Aguarico

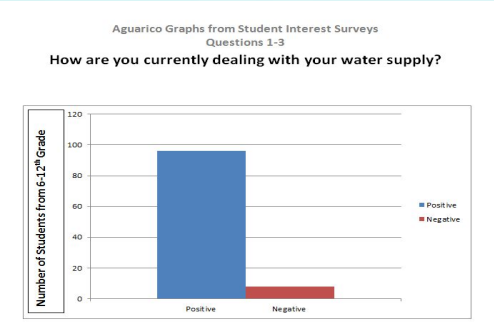
Ramey Unit School, 8th Grade
Aguadilla, Puerto Rico
May 2, 2018

Improving the Drinking Water Quality After Hurricane Maria Using Natural Resources

Team members: *Bria Roettger, Kailey Aponte, and Janeliz Guzman*

Engineering Design Process

Problem in our Community



- According to a survey taken on our school about one month after Maria hit, **83% had running water**, though most of the tap water was contaminated.
- Victims were required to take desperate measures to gain potable drinking water, as the water was contaminated due to the shutdown of city purification systems because of lack of electricity.

- Many people drank hazardous water from rivers rooftops, and faucets.
- Contaminated water led to the spread of bacteria-related diseases such as Leptospirosis, a dangerous pathogen that thrives in animal urine.
- All of our team members experienced the struggle of getting reliable potable water. Based on these events, Aguarico became motivated to find a possible solution to this issue.

- Water contamination is not a new issue in Puerto Rico.
- In 2015, 70% of Puerto Rico's population received water that violated federal health standards.
- Water contamination is a critical problem that Puerto Ricans face, especially after the hurricane.

Problem Statement/ Hypothesis

<u>Problem Statement:</u>

How can we prevent bacteria-related illnesses through water contamination during the aftermath of Hurricane Maria?

After creating our problem statement,

*we made **inferences**, **observations**, and **predictions** to produce the hypothesis.*

<u>Hypothesis:</u>

If we filter contaminated water using a modified solar water distiller and secondary filtration system, then the output water quality will be purified and safe for consumption.

Engineering Design

Resources Used: Websites, articles, journals, interviews, books, and presentations
*Annotated Bibliography available upon request

Subject Matter Experts:

Drew Koslow: Biologist and conservationist who works for the nonprofit organization Ridge to Reef:

- He handed out water filters after Hurricane Maria, and discussed with us certain effective filtration materials. He also gave us information on our water treatment infrastructure, and his opinion on where Puerto Rico stands as far as infrastructure both before and after the Hurricane.

Ruby Rivera: Marine biologist who also works for Ridge to Reef

- She was valued for her knowledge of Puerto Rico, as she is Puerto Rican herself. She talked to us about her work, handing out filters and supplies to the locals post-storm, and how the filters worked.

Science and computer teachers at Ramey Unit School

- The science and computer teachers at Ramey Unit school, helped us create our prototype, and test the water samples.

David Sasscer: Civil Engineer

- Mr. Sasscer visited our classroom to observe our presentations and give us feedback about being an engineer. He said that he process is ongoing and at times you need to say that a product is good enough for now.

Steve Tamar: Microbiologist

- Mr. Steve Tamar helped us in running the water tests and taught us how to make those test ourselves. He informed us the the current water contamination issue that Puerto Rico.

What we Learned in our Research

Aguarico learned about the water crisis and effects of Hurricane Maria from personal experiences, interviews, field trips, observations, and research.

Most importantly, we learned how to problem solve without the conveniences we had before Hurricane Maria, and we connected with friends, family, and community members as we all joined to help recover and improve after the storm.

Our team researched the following topics:

- Water Contamination before the storm
- How Hurricane Maria contributed to water contamination
- Types of bacteria-related diseases carried through contaminated water
- Resources that were brought to Puerto Rico as part of the relief effort
- Issues with the Guajataca Reservoir and water sanitation systems
- Local and natural resources found around Puerto Rico

Materials Used to Build the Prototype

Our team constructed two different prototypes with materials that are natural resources and accessible to residents in Puerto Rico such as:

- Coconut charcoal (Burnt inner nut of a coconut)
- Coconut husks
- Sand

We also implemented materials that were common in everyday households. These materials include:

- PVC pipes
- 5 gallon buckets
- Screens/mesh
- Coffee filters
- Copper tubing

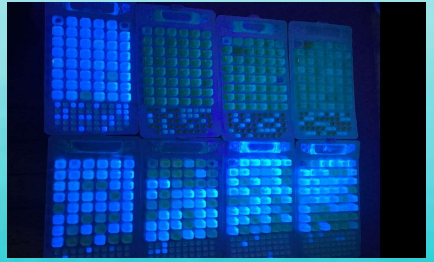
Testing Materials and GLOBE Protocols

After constructing various prototypes, we ran the water through these devices and tested the water samples for: **E.coli, Enterococci, Coliforms, Dissolved Oxygen, Conductivity, pH, and Temperature**

GLOBE Materials:

Using the Globe Materials, we used probes to test for:

- Conductivity
- Distilled Oxygen
- pH
- Water temperature



Additional Testing Materials:

Because there were no GLOBE protocols for testing water samples, our team partnered with the **Surfrider Foundation** to test filtered city and irrigation water for **E.coli, Enterococcus, and Coliform bacteria** by using:

- Enterolert tests
- Colilert tests

Analysis

We analyzed our data using **EPA** safe drinking levels

Source:

https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#three

Contaminant	**Instrument Used to test for contaminants**	**MCL (mg/L)**
Enterococcus	Enterolert	0
Tot. coliforms	Colilert	0
E.coli	Colilert	0
Dissolved Oxygen	Dissolved Oxygen Probe	Minimum 5 mg/L
Conductivity	Conductivity probe	5.9
PH	PH sensor	6.5-8.5
Temperature	Thermometer	*Not specified

Comparing our results to the EPA safe drinking levels allowed us to evaluate the effectiveness of our device.

First Test Results

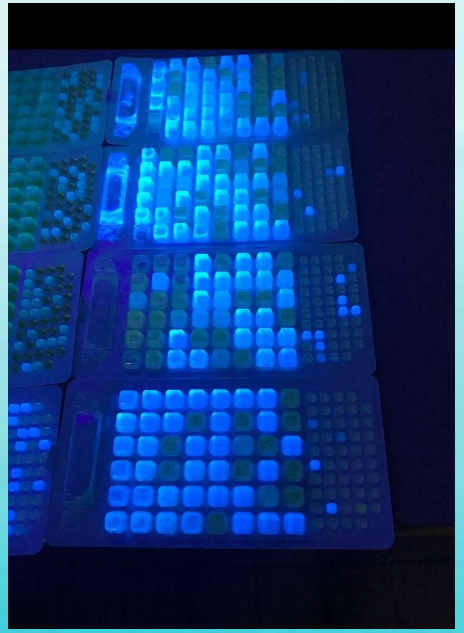
The results of our first test included running tap water (AAA) and irrigation water from the Guajataca watershed through our filter which is shown below:

Aquarico Filter Test from Feb 1			
Sample Source	Enterococcus	tot. coliform	E. coli
	CFU/100ml	CFU/100ml	CFU/100ml
AAA			
Raw	2	0	0
Agaurico	2419.6	>2419.6	0
Irrigation			
Raw	135.4	>2419.6	178.2
Aguarico (student)	4.1	>2419.6	110

Second Test Results

Our second prototype included sterilizing all of our filtration materials (**sand, husk, and coconut charcoal**), and transferring them to one five-gallon plastic bucket. The results are shown below:

Aguarico filter test results from Feb 20			
Sample source			
Irrigation			
raw	19	>2419.6	104
Aguarico old irrigation water	2	0	0
Aguarico new irrigation water	24.5	1986.3	67
AAA			
raw	0	0	0
Aguarico (no other ID)	0	0	0
AAA from hot water filter	0	244	0



Third Test Results

Our final test was conducted by testing four different filters, as shown below. According to the table, the **sand/husk/regular** charcoal proves to filter the water most effectively and maintains EPA levels safe drinking water.

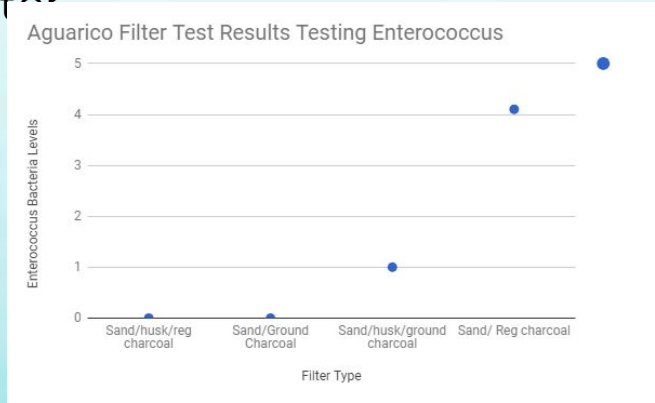
Aguarico Filter Test Results from Feb 27			
Sample Source			
Irrigation			
Sand/husk/reg charcoal	0	0	0
Sand/Ground Charcoal	0	30.7	43.5
Sand/husk/ground charcoal	1	49.6	30.1
Sand/ Reg charcoal	4.1	33.3	52

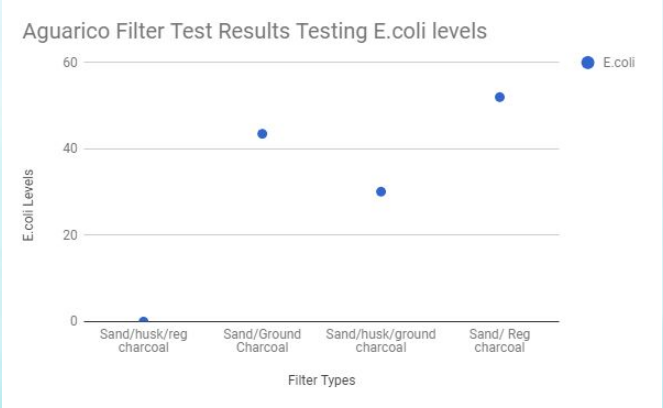
Final Test Results

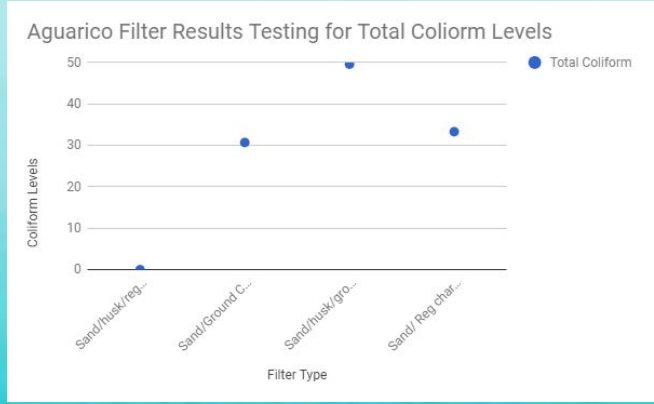
After analyzing the data we came to the conclusion that the sand/husk/regular filter performed better than the other prototypes tested. The results from this filter are shown below:

Aguarico Final Prodotype Test Results									
Sample Type	Enterococcus	tot. coliforms	E.coli	Dissolved Oxygen	Conductivity	PH Sensor	Tempature	EPA Approve?	
Irrigation				mg/l	ms/cm		°C		
Raw	19	>2419.6	104						
Sand/husk/reg charcoal (Final prodotype)	0	0	0	8.42	312	6.84	22.4	Yes	Decreased all bacteria levels to safe drinking conditions
AAA									
Raw	0	0	0						
Sand/husk/reg charcoal (Final prodotype)	0	0	0	N/A	N/A	N/A	21.6	Yes	Maintained safe drinking levels

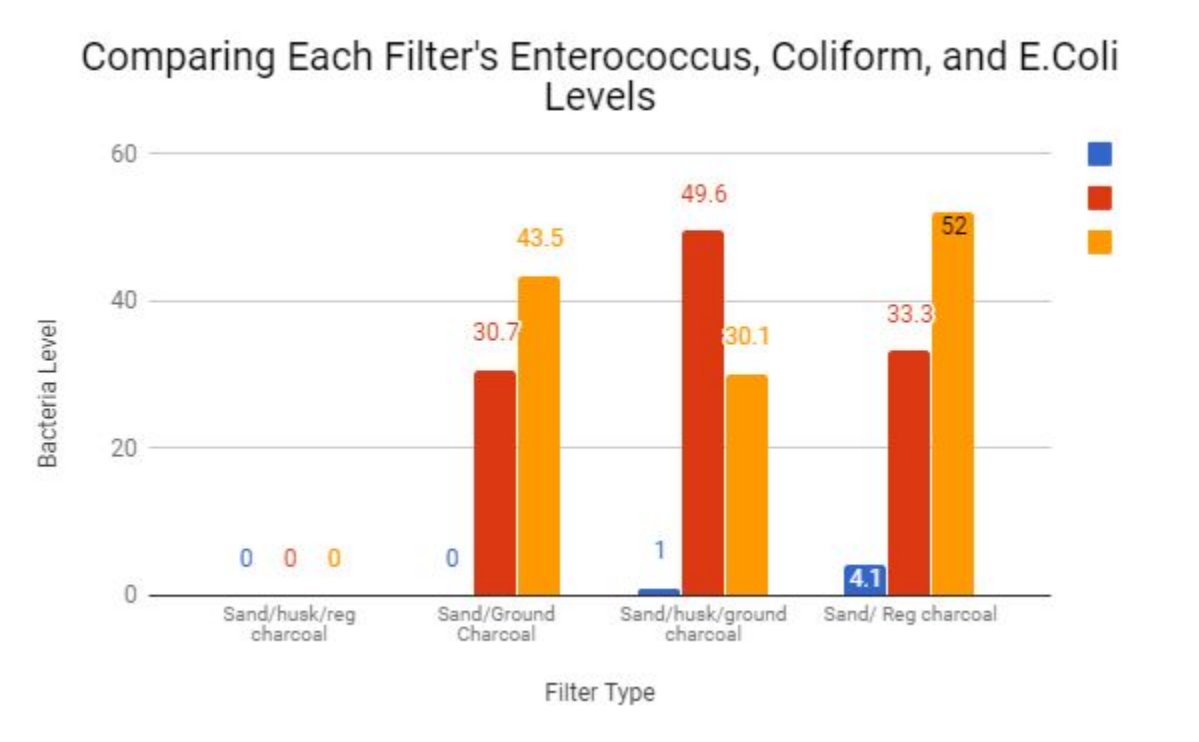
The following charts compare the four different filter results in the amount of Enterococcus, coliform, and E.coli levels found present in the water.







The following graph represents the effectiveness of the different filters tested for **enterococcus, coliform, and e.coli levels.** This supports that the **sand/husk/regular charcoal** filter performs the best in filtering out the contaminants.

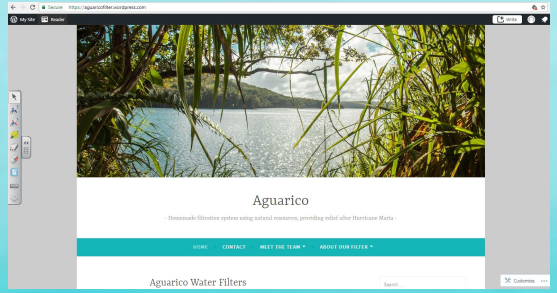


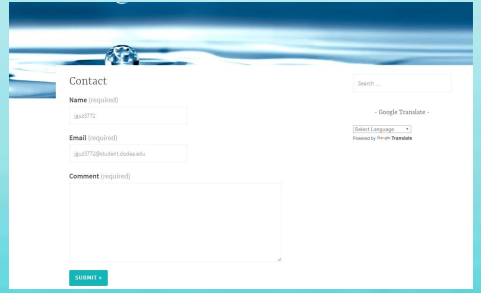
Data Analysis

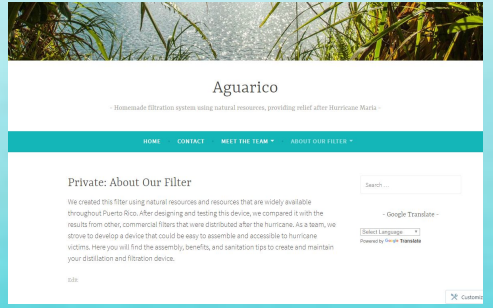
- According to our results, not only did we manage to **improve our prototype with each trial**, we were also able to succeed in **eliminating all coliforms, enterococcus, and e.coli** from both city (AAA) and contaminated irrigation water samples.
- Our data supports that our **sand/coconut husk/ regular charcoal,** filter works most effectively in purifying contaminated water.
- This means that we reached our goal and supported our hypothesis of developing an **effective filtration and decontamination** device using **local materials** that could be used during the aftermath of Hurricane Maria.

Developing our Website

- Our team later transferred all of our information from our test results into a website, through wordpress
- Our hope would be to allow the users to easily access the website, and learn how to assemble our Aguarico filter, using the natural resources required.







Link: https://aguaricofilter.wordpress.com/filter-design/

Community Impact

Image Produced by:
https://www.nbcnews.com

- Our device could provide a new and reliable source of safe drinking water for all residents across the island.
- By simply empowering people to build their own filters, Aguarico could possibly reduce the number of deaths or illnesses that resulted from the consumption of contaminated water.
- Because resources used to construct our device are widely available throughout Puerto Rico, the production and distribution of it would be more reliable than other commercial filters.

In the future, we would like to modify our filtration device by applying silver infused ceramic within the filter. We would also modify the distilled water section to verify that it is a reliable source to sterilize contaminated water. In addition, our team would like to educate our community to construct our system for their own use, through the use of our website.

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THE GLOBE PROGRAM

Global Learning and Observations to Benefit the Environment

Abstract

Research Questions

Hypothesis

Introduction

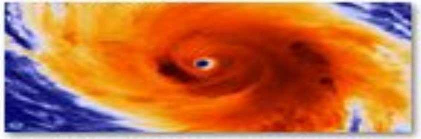
Research Methods

Study Site

Guajataca Water Shed, Puerto Rico

GLOBE Badges

- Four Star Research Badge
- Collaboration
- Community Impact
- Engineering Solution



Hurricane Maria devastated Puerto Rico and its infrastructure on September 20, 2017.

Image by NASA

Results

Discussion

Comparison with Similar Studies

Comparing Each Prototype Tested

Conclusion

Bibliography