 1,000 liters of water for $0.58
- New membrane technology allows 4.3 times more water flow and has greatly reduced the maintenance cost of the plants
- Produces 627,000 cubic meters of water daily

Economic Factors:

- Construction costs were about $500 million
- In 2015, this plant was heralded as the cheapest and largest producing desalination plant ever made
- Sorek was a response to the seven year drought Israel faced beginning in 2000. In that time period billions of dollars were spent on reactive, short term fixes, showing the need for more reliable solutions.

Political Factors:

- Was initiated through Israel's Water Desalination Federal Agency
- Desalination plants and water allocation are controlled federally by the Ministry of National Infrastructure
- Millions are spent on organizations and campaigns to highlight the importance of sustainable water usage
- Historically, water scarcity had been a source of much political conflict in Israel

California:

- Most of Southern California receives only 10 inches of rain per year
- Bulk of California's water is coming from Colorado at an unsustainable price and amount
- Current issue California is facing: "You can't conserve or recycle what you don't have" – San Diego County Water Authority

Carlsbad:

- Will provide 50 million gallons of drinkable water daily
- $0.07 / gallon
- 14 environmental lawsuits against the plant since plan was approved

Economic Factors:

- Costs will total nearly $690 million
- Nearly $200 less per acre foot than importing from outside California
- California is losing an estimated $2.2 billion each year the drought continues
- San Diego county is home to 35 companies that specialize in desalination

Political Factors:

- Ten other California counties have agreed to purchase water from the Carlsbad plant and have begun exploring adding their own plants despite the environmental risks
- Desalination plants have become a critical issue in determining local elections
- A survey in San Diego county determined that "9 out of 10 residents approve of desalination plants" – San Diego Water Authority

Impediments to Desalination Plants:

- High costs
- Coastal degradation
- Energy intensity
- Two volumes of sea water produce one of fresh water

Alternative Water Provisions:

- Wastewater recycling
- Groundwater pumping
- Diverting rivers
- Imported water
- Rainwater harvesting

Energy Consumption:

- Traditionally, high energy intensity is the main reason costs are seen as prohibitive
- 15,000 kilowatt-hours of power / million gallons of fresh water produced
- Sorek has its own natural gas power plant on site to reduce costs, which reroutes excess energy to the national power grid

Ecologic Impact:

- Sea Water intake pipes can be dangerous for both small and large organisms
- Intake pipes draw in large amounts of fish eggs and larvae
- Salinity levels of the brine is very harmful to the ocean if dumped improperly

Poster #38

Wastewater Recycling: Why Current Processes Surpass Past Methods

Ted Granbois, Amanda Grisanti, and Eric Herbst

With the increased fear of droughts, efforts are being made to conserve and reuse water. Rather than trying to pump in more water to the drought areas, reusing the already used water keeps the water in a continuous cycle of use. Wastewater recycling is a popular method used to collect water that has been discharged with waste and sewage. Recycling wastewater reintroduces water back into normal human usage and helps fight against droughts many places face. Different methods of wastewater treatment produce different qualities of water that are used for agriculture, water for cooling towers, and water for domestic use, however, some methods are better than others. We researched three main methods used in wastewater recycling systems: microfiltration, reverse osmosis, and UV light treatment. Additionally, we compared older techniques to the newer techniques and explained why the new techniques are more efficient and environmentally friendly. Many of the older techniques used chemicals to treat the water, however, the methods were expensive and unsustainable. The purpose of the new techniques was to both help the environment and increase efficiency. With the ever changing technologies, it is our hopes that waste water treatment plants will become efficient enough and affordable for nations around the world to have properly cleaned drinking water.

Wastewater Recycling: Why Current Processes Surpass Past Methods

Amanda Grisanti, Ted Granbois, Eric Herbst
Lafayette College 2016

Introduction

Reusing water has become a common practice especially in areas with low water supplies. The main concerns for the treatment processes are the impacts on the environment and filtration quality to ensure the benefits of the system.

Hypothesis and Prediction

Hypothesis: The new processes for wastewater treatment are more efficient and are more environmentally friendly compared to the older methods of treatment.

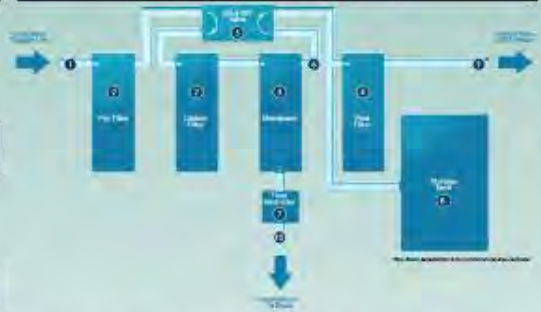
Microfiltration

- Filters pathogens out of water streams
  - Commonly used with other methods of filtration
  - Pore sizes ranging from 0.1 to 10 micrometers
    - Removes larger sediments/pollutants

Pros:Low pressure microfiltration uses less energy and costs less, 30% lower cost for chemicals than direct filtration, low maintenance

- Older Method-Chlorine
  - John Snow, cholera, and the Broad Street Pump; London in the 1800's
  - U.S Council of Environmental Quality reports the risk of cancer increased by 93% in people drinking chlorinated water
    - Chlorine combines with organic matter to form trihalomethanes which cause major health issues
  - Chlorine resistance

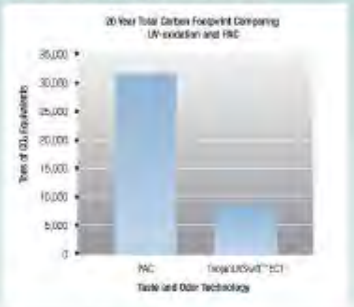
Reverse Osmosis



- Demineralized/deionized water by pushing it under pressure through a semi-permeable Reverse Osmosis membrane
  - Use of high pressure pump and semi-permeable membrane allow passage of water molecules only
- Removes up to 99+% of dissolved salts, particle, colloids, organics, bacteria, and pyrogens
- As membrane performance increases, so does the RO system:
  - Factors affecting membrane performance: Pressure, Temperature, Salt Concentration, Recovery, pH
- Reverse Osmosis vs Forward Osmosis
  - RO is better; more applicable to wastewater treatment, higher energy efficiency, FO is sometimes used prior to using RO

UV Light Treatment

- UV-oxidation radicalizes hydrogen peroxide to break down odor and taste causing contaminants
- UV photolysis deactivates bacteria
- Requires no additional dry-solids removal
- Has a higher efficiency and lower carbon footprint than powdered activated carbon (PAC) systems
- UV-oxidation reduces geosmin concentration 25% more than PAC
- UV-oxidation complies with USEPA Long-Term 2 Enhanced Surface Water Treatment Rule



Conclusion

The combination of all three new methods of water treatments is going to impact the environment least and ensure clean water more efficiently than the older methods.

- Eliminates waste water discharge to bodies of water
- In some cases, recycled water has higher levels of nutrients used for agriculture
  - If chlorinated water is used for agriculture, remnants of chlorine or harmful byproducts left in the water would kill crops
- Augment surface water reservoirs
- Increases quality of water to ecosystems without the concern of harmful chemicals that would reduce animal populations

Poster #39

The Wastewater Infrastructure Crisis in New York City

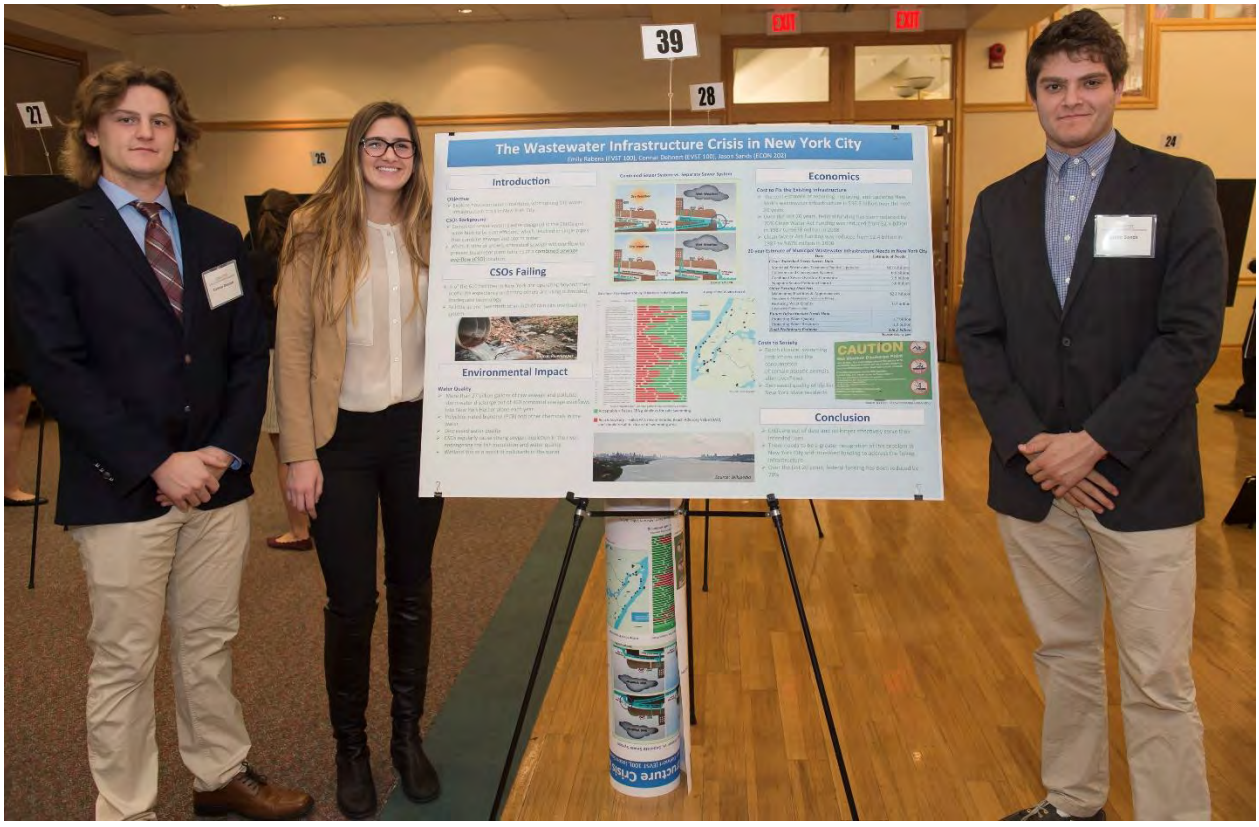
Connar Dehnert, Emily Rabens, and Jason Sands

Our poster examines how economics interferes with solving the wastewater infrastructure problem in New York City and analyzes the environmental impact of the failing infrastructure.

New York City is primarily served by a combined sewer system. Combined sewer systems were designed in the 1800s and were built to be cost efficient, which resulted in single pipes that combine sewage and storm water. It takes a mere 1/20th of an inch of rain to overwhelm the pipe capacity in which untreated sewage will overflow to prevent treatment plant failures. In New York City, there are 460 combined sewage overflow (CSO) outfalls where more than 27 billion gallons of raw sewage and polluted storm water are released into the Hudson River each year.

Water quality is directly affected by CSOs. Impaired water quality poses a threat to aquatic ecosystems in the Hudson River and endangers fish populations. Decreased water quality also affects recreational use especially after it rains.

New York City receives limited federal and state assistance in maintaining wastewater infrastructure. Over the last 20 years, federal funding has been reduced by 70 percent. New York City significantly lacks the funding necessary to update the infrastructure, which is estimated to be $36.2 billion over the next 20 years.



The Wastewater Infrastructure Crisis in New York City

Emily Rabens (EVST 100), Connar Dehnert (EVST 100), Jason Sands (ECON 202)

Introduction

Objective

- Explore how economics interferes with solving the water infrastructure crisis in New York City

CSOs Background

- Combined sewer systems were designed in the 1800s and were built to be cost efficient, which resulted in single pipes that combine sewage and storm water
- When it rains or snows, untreated sewage will overflow to prevent treatment plant failures at a combined sewage overflow (CSO) location

CSOs Failing

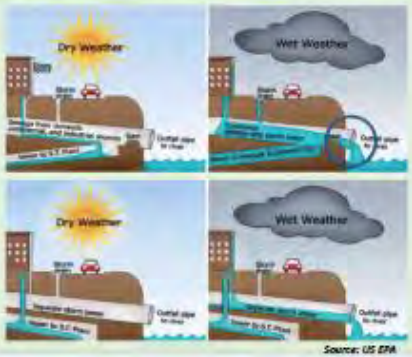
- ¼ of the 610 facilities in New York are operating beyond their useful life expectancy and many others are using outmoded, inadequate technology
- As little as one-twentieth of an inch of rain can overload the system

Environmental Impact

Water Quality

- More than 27 billion gallons of raw sewage and polluted stormwater discharge out of 460 combined sewage overflows into New York Harbor alone each year
- Polychlorinated biphenyl (PCB) and other chemicals in the water
- Decreased water quality
- CSOs regularly cause strong oxygen depletion in the river, endangering the fish population and water quality
- Wetland loss as a result of pollutants in the water

Combined Sewer System vs. Separate Sewer System



Data from Riverkeeper's Study of Bacteria in the Hudson River

A map of the 20 sites tested

Source: Riverkeeper - All data gathered by community volunteers

Acceptable = Passes EPA guidelines for safe swimming.

Beach Advisory = Fails EPA's recommended Beach Advisory Value (BAV), and should result in closure of swimming area

Economics

Cost to Fix the Existing Infrastructure

- The cost estimate of repairing, replacing, and updating New York's wastewater infrastructure is $36.2 billion over the next 20 years
- Over the last 20 years, federal funding has been reduced by 70% Clean Water Act Funding was reduced from $2.4 billion in 1987 to %678 million in 2008
- Clean Water Act Funding was reduced from $2.4 billion in 1987 to %678 million in 2008

20-year Estimate of Municipal Wastewater Infrastructure Needs in New York City

Data	Estimate of Needs
Clean Watershed Needs Survey Data	
Municipal Wastewater Treatment Facility Upgrades	$13.6 billion
Collection and Conveyance Systems	6.6 billion
Combined Sewer Overflow Correction	7.5 billion
Nonpoint Source Pollution Control	3.0 billion
Other Existing Data Sets	
Maintaining Facilities & Appurtenances Operation & Maintenance; Auxiliary Power	$2.1 billion
Restoring Water Quality Unsewered Communities	0.7 billion
Future Infrastructure Needs Data	
Protecting Water Quality	1.7 billion
Protecting Water Resources	1.0 billion
Total Preliminary Estimate	*$36.2 billion*

Source: dec.ny.gov

Costs to Society

- Beach closure, swimming restrictions and the consumption of certain aquatic animals after overflows.
- Decreased quality of life for New York State residents

Source: NY Dept. of Environmental Conservation

Conclusion

- CSOs are out of date and no longer effectively serve their intended uses
- There needs to be a greater recognition of this problem in New York City and increased funding to address the failing infrastructure
- Over the last 20 years, federal funding has been reduced by 70%

Poster #40

Pollution of the Amazon Due to Mining Activities from an Economic and Policy Standpoint

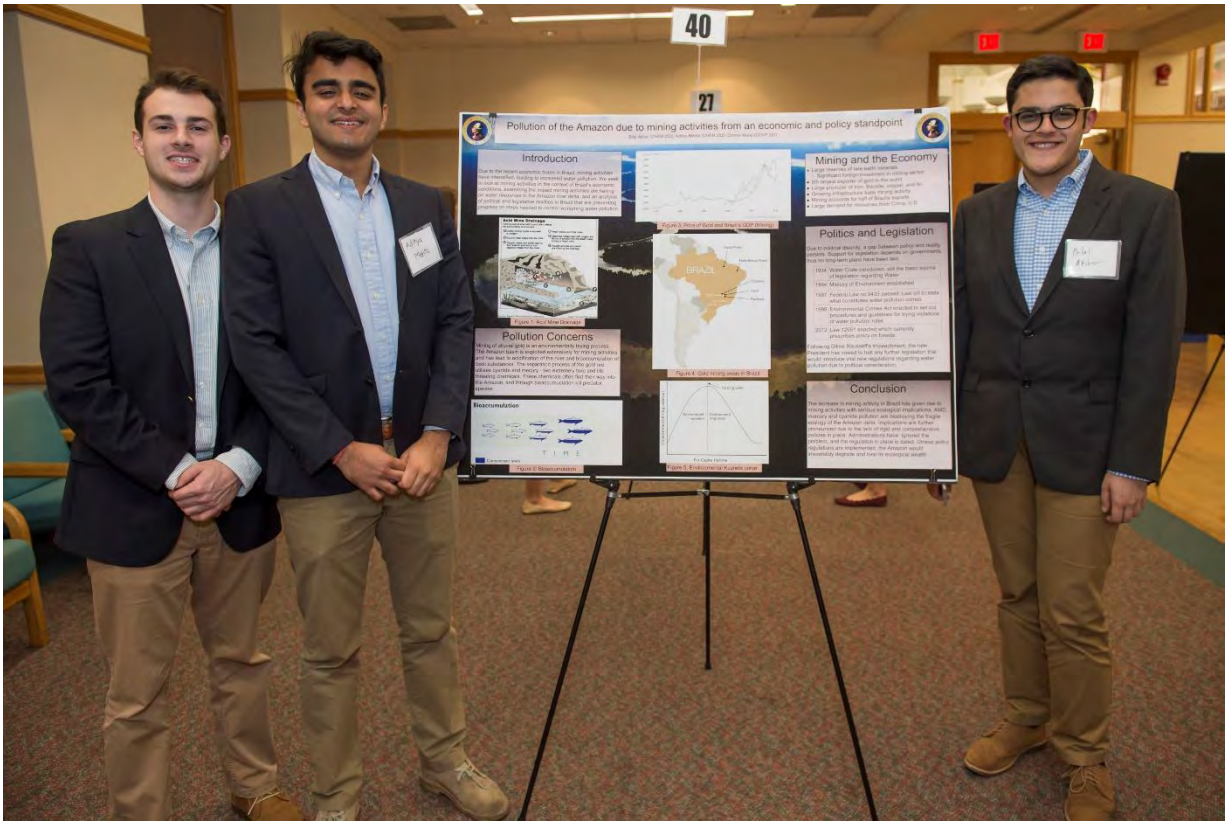
Bilal Akbar, Aditya Mehta, and Connor Morel

The purpose of this poster is to analyze the pollution of the Amazon River due to growth in mining activities around the delta from an economic and political perspective. Brazil's emerging economy and rising gold prices have catalyzed growth in the mining industry over the past few years. Mining has traditionally been a key component of Brazil's economy, and most of these activities tend to take place around the Amazon delta.

The Amazon is host to some of the world's most diverse ecology. The growth in mining activities had degraded this biodiversity and poses a great threat of permanently destroying the ecology around the Amazon. Acid mine drainage, mercury and cyanide pollution are three major forms of water pollution that have degraded the Amazon. Acidification of the river and presence of hazardous chemicals poses a great threat to the river's delicate ecosystem.

Brazil's GDP has been accelerating at a rate of around 5% per year for the past couple of decades. This growth rate has been made possible by the mining sector which has been growing exponentially. Gold mining is a major metal that is mined in Brazil, and the process involved in the process is extremely detrimental to the survival of the Amazon.

Brazilian policy (or its lack of) in the mining industry has catalyzed the pollution. Illegal mining has been on the rise to meet the excess demand, and the lack of proper policy to watch over the industry has affected the ecology of the Amazon.



Pollution of the Amazon due to mining activities from an economic and policy standpoint

Bilal Akbar (CHEM 252), Aditya Mehta (CHEM 252), Connor Morel (GOVT 231)

Introduction

Due to the recent economic boom in Brazil, mining activities have intensified, leading to increased water pollution. We seek to look at mining activities in the context of Brazil's economic conditions, examining the impact mining activities are having on water resources in the Amazon river delta, and an analysis of political and legislative realities in Brazil that are preventing progress on steps needed to control worsening water pollution

Figure 1: Acid Mine Drainage

Pollution Concerns

Mining of alluvial gold is an environmentally taxing process. The Amazon basin is exploited extensively for mining activities and has lead to acidification of the river and bioaccumulation of toxic substances. The separation process of the gold ore utilises cyanide and mecury - two extremely toxc and life threating chemicals. These chemicals often find their way into the Amazon, and through bioaccumuclation kill predator species.

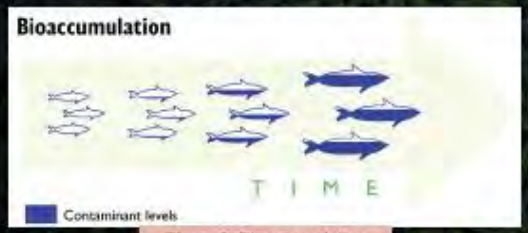


Figure 2: Bioaccumulation

Figure 3: Price of Gold and Brazil's GDP (Mining)

Figure 4: Gold mining areas in Brazil

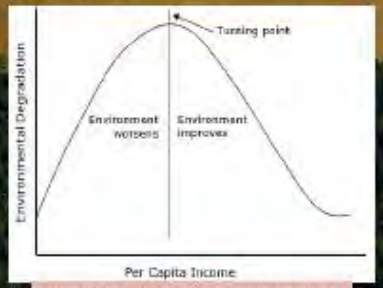


Figure 5: Environmental Kuznets curve

Mining and the Economy

- Large reserves of rare earth minerals
  - Significant foreign investment in mining sector
- 5th largest exporter of gold in the world
- Large producer of Iron, Bauxite, copper, and tin
- Growing infrastructure fuels mining activity
- Mining accounts for half of Brazils exports
- Large demand for resources from China, U.S

Politics and Legislation

Due to political disunity, a gap between policy and reality persists. Support for legislation depends on governments, thus no long-term plans have been laid.

1934	Water Code introduced, still the basic source of legislation regarding Water
1994	Ministry of Environment established
1997	Federal Law no.9433 passed: Last bill to state what constitutes water pollution crimes
1998	Environmental Crimes Act enacted to set out procedures and guidelines for trying violations of water pollution rules
2012	Law 12651 enacted which currently prescribes policy on forests

Following Dilma Rousseff's impeachment, the new President has vowed to halt any further legislation that would introduce vital new regulations regarding water pollution due to political consideration.

Conclusion

The increase in mining activity in Brazil has given rise to mining activities with serious ecological implications. AMD, mercury and cyanide pollution are destroying the fragile ecology of the Amazon delta. Implications are further pronounced due to the lack of rigid and comprehensive policies in place. Administrations have ignored the problem, and the regulation in place is dated. Unless policy regulations are implemented, the Amazon would irreversibly degrade and lose its ecological wealth.

Poster #41

The Untapped Potential of America's Wastewater Treatment Plants

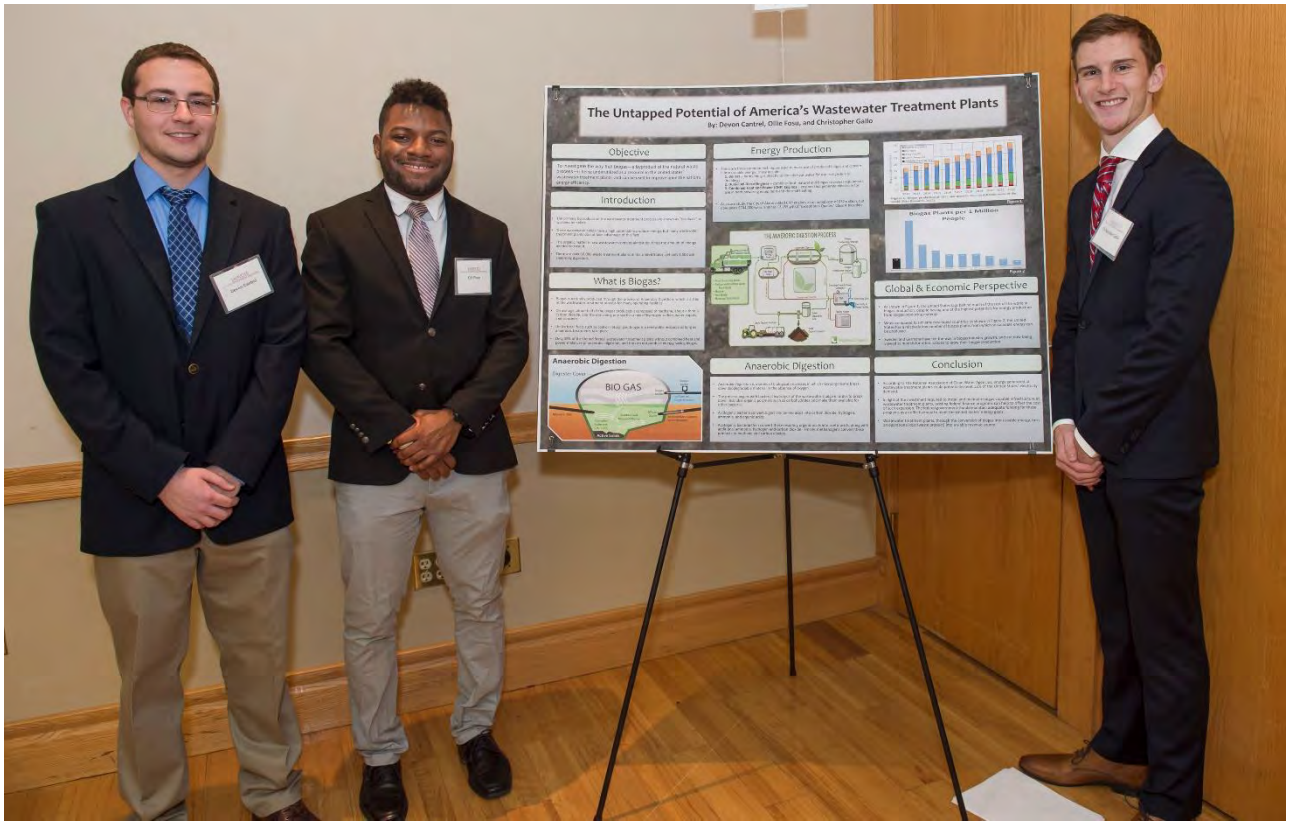
Devon Cantrel, Olli Fosu, and Christopher Gallo

The focus of this research is to assess and analyze the way that biogas— a natural byproduct of the wastewater treatment process— can be used to generate useable energy, and thus reduce the overall energy consumption of the wastewater treatment process.

Initial stages of wastewater treatment act to remove and separate wastewater solids, which are considered to be 'residuals'. Currently, nearly half of all residuals produced by municipal wastewater treatment systems are landfilled or incinerated, resulting in harmful environmental effects.

Biogas is a fuel that is generated from the anaerobic treatment of biosolids. In a typical wastewater treatment plant, the biosolids are pumped to an anaerobic digester that contains microorganisms; these organisms break down the organic matter contained in the sludge, thus making it useful for purposes such as soil conditioning and fertilization. However, the process of breaking down the organic matter produces biogas, which (in wastewater) contains useable energy amounting to almost ten times the energy required for treatment if an effective purification process is used. As a result, there are wastewater treatment plants that can produce 100% of their energy requirements through the use of biogas.

A multidisciplinary approach is required to analyze the legal, environmental, and societal implications of improving wastewater treatment plant energy efficiency. This perspective will allow us to better understand the feasibility of energy improvements when all disciplines are weighed, and thus assist in guiding a physical result that accounts for the interconnected nature of our global energy challenges.



The Untapped Potential of America's Wastewater Treatment Plants

By: Devon Cantrel, Ollie Fosu, and Christopher Gallo

Objective

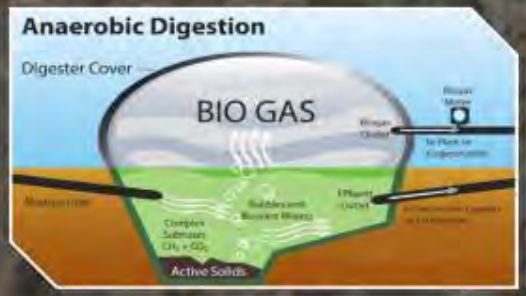
To investigate the way that biogas—a byproduct of the natural waste process—is being underutilized as a resource in the United States' wastewater treatment plants, and can be used to improve upon the nation's energy efficiency.

Introduction

- The primary byproducts of the wastewater treatment process are known as "residuals", or wastewater solids.
- These wastewater solids have a high potential to produce energy, but many wastewater treatment plants do not take advantage of this fact .
- The organic matter in raw wastewater contains almost ten times the amount of energy needed to treat it.
- There are over 16,000 waste treatment plants in the United States, yet only 1,500 use anaerobic digestion.

What is Biogas?

- Biogas is naturally produced through the process of Anaerobic Digestion, which is a step in the wastewater treatment process for many operating facilities.
- On average, about half of the biogas produced is composed of methane, about a third is carbon dioxide, and the remaining one-sixth is a mix of hydrogen sulfide, water vapors, and siloxanes.
- Unlike fossil fuels such as coal or natural gas, biogas is a renewable resource as long as anaerobic treatments take place.
- Only 43% of the United States' wastewater treatment plants without combined heat and power make use of anaerobic digestion, and thus do not produce energy-saving biogas.



Energy Production

- There are three common techniques used to make use of produced biogas and convert it into useable energy. These include:
  1. Boilers – burns the gas directly to directly heat water for use in digesters or buildings.
  2. Dual-Fuel Diesel Engines – combines both natural and biogas to power equipment.
  3. Combined Heat and Power (CHP) Engines – engines that generate electricity for use in both powering equipment and thermal heating.
- As a case study, the City of Akron added CHP engines at an initial cost of $32 million, but now saves $704,000/year, and has 12,255 yd³ of "Exceptional Quality" Class A biosolids.

Anaerobic Digestion

- Anaerobic Digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen.
- The process begins with bacterial hydrolysis of the wastewater sludge in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria.
- Acidogenic bacteria convert sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids.
- Acetogenic bacteria then convert these resulting organic acids into acetic acids, along with additional ammonia, hydrogen and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide.

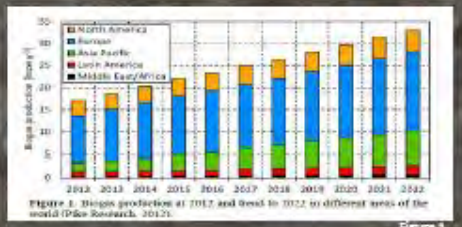


Figure 1. Biogas production at 2012 and trend to 2022 in different areas of the world (Price Research, 2012).

Figure 1

Figure 2

Global & Economic Perspective

- As shown in Figure 1, the United States lags behind much of the rest of the world in biogas production, despite having one of the highest potentials for energy production from biogas-producing material.
- When compared to similarly developed countries as shown in Figure 2, the United States has a relatively low number of biogas plants from which sustainable energy can be produced.
- Sweden and Germany have led the way in biogas industry growth, and are now being viewed as models for other nations to grow their biogas production.

Conclusion

- According to The National Association of Clean Water Agencies, energy generated at wastewater treatment plants could potentially meet 12% of the United States' electricity demand.
- In light of the investment required to install and maintain biogas-capable infrastructure at wastewater treatment plants, existing federal finance programs can help to offset the cost of such expansion. The federal government should maintain adequate funding for these programs as an effective way to meet the United States' energy goals.
- Wastewater treatment plants, through the conversion of biogas into useable energy, turn an operational cost (waste product) into a viable revenue source.

Poster #42

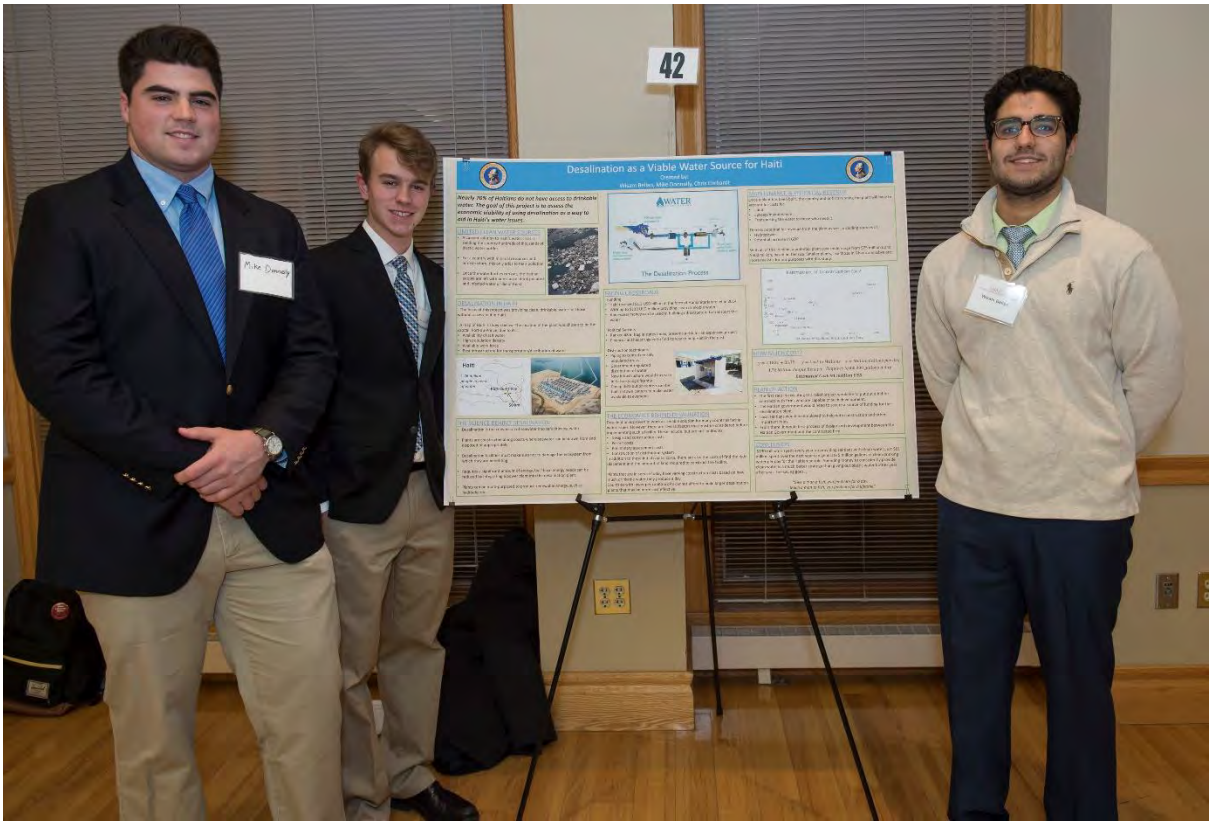
Desalination as a Viable Water Source for Haiti

Wisam Bellan, Mike Donnelly, and Chris Ehrhardt

Third World countries have long dealt with lack of clean water for their citizens to drink. This project will explore the viability of using desalination as a means to get clean drinking water to third world citizens. Coastal countries that are struggling economically, are countries that have been given a closer look. The research was focused on providing Haiti with clean water. Successful desalination plants in Israel, Libya and Ghana were studied to set parameters for plants that could be made in Haiti.

Desalination is the chemical process involving stabilization, filtration, neutralization, and distillation of seawater in order to turn it into fresh, sterile water. The process of desalination is designed and built in a large plant, seawater is desalinated and distributed as is needed from these plants.

By analyzing the costs and production ability of desalination plants in Israel, Ghana, and Libya, we have been able to estimate the cost of a plant in Haiti based on its need for water. This estimation includes the following costs; design and construction, capital and labor, and materials. Once the plant is constructed, the firm and/or government agency running the plant will have to consider maintenance, labor, and power costs. Based on our research, we find that producing a large, single plant will help reduce these costs mentioned above. Our project aims to show how this kind of water production will prove to be cost effective in the future and help sustain Haitians for years to come.



Desalination as a Viable Water Source for Haiti

Created by:
Wisam Bellan, Mike Donnelly, Chris Ehrhardt

Nearly 70% of Haitians do not have access to drinkable water. The goal of this project is to assess the economic viability of using desalination as a way to aid in Haiti's water issues.

LIMITED CLEAN WATER SOURCES

- A current solution to Haiti's water crisis is sending the country hundreds of thousands of plastic water bottles
- For a country with minimal resources and infrastructure, this only adds to their pollution
- Once the water bottles run out, the Haitian people are left with one choice: drink polluted and infected water or die of thirst.

DESALINATION IN HAITI

The focus of this project was providing clean, drinkable, water for those without access to it in Haiti.

A map of Haiti is shown below. The location of the plant was chosen to be the capital, Port-au-Prince, due to its:

- Availability of salt water
- High population density
- Available work force
- Best infrastructure for transportation/distribution of water

THE SCIENCE BEHIND DESALINATION

- Desalination is the conversion of seawater into safe drinking water
- Plants are constructed along coasts where seawater can be drawn from and disposed of appropriately
- Desalination facilities must make sure not to damage the ecosystem from which they are benefiting.
- Requires a significant amount of energy, but those energy needs can be reduced by integrating a power plant into the desalination plant.
- Plants can be multi-purposed to produce renewable energy, such as hydroelectric.

FACING CROSSROADS

Funding

- Haiti received $1.3 USD billion in the form of Humanitarian relief in 2014.
- With up to $130 USD million providing clean drinkable water.
- Any excess money can be used in building infrastructure to transport the water

Political Barriers

- Ranked #8 in fragile states index, presents a risk for an expensive project
- Financial aid has struggled to find its way to help Haiti in the past

Distribution techniques

- Piping to central densely populated areas
- Government regulated distribution of water
- New infrastructure would increase initial costs significantly
- Cheap distribution centers can be built in town centers to make water available to everyone

THE ECONOMICS BEHIND DESALINATION

Desalination is proven to work as a viable solution for many countries facing water issues. However, there are several factors that must be considered before implementing such a facility. These include, but are not limited to:

- Design and construction costs
- Permit costs
- Preliminary assessment costs
- Construction of distribution system

In addition to these initial capital costs, there are also the costs of find the right placement and the amount of land required to construct the facility.

Plants that are in service today have varying construction costs based on how much drinkable water they produce a day.
Countries with lower per capita GDP's cannot afford to build larger desalination plants that may be more cost effective.

MAINTENANCE & POTENTIAL REVENUE

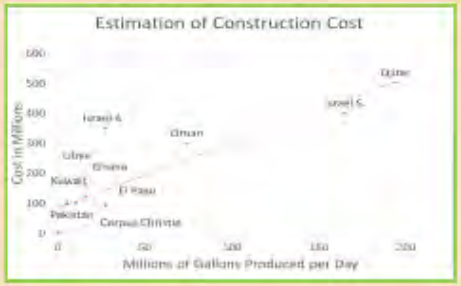
Once a plant has been built, the country and or firm running the plant will have to account for costs for:

- Labor
- Upkeep/maintenance
- Transporting the water to those who need it.

There is potential for revenue from the plant as well, including sources of:

- Hydropower
- Potential increase in GDP

With all of this in mind, a potential plant cost could range from $75 million up to $500 million, based on the size. Smaller plants, like those in Ghana and Libya are more realistic for our purposes with this study.



HOW MUCH COST?

$y = 2.182x + 83.79$ $y = Cost\ in\ Millions$ $x = Million\ Gallons\ per\ day$

1.76 Million People Benefit Requires 5,000,000 gallons a day

Estimated Cost: 91 million USD

PLAN OF ACTION

- The first step in executing this relief project would be to put out a bid for contracts with firms who are capable of such development.
- The Haitian government would need to secure a source of funding for the desalination plant.
- Local Haitians would be employed to help with construction and other important roles.
- From there, it would be a process of design and development between the Haitian Government and the contracted firm.

CONCLUSION

$130 million is spent every year on providing Haitians with clean water. Just $91 million spent over the next year can generate 5 million gallons of clean drinking water per day for the Haitian people. Spending money to consistently provide clean water is a much better strategy than giving out plastic water bottles year after year. The saying goes...

"Give a man a fish, you feed him for a day...
teach a man to fish, you feed him for a lifetime"

Poster #43

Gowanus Canal: The Forgotten Superfund Site

Allan Dalapicola, Olivia Guarna, and Jonathan Renzulli

The Gowanus Canal, hailed by the EPA as one of the most polluted canals in the country, runs a stretch of 1.8 miles through Brooklyn, NY. With over 100 years of industrial and domestic waste pollution, the EPA finally named the canal a Superfund site in 2010, placing it on the National Priorities List and making it a candidate for clean up. Currently, however, the conditions of the canal are no better than they were six years ago, or even 100 years ago.

This poster explores the reasons for the neglect of the Gowanus Canal. What environmental roadblocks exist to prevent clean up? What about the economic and social situation of the Gowanus neighborhood has contributed to this neglect? Our poster looks at the Love Canal, the first ever Superfund Site, and draws parallels to the Gowanus Canal. Why was the pollution in Love Canal addressed immediately, while the environmental abuse in Gowanus was forgotten?

The poster examines the history of the Gowanus Canal and the current state of pollution. It studies the health and safety risks that exposure to certain chemicals, such as polychlorinated biphenyl (PCB), polycyclic aromatic hydrocarbon (PAH), and other volatile organic compounds (VOC) pose, as well as the danger of these chemicals spreading to residential areas during floods. It also analyzes the proposed clean up plan, which includes an estimated $500 million worth of sediment dredging and looks at the negative visual and olfactory impact that the canal has on residents of the neighborhood.

Gowanus Canal: The Forgotten Superfund Site

Olivia Guarna '19 (CE 321), Allan Dalapicola '19 (CE 321), Jon Renzulli '17 (ECON 202)

Background

Gowanus History:

- 100 ft wide x 1.8 mi long canal expanded from Gowanus creek in Brooklyn, NY in 1960s to accommodate transportation of industrial goods
- Raw sewage and industrial waste dispelled into canal for 100 years
- By late 1900s, raw sewage and other waste no longer being dumped directly into canal

Past Gowanus Canal: Early 1900s, deemed the busiest canal of the country

Superfund Site Status:

- Today, one of the most polluted waterways in the US
- EPA named canal a superfund site in 2010; became a candidate for cleanup
  - Since then, almost no progress has been made

Current State of Pollution:

- The look and smell
- Lingering effects of industrial waste: deep, toxic sediment
  - PAHs, PCBs, heavy metals, along with bacteria and viruses, and other volatile organic compounds (VOCs)
  - Health and safety risks: VOCs and flooding
- Combined sewage overflow (approx. 370 million gallons/year)

Present Gowanus Canal: 2016

Drawing a Comparison: Love Canal

The Love Canal story:

- Partially dug canal used as hazardous waste dumping site in Niagara Falls, NY
- Land sold to Niagara Falls Board of Education for $1.00
  - Land developed with residential properties and elementary school
- Toxins began to seep up from ground in a "black sludge"
  - Toxins included 12 known carcinogens, Dioxin, among others
- Health effects:
  - Birth defects, miscarriages, stillbirths
  - In children, increased cases of central nervous system diseases, respiratory problems, cancer
- 1980: government and EPA created CERCLA, named Love Canal the first Superfund site
  - Families evacuated from Emergency Declaration Area
  - Cleanup focused on treatment and removal of contaminants
- Site currently poses no risk to health and safety

School kids in protest against the Love Canal environmental scandal of 1976.

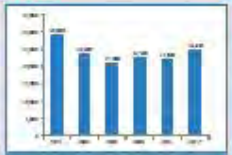
How are the two canals alike?

- Superfund site status
- Presence of harsh chemicals, including carcinogens

Why Not Gowanus?

Economic and social roadblocks:

- Large population decline from 1970 to 1990
  - Neighborhood less inhabited and somewhat abandoned
- Most of neighborhood is still zoned for manufacturing
  - Forgotten because industrial neighborhoods don't have the same importance that residential neighborhoods do



Population of Gowanus: 1970-2013

Compared to Love Canal:

- Pollution is less visible
  - Inhalation of VOCs vs. "black sludge"
- Children were the face of the Love Canal issue, rather than residents of a historically industrial neighborhood

Importance of immediate cleanup:

- Known affects of exposure to carcinogens and VOCs
- Growth of population in Gowanus in recent years
  - Housing developments on water front

Where do we go from here?

Proposed EPA clean up plan:

- 581,000 yd^3 of sediment to be dredged along length of canal
- Cap on remaining sediment with "active," "isolation," and "armor" layers
- 8 million gallon retention tank to reduce combined sewage overflow into the canal by 74%
- Estimated cost: over $500 million

Implemented green infrastructure:

- 2100 ft^2 Sponge Park on 2nd Street, adjacent to canal, to act as riparian buffer
- Will filter and store storm runoff before it reaches canal
- Uses alternating gravel beds with soil and plant beds for optimal absorption and water storage

Sponge Park: a current green infrastructure solution

The Gowanus Canal: A global issue

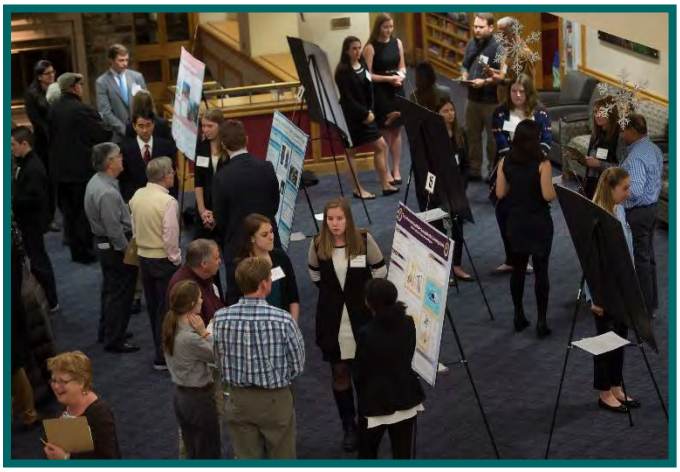
A social and environmental obligation:

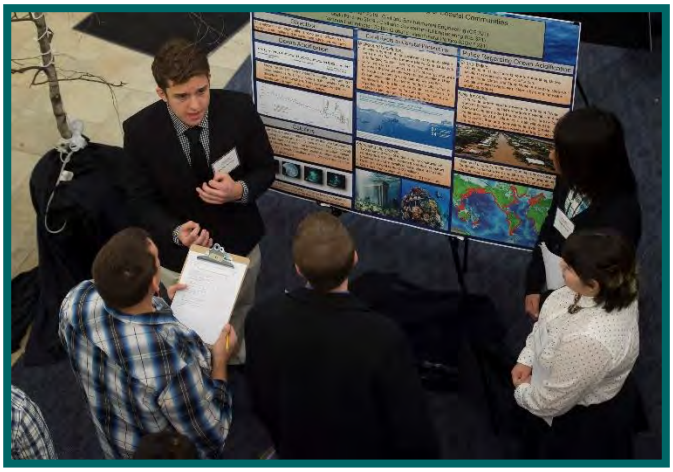
- Brownfields need to be cleaned up
  - Making productive use out of abandoned land is good for economy and environment
- A social justice issue
  - Brownfields must be addressed immediately, no matter the type of person who is affected

References

Available upon request

Photo Gallery





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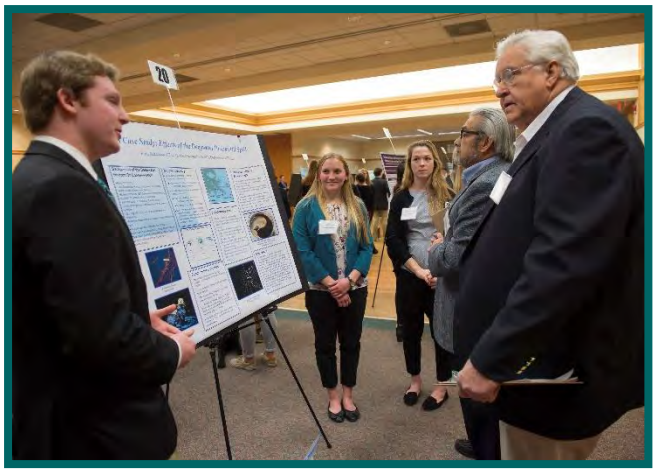

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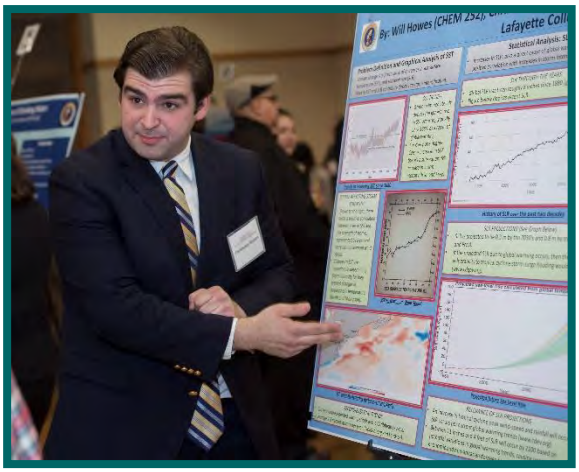

Photo Gallery

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Thank you, Judges!

Thank you to our judges for your continued support. The success of this event would not be possible without you.

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