GLOBE INTERNATIONAL VIRTUAL SCIENCE SYMPOSIUM
Project Elements and Criteria

Theme: Environmental Problems and Solutions
Presentation: Poster
Team Name: Aguarico
Grade: 10
School: Ramey Unit School
Location: Aguadilla, Puerto Rico
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A Study of Effective Water Filtration Using Natural Resources Available in Puerto Rico

Abstract

Puerto Rico is an island that is frequently under the threat of natural disasters, which can cut out power and leave many people homeless or lacking everyday resources, such as potable drinking water. Our team, Aguarico, decided to find a solution for this problem. Using previous research and experience as motivation, we developed our research questions: (1) How can we create an effective and easily-accessible water filtration system to ensure safety of water quality for people in Puerto Rico who may not have everyday access to potable drinking water, especially after a natural disaster? And (2) What are the similarities and differences between a filtration system using coconut husks, charcoal, and sand and a filtration system using banana peels, sand, and cilantro in the context of coliform, enterococci, dissolved oxygen, nitrates, water transparency, and pH? Based on these questions, we dove into experimentation with the two filtration systems. We found that our first prototype was able to remove all enterococci, E.coli, and coliform bacteria from both city and irrigation water samples Our second prototype, on the other hand, left one unit of enterococci bacteria in irrigation water. We also ran testing using GLOBE protocols, and compared and analyzed our data using graphs and charts. Overall, we determined that, while our first filter, which implemented coconut husks, coconut charcoal, and sand was more effective in purifying water, our second filter, which utilized banana peel, cilantro, and sand was more practical and easy to build. Both of these filtration systems proved to have a broad range of capabilities and potential for use in the aftermath of natural disasters. In the future, we hope to provide more outreach in our community to raise awareness about the usefulness of a natural, affordable filtration system, helping those without access to safe drinking water.

Key words: Purification, Water Filter, Natural Disaster, Natural Resources, Bacteria, Effectiveness, Capabilities, Accessibility.

Research Questions

The research we did encompassed finding solutions to problems in Puerto Rico. One of the main issues we observed was the danger of water contamination, which, especially after Hurricane Maria hit in 2017, was a widespread risk for thousands of Puerto Rican citizens. Our team decided to focus on this problem and try to develop a way to bring potable drinking water to those who lacked access. Thus, our research questions were (1) How can we create an effective and easily-accessible water filtration system to ensure safety of water quality for people in Puerto Rico who may not have everyday access to potable drinking water, especially after a natural disaster? and (2) What are the similarities and differences between a filtration system using coconut husks, charcoal, and sand and a filtration system using banana peels, sand, and cilantro in the context of coliform, enterococci, dissolved oxygen, nitrates, water transparency, and ph?

In 2018, we performed research on a water filtration system using coconut husks, sand, and coconut charcoal. The purpose of this filtration system was to attempt to provide an effective and easily accessible way to supply clean, drinkable water to people around the island who had experienced the devastating effects of Hurricane Maria. Through a series of tests, we were able to produce water with zero traces of E.coli, enterococci, and coliform bacteria (See Results). We analyzed these outcomes and even created a website to share this solution with our community. In 2020, we decided to work on improving our methods and create a filter that was even more effective.

The focus of our research project this year delves into the topic of determining the filtration abilities of two different natural resources: banana peels and cilantro. The possibility of using these materials arose as we searched for ways to make our filtration system all the more accessible to people around the island. Through some research, we landed on these basic groceries, deciding that they would serve a good purpose in helping us compare and contrast our data and identify the pros and cons of using the different materials. Through testing, we hoped to come to a consensus on which materials would be more successful. And so, ideas were concocted, and the research process began.

We researched the benefits of using cilantro and banana peels as filtration methods and found that both had already been proven to be functional in removing heavy metals from contaminated water. We also used research from last year to reiterate the purpose of coconut husks and charcoal in purifying water and removing waterborne diseases. A question arose among our team as research progressed: would cilantro and banana peel also remove waterborne bacteria, namely E.coli and Enterococcus, or was its only purpose to extinguish metals? We decided to use this question to our advantage and test it ourselves. We also decided to test these specific materials because of their availability; items like cilantro and bananas were sold all over Puerto Rico in fruit stands. This was especially helpful to us because, as most of these fruits were grown and collected naturally by the vendors, there was much less of a chance that chemicals had been used to grow them.

After it was decided that we would use these materials, along with the incorporation of sand for the filtration of waterborne particles, we decided that it would be most beneficial to test the new water filter using the same criteria as our filter of 2018 and compare the results. Our new filtration system was designed using different sterilization and assembly protocols, as we were attempting to create an even more easily-built and maintained method of obtaining potable

water for Puerto Ricans, especially as the danger of unsafe drinking water arises because of natural disasters. Recently, we have experienced damaging earthquakes which caused extensive damage to many buildings in the southern part of the island. According to an article published by USA Today, “Many on the island have lost their homes, and thousands remain in shelters. Some are sleeping outside or in open plazas for fear that the buildings could collapse.” This damage also contributed to loss of power and water supply in certain regions of the island. As mentioned in a Washington Post article, the seismic activity on the island resulted in “300,00 customers without water service”. It was apparent to us that, in a time like this where many of these people did not have easy access to clean water, it was important to establish the easiest and best way to provide clean, drinkable water. We decided on our two research questions because they best fit our goals. It was interesting to compare the data since it helped us determine the pros and cons of these materials and find the safest way, out of the materials we established, to help people in our community obtain potable water.

GLOBE Virtual Science Symposium- Badges and Criteria for HS and UG Science Projects

Introduction

"Over two-thirds of the population of Puerto Rico was at potential risk of exposure to bacterial contamination in the aftermath of Hurricane Maria, according to government test results obtained by NRDC." This was a statement written by the Natural Resources Defense Council in 2017, directly after Hurricane Maria devastated the island. In the years after the hurricane, water quality improved, and many on the island regained access to clean drinking water. Then, multiple large earthquakes struck the southern parts of the island, rendering many homeless. As said in USA Today, "Ponce has sustained more than $150 million in damages, according to U.S. Rep. Darren Soto (D-Fla.), who visited the island Saturday. More than 700 people are homeless". Natural disasters are an issue that, especially in Puerto Rico, have left many without access to basic necessities, namely potable water. Our team saw this as a definite health risk and decided to take action to develop a way for people to obtain safe water using materials they could find in their homes. Previously, we conducted research on a filtration device using coconut husks, charcoal, and sand, and found that our device was able to produce clean water that tested negative for any amount of enterococci, E.coli, or other coliform bacteria. The next step was to identify materials that could be more accessible for Puerto Ricans after a natural disaster, including those living in urban areas. Through research, we found that banana peels and cilantro could both "absorb metals, leaving cleaner drinking water," according to TIME. There had already been research done listing the benefits of these materials, but we wanted to compare their effectiveness, along with the implementation of sand, which, as illustrated in an article called "Natural Materials Used for Water Filtration" by Sciencing, "can filter out particles as small as 25 microns", to that of our previous filtration device, and analyze

the costs and benefits of both. Therefore, we established research questions relating to our goal, which was to compare the effectiveness of the two filters regarding certain bacteria, conductivity, ph, nitrates, and dissolved oxygen, and to determine if this was a filter that could be made easily and used to help those who may not have access to safe drinking water in the event of a natural disaster.

Research Methods

Research methods for Filter 1: The coconut filter

The methods used to test our prototype and compare it with filter 2 included probes, sensors, and bacteria tests. The results were listed and organized on an excel chart. We analyzed our data based on our research questions: (1) How can we create an effective and easily-accessible water filtration system to ensure safety of water quality for people in Puerto Rico who may not have everyday access to potable drinking water, especially after a natural disaster? and (2) What are the similarities and differences between a filtration system using coconut husks, charcoal, and sand and a filtration system using banana peels, sand, and cilantro in the context of coliform, enterococci, dissolved oxygen, conductivity, and ph?

Data was collected and evaluated based on the amount of total coliforms, enterococci, and E.coli bacteria present in the water samples collected. The protocols followed to collect data are the same used by the Environmental Protection Agency (EPA) to determine if our drinking water is free of bacteria and contaminants. In addition, we collected data such as pH level, conductivity, turbidity, temperature, and ORP Sensor.

We compared our data collected on February 1, 2018, February 20, 2018 , February 27, 2018, and February 28, 2018. Over the course of these tests, our filter's performance improved. Originally, it did not eliminate all of the bacteria necessary to be effective. This data supported

our idea to improve the overall performance of our filter. We could do this by following stricter sanitary procedures, testing new materials, changing our design, or creating a more efficient primary solar water distiller. On the last test, completed on February 28, 2018, zero coliforms, enterococci bacteria, or E.coli bacteria were present for one of our tests. This was significant because our prototype successfully sterilized contaminated water for the purpose of drinking. The next step was to analyze how well this filtration system worked compared to the newly-established filter, which used banana peels, cilantro, and sand.

Research methods for Filter 2: The banana-cilantro filter

The methods utilized to test filter 2 and compare it with the results of filter 1 were similar to the methods used for filter 1. The same testing methods were used and filter 2 was tested for the same aspects. The differences in this test were esimply the filtration materials: banana peels, cilantro, and sand.

During the raw water testing, which was conducted on March 3 and 4, we worked on testing and collecting data on the contaminants and bacteria in the tap water and the irrigation water, using the same testing tactics as the Environmental Protection Agency. We did not find any E. Coli. and Enterococci bacteria in the tap water. On the contrary, the irrigation water had numerous amounts of bacteria present in both the entrolert and colilert tests. We proceeded to test the irrigation water and tap water with different probes, testing for pH, dissolved oxygen, and conductivity levels.

We ran post-tests tests on March 5, 2020. After collecting results from our tests, we found that this filter successfully filtered out all E.coli and coliform bacteria and left one unit of enterococci bacteria in the water. These results show that the filter was not as effective, which would be good for making comparisons when we analyzed our data.

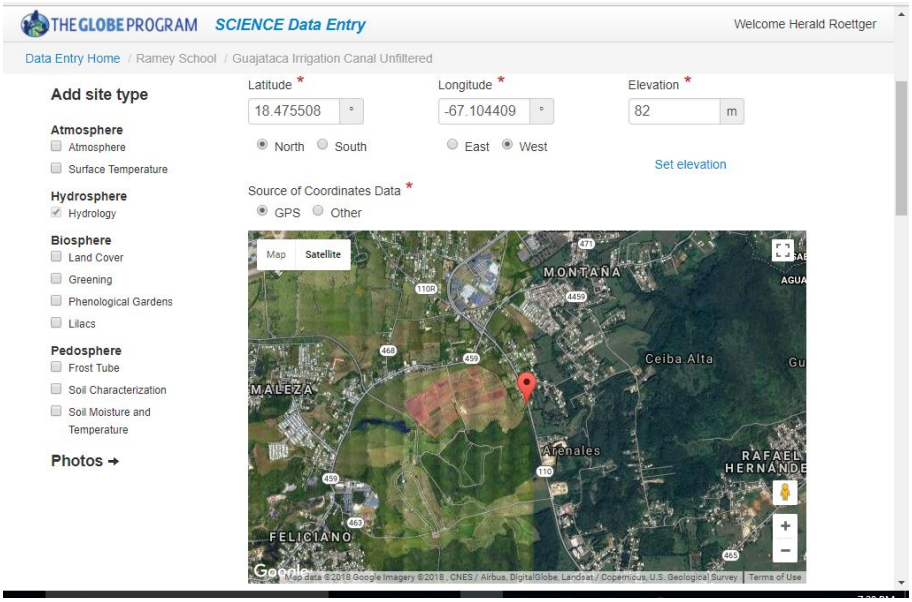
Testing protocols

- Pretest on water
- Sterilization of materials for testing purposes
- Filter assembly
- Run water through filter beginning with tap water
- Run probe testing
- Allow 24 hours for enterolert and colilert testing
- Compare and analyze data

Study Site

Cibuco-Guajataca Watershed -- 21010002

Cibuco-Guajataca, Puerto Rico



Latitude: 18° 23' 30.59" N

Longitude: -66° 55' 15.59" W

The water samples were taken directly from the Guajataca Irrigation Canal. This water source, the Cibuco-Guajataca Watershed, comes from the Guajataca Lake (Lago Guajataca) and was created by the Puerto Rico Electric Power Authority. It is a reservoir located between the municipalities of San Sebastián, Quebradillas, and Isabela in Puerto Rico. It is used for irrigation and potable water. The climate is Tropical Marine with an average temperature of 80 degrees Fahrenheit. Winds blow from the east and there is moderate rainfall. Hurricanes commonly occur between August and October.

Data collection

For Filter 1 (Sand, Charcoal, and Coconut husks)

The GLOBE protocols used to help answer our research questions included: Dissolved Oxygen Probe (mg/L), Conductivity Probe, PH Sensor, and bacteria tests for E Coli, Coliform, and Enterococci strands.

Sampling Method: Aguarica conducted four trials with two samples each to test our prototype and compare it with other water filters. Our first trial was conducted on February 1, 2018 using irrigation water samples from Guajataca Watershed and city water (AAA) collected from Ramey Unit School. During this session, we compared results from both water sources with five different water filters used in Puerto Rico. This activity was done at Costa Salud, a Community Health Center located in Rincon, Puerto Rico with Mr. Steve Tamar. Our second sample followed the same protocol and procedures and was conducted at Ramey Unit School located in Aguadilla, Puerto Rico with a new sample of irrigation water from Guajataca and a new AAA sample from Ramey Unit School. Our third trial was done at Ramey Unit School and was supported by Mr. Herald Roettger with a new sample of irrigation water from Guajataca and a new AAA sample from Ramey Unit School. Our final trial was conducted at Ramey Unit School and was supported by Mr. Herald Roettger with a new sample of irrigation water from Guajataca and a new AAA sample from Ramey Unit School.

For Filter 2 (Cilantro, Sand, Banana)

Data Analysis

In order to analyze data from our trials, we had to put it in a spreadsheet so we could compare it with other filtration devices. Using this spreadsheet, we could place our data in a scatterplot to observe how much our filter improves or worsens. Using this scatterplot, we could

apply a trendline (or line of best fit/ regression line) and be able to predict how well our filter will do in the future if it keeps improving. There was no specific mathematical equation we used because we were comparing trends between the data in order to determine its effectiveness. Also, in order to keep our trials constant, we needed to keep our times and numbers constant as well. It also means that we need to measure exactly how much of each material we were placing in our filter, and keep the same measurements for every setup. If we did this, we would be able to rule out irregularities in our data that could come from using different amounts, because not all of the bacteria may be killed. It could also rule out the possibility of different filtration times due to inconsistent measurements, meaning water could soak more in the filter during the first trial than the second if the measurements are off.

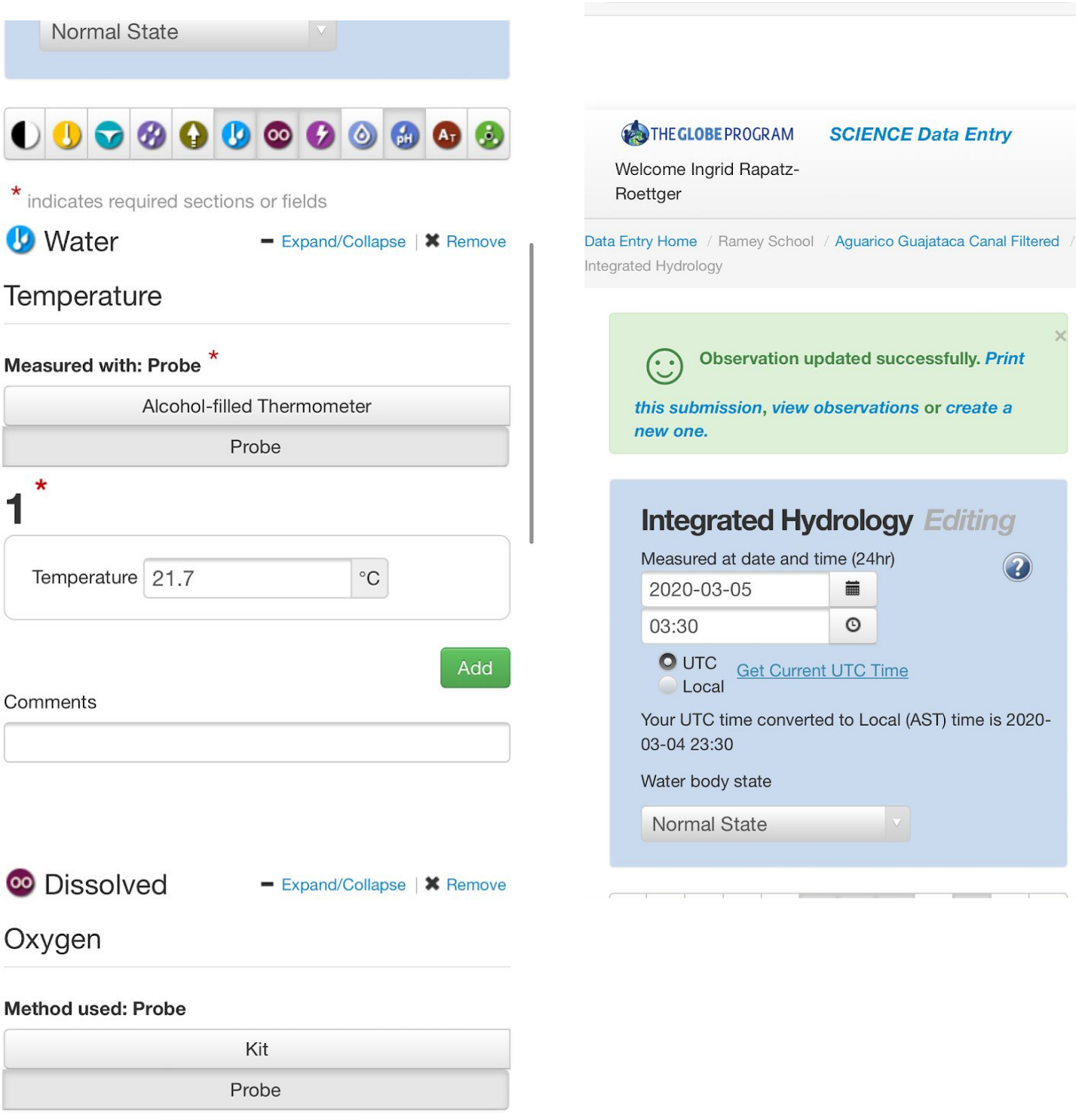
The data presented was sufficient to answer the research questions:

The data provided answered our research questions, which were (1) How can we create an effective and easily-accessible water filtration system to ensure safety of water quality for people in Puerto Rico who may not have everyday access to potable drinking water, especially after a natural disaster? and (2) What are the similarities and differences between a filtration system using coconut husks, charcoal, and sand and a filtration system using banana peels, sand, and cilantro in the context of coliform, enterococci, dissolved oxygen, conductivity, and ph?

The data that was collected from testing showed a difference between the two filters used. Filter 2 didn't seem to work as effectively as filter 1, but filter 1 was a lot harder to build and develop. We were able to analyze these differences in our data, which is shown in the Results section. We were also able to create two filters which both worked sufficiently in removing bacteria from water. Both of these filtration systems could be used around the island

and we hope to provide community outreach to those who may struggle in the aftermath of a natural disaster.

Print screen of GLOBE Visualization page



Results

Aguarico tested the coliform, enterococcus, and E.coli bacteria levels for all our prototype water samples. In addition, we tested the dissolved oxygen, conductivity, and pH of water filtered through both filtration systems. Tests were done based on EPA guidelines for our criteria. These guidelines are pictured below.

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

After determining these guidelines, we created charts showing the improvement from the raw, unfiltered water to that which was filtered. The results of our first tests, performed in February 2018, included running tap water (AAA) and irrigation water from the Guajataca watershed through the prototypes built with coconut husks, coconut charcoal, and sand.

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

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

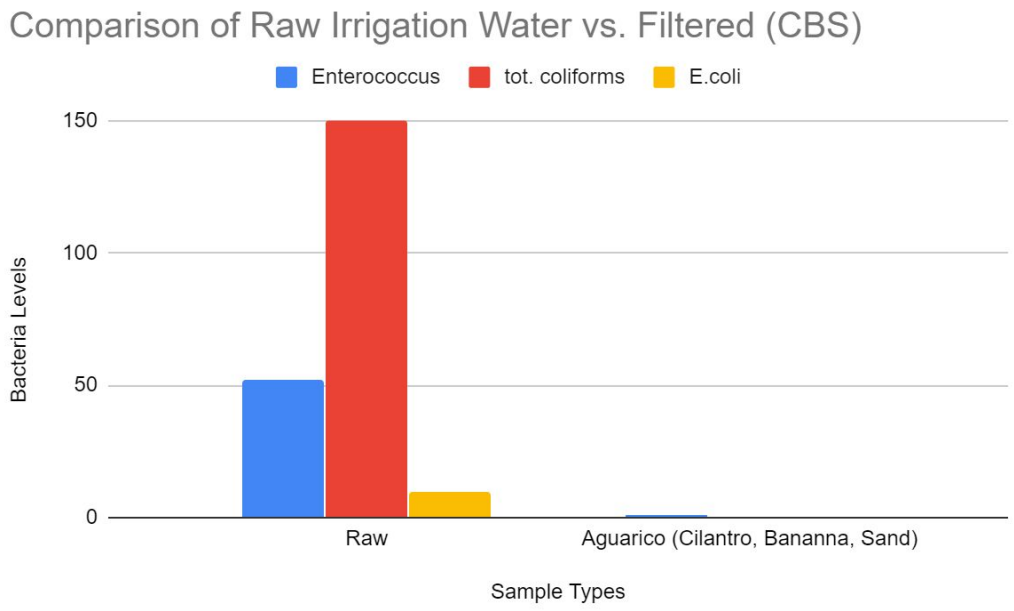
This was the final chart that was created for the results from our coconut husks, coconut charcoal, and sand filter. As we can see, our team managed to bring bacteria levels to zero and demonstrated through probe testing that dissolved oxygen content, conductivity, and ph all met the EPA guidelines.

Aguarico Final Prodotype Test Results						
Sample Type	Enterococcus	tot. coliforms	E.coli	Dissolved Oxygen	Conductivity	PH Sensor
Irrigation				mg/l	ms/cm	
Raw	19	>2419.6	104			
Sand/husk/reg charcoal (Final prodotype)	0	0	0	8.42	312	6.84
AAA						
Raw	0	0	0			
Sand/husk/reg charcoal (Final prodotype)	0	0	0	N/A	N/A	N/A

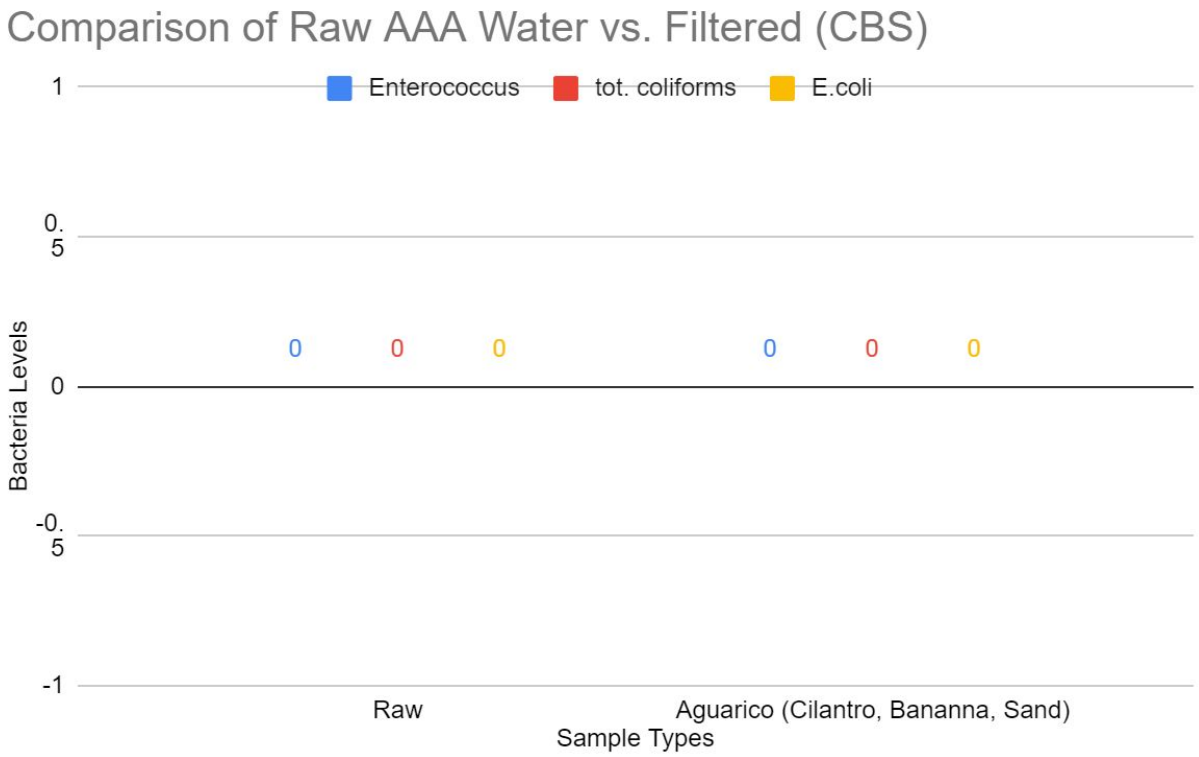
After completing tests on our first filtration system, we needed to test the second one, which incorporated banana peel, cilantro, and sand for the same criteria. We performed tests for this system in one day, on March 5, 2020. The results from this filter can be shown below:

Aguarico; Cilantro/Bananna/ Sand: Filter test							
Sample Type	Enterococcus	tot. coliforms	E.coli	Dissolved Oxygen	Conductivity	PH Sensor	
Irrigation				mg/l	ms/cm		
Raw	52.1	150	9.7	7.9	378	6.76	
Aguarico (Cilantro, Bananna, Sand)	1	0	0	8.1	545	6.15	
AAA							
Raw	0	0	0	7.7	373	6.99	
Aguarico (Cilantro, Bananna, Sand)	0	0	0	8.3	435	6.5	

The results demonstrated that the filter with cilantro, banana, and sand was able to effectively filter out all of the coliform and e.coli bacteria found present in the irrigation water sample. It also demonstrates that it neary filtered out all enterococcus bacteria, with the results of 1. Additionally, the filter was able to maintain the AAA (tap water) bacterial levels of 0. Finnlay, the filter was able to maintain the dissolved oxygen, conductivity and PH levels at safe levels according to the EPA guidelines, stated above.



This graph provides a specific visual representation that was able to effectively filter out all E.coli and coliform bacteria found present in the water, leaving very low levels of enterococcus.



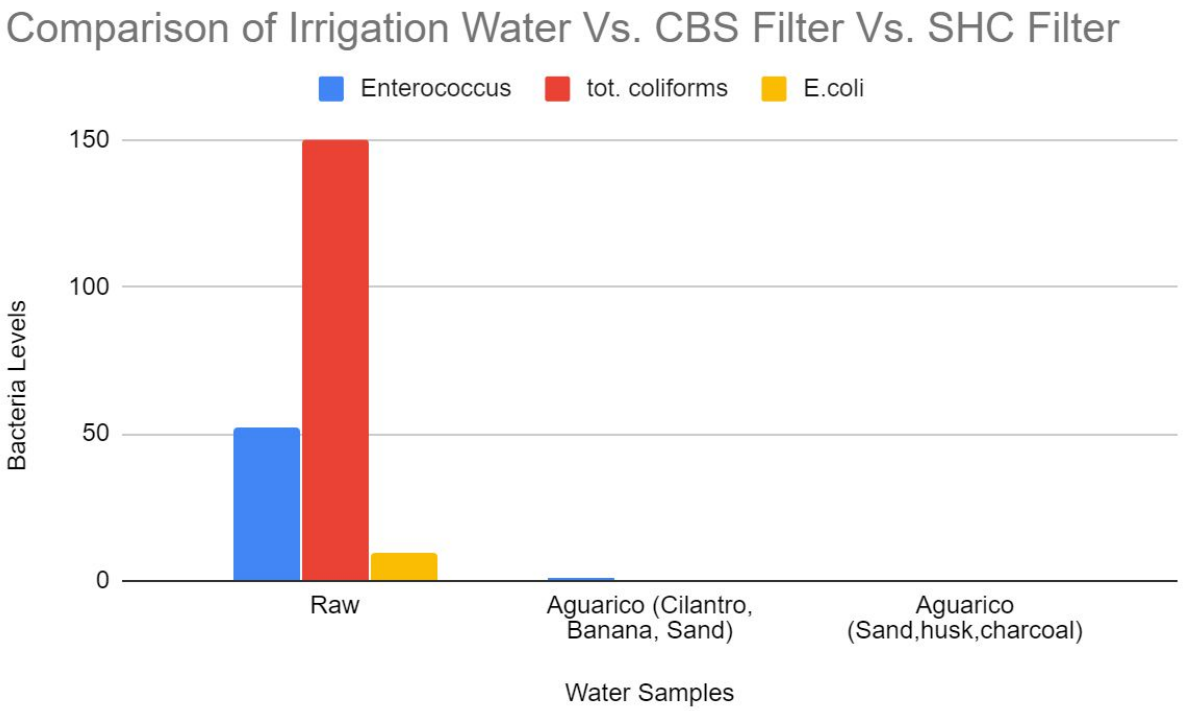
This graph demonstrates how the new Aguarico Filter was able to maintain healthy bacterial levels in the AAA water samples.

Overall, the testing from both of these filtration systems managed to reduce bacterial levels in the water. However, as you can see, the coconut husk, coconut charcoal, and sand filter was able to remove the bacteria more sufficiently than the banana peel, cilantro, and sand filter, which did not reduce its levels to zero.

Once testing for both filtration systems were completed, we needed to place the results in a chart together to compare the data. This chart is shown below.

Comparing Aguarico Filter Results (CBS vs SHC)					
Sample Type	Enterococcus	tot. coliforms	E.coli		
Irrigation					
Raw	52.1	150	9.7		
Aguarico (Cilantro, Banana, Sand)	1	0	0	The CBS Filter was shown to be less effective in filtering out enterococcus	
Aguarico (Sand,husk,charcoal)	0	0	0		
AAA					
Raw	0	0	0		
Aguarico (Cilantro, Banana, Sand)	0	0	0		
Aguarico (Sand,husk,charcoal)	0	0	0		

Our initial testing in 2018 showed that the Aguarico filter with sand, husk, and charcoal was able to effectively filter out all contaminated found present in the different water samples tested. The new filter using Cilantro, Banana, and Sand was able to reduce the coliform and E.coli levels to 0, but was proven to not effectively filter out the enterococcus bacteria found in the irrigation water samples.



This graphs compares the bacterial levels found in the three different water samples

Discussion

Interpretation of results

According to our primary results for the charcoal, husk, and sand filter, not only did we manage to improve our prototype with each trial, we were also able to succeed in eliminating all coliforms from both city (AAA) and contaminated irrigation water samples. The results from our final trial were the best and most significant.

For our second filter, we performed one trial, testing the effectiveness of the combination of banana peels, sand, and cilantro in filtering out contaminants commonly found in water samples. According to the results, it was proven to effectively filter out all coliform and e.coli bacteria found in the irrigation water samples. Additionally, it was able to maintain sufficient

levels in the AAA water samples. Unfortunately, there was a low amount of enterococcus bacteria found present in the filtered Aguarico sample. This shows that the initial filter containing charcoal, husk, and sand filter was most effective in filtering out contaminants found in the water samples.

Possible sources of error

During the process of testing the filter containing charcoal, husk, and sand, we encountered some sources of contamination. In the first trial of our experiment, we did not properly sterilize any of our materials, which caused our bacteria count to increase dramatically. In order to improve after this, we created a set of protocols that would make sure all of our materials were clean. The second test we ran showed that the bacteria count dropped, meaning our filter was improving and the protocols we set were effective. However, when we ran our third trial, we discovered that outside contaminants had somehow affected our results, causing our bacteria count to once again increase. After this experience, we made sure all of our materials were completely clean, and on our fourth trial, we managed to bring our results down to zero, meaning no bacteria was detected.

During the filter text containing cilantro, banana, and sand, continued to follow the safety protocols used in the initial test. Regardless, forms of cross contamination could have occured when constructing and testing our water samples because of particles in the air or leftover contaminants that managed to stick to our materials through our sterilization processes. This may have contributed to the percent of enterococci bacteria found in the results.

Comparison with similar studies

Our team compared our filtration system to several other commercial filters that were distributed throughout Puerto rico during the aftermath of Hurricane Maria. These included: Sawyer, Agua Cera (Long), Agua Cera (Short), Agua Cera (Cylinder), and Brita.

Comparison of Aguarico Filters vs other filters			
	Enterococcus	tot. coliforms	E. coli
	CFU/100ml	CFU/100ml	CFU/100ml
Sample source			
Irrigation			
raw	19	>2419.6	104
Sawyer bucket	2	0	0
Long (ceramic)	0	0	0
Short (ceramic)	0	0	0
Cylinder (ceramic)	0	0	0
Aguarico (SCH)	0	0	0
Aguarico (CBS)	1	0	0
AAA			
raw	0	0	0
Sawyer bucket	0	0	0
Long (ceramic)	0	0	0
Short (ceramic)	0	0	0
Cylinder (ceramic)	0	0	0
Aguarico (SCH)	0	0	0
Aguarico (CBS)	0	0	0

Discuss whether results support the hypothesis or not, and why

Our primary hypothesis was that, through the use of these two different filtration systems, we would be able to effectively analyze and compare how well each one worked and outline potential costs and benefits for each in order to determine which materials would be best to use in the event of a natural disaster in Puerto Rico. Based on the results of our experimentation, it has become apparent to us that our hypothesis could be supported. We can see the improvement of filtration quality in the coconut husk, coconut charcoal, and sand filter, which worked somewhat better than the sand, cilantro, and banana peel filter (see graphs in

Results). This has led us to determine that, although both filters essentially work well, the coconut husk, coconut charcoal, and sand filter proves to function the best, although it may be harder and less efficient to construct.

Conclusions

Reaching our Conclusion

In conclusion, we found that our coconut husk, coconut charcoal, and sand filter (or filter 1) was able to reduce all bacteria levels in water to 0 for both tap and irrigation water. The cilantro, banana peel, and sand filter (filter 2), however, was able to reduce all bacteria levels in the AAA water to 0, but it left one unit of enterococci bacteria in the irrigation water. Both filters were able to maintain conductivity, pH, and dissolved oxygen levels that were within EPA guidelines. The data we collected was sufficient in answering our research questions and confirmed our hypothesis. We noticed that, although filter 1 was much more time-consuming and less easy to build, it was generally more effective in the filtration of bacteria. Filter 2 also worked relatively well, but it did not filter out all bacteria and we noticed that the conductivity level of the water was higher after it was tested than in raw water samples. We believe that, for the purpose of implementation, people could use a combination of both filtration systems or mix-and-match the materials they use in order to produce an effective prototype that can be easily built and implemented into homes, and beneficial during natural disasters.

Relevance

Puerto Rico is a small island that experiences hurricanes, earthquakes, power outages, and more disasters that can cause people to lose their access to everyday resources such as power, water, or, in some cases, even their homes. We relate to this issue especially because we have experienced it firsthand, and we know that many on the island are in worse

circumstances than us. Due to this, we wanted to find a solution to one of these issues by developing a natural water filtration system that could be built and utilized by people all over the island.

Future Methods/Improvements

In the future, we hope to continue our community outreach by updating our previously built website and going out in our community to give demonstrations on how to build these filtrations. It is our ultimate goal that people in Puerto Rico can be supplied with a safe source of drinking water, especially considering the multitude of natural disasters that often render many people without resources. We also hope to continue work on our filter design to make it even more practical. We will do this by experimenting with many different materials and even testing its implementation into our own homes. Overall, we want to bring awareness to our community and design a filtration system that is effective, practical, and easy to build and keep at home.

Impact of working with a project mentor

Our project mentor greatly impacted us during the completion of this project. Without Mrs. Roettger, we may not have had the motivation to pull this together and stay on track to complete our project by the deadline. She has been guiding us, giving us advice, and even dishing out pep talks when we needed them. She came to school outside hours to let us work, and she asked us questions that deepened our levels of thinking and analyzing information. Working with Mrs. Roettger helped us learn more about our topic, develop research and collaboration skills, and focus on tasks that may seem hard or frustrating. We really couldn’t have done this without her, and we will always be grateful.

Badge Criteria

I Make an Impact

Our project stemmed from our interest in providing assistance to our community after events like natural disasters, which we know from personal experience can be traumatizing and can leave many without access to their everyday needs. We began our journey in 2018, after nearly Category 5 Hurricane Maria shook the island, leaving many without power or, more importantly, safe drinking water. Almost immediately, we saw this as an issue and decided that we needed to find a solution for it. Thus, the idea to create a water filtration system using natural, local materials arose and we began to work on developing it. We created a successful filtration system using coconut husks, coconut charcoal, and sand, and spread the word by creating pamphlets on how to create the device and even establishing a website to share our findings with our community. Later on, in 2020, the island was again rattled… literally. Hundreds of earthquakes, some of them reaching a magnitude of 6.4, shook the south side of the island. Houses collapsed and the power plants for the whole island were cut out, leaving us all in the dark and, for many, without a safe water source. It was then that we decided to expand on our filtration methods by finding a system that was a lot more easy to build, using banana peels, cilantro, and sand. We hope to update our website in the future with the information about our new filter and continue our outreach into finding affordable ways to help Puerto Ricans.

I am a STEM Professional

Over the course of our endeavor, We collaborated with multiple experts in the field in order to increase our knowledge and help insure we had a proper experimentation process. We worked with Mr. Colon, a teacher at our school, to learn how to create coconut charcoal. We collaborated with Mr. Roettger, another teacher at Ramey, to properly test our water samples.

We also interviewed scientists such as Zapata Yesmin and Drew Koslow to gather knowledge on the state of water filtration after Hurricane Maria and the dangers that unsafe drinking water could possess. These interactions helped us in ensuring that our prototype was able and would work sufficiently enough to produce clean results.

I am a Data Scientist

Our filtration system delves into the idea of creating a tested, affordable, easy to manage method of providing potable drinking water to people in Puerto Rico in the event of a natural disaster. We experimented with different ways of designing the devices, beginning by using screens between layers of material, then proceeding to implement coffee filters, as well as testing various resources for their effectiveness in the filtration of bacteria. Through our experimentation, we learned about how sand can remove tiny particles from water, banana peels can deplete heavy metals, and charcoal can purify water and improve its taste, along with so much more. After a few failed attempts to effectively clean water samples, we had to adjust our sterilization protocols to make sure we weren't just putting more bacteria into the water. We learned how to test for bacteria like E. coli, enterococci, and other coliforms, and we developed skills in using probes and collecting data, later to be analyzed in graphs and charts to see just how well, if at all, our solution worked. After collecting all of our data, we then compared the results between the two filters to determine the benefits and costs of each.

Bibliography/citations

The following annotated bibliography was used to support our research. These resources include articles, books, interviews, presentations, and websites. Attached to each citation is a summary. These resources helped us gather information for our project, to compare

results from two different filtration systems which utilize natural and easily-accessible materials in order to help Puerto Ricans in the event of a natural disaster.

Bacterial Testing Used

1) E. Coli Bacteria Testing
2) Coliform Bacteria Testing
3) Enterococcus Bacteria Testing

GLOBE Protocols Used

1) Conductivity Probe
2) Dissolved Oxygen
3) pH Probe

Sources beyond those powered by GLOBE

George Https, Luke, and Luke George. “11 Plants That Filter Water .” Mr Water Geek, 10 Jan, 2020. www.mrwatergeek.com/plants-that-filter-water/#2_Cilantro_As_Water_Filter.

This source provides information on purifying water using distinct plants. This article was useful for determining how to effectively use cilantro and bananas peel as a filter for bacteria and metals in the water. It also briefly explains how each prospective plant can serve as a filtration system.

Crouse, Theresa. “The Bizarre Use of Banana Peels for Your Survival Water.” Survivopedia, 5 May 2014, www.survivopedia.com/banana-peel-water-filter/.

This is a crucial source that contains information on using banana peels as filtration system in comparison to charcoal, which is not as easily-accessible to the public. The acids and molecules in banana peels, such as sulfur, nitrogen, and carboxylic acid, serve as magnets. The

positive ions of metals irrigation water is attracted to the negative ions of the carboxylic acid in the banana peel, withdrawing the dissolved metals from water. To make a water filter using banana peels, there is not much equipment needed beyond the peel itself and a coffee filter or cheesecloth. According to research, "...the banana peels can be used as water filters up to 8 times and still be effective." This shows how convenient and effective it can be to use bananas as filtration systems.

"Persistent Earthquakes Put Puerto Rico on Edge." CNN, Cable News Network, www.cnn.com/interactive/2020/01/us/puerto-rico-earthquakes-cnnphotos/index.html

This article discusses the effects and casualties of the numerous earthquakes Puerto Rico has faced since late December. As mentioned in the article, "Since December 28, the Caribbean island has been struck by more than 500 earthquakes with a magnitude of 2 or greater." Many people who lived in the south of the island, lost their homes after the 6.4 earthquake, which impaired and damaged many structures in south coast towns like Guayanilla, Ponce, and Guanica. These abrupt earthquakes created a lot of tension and fear in the island. Many were left without water and electricity service due damaged power plants and grids throughout Puerto Rico, and fled to shelters or slept in tents outside of their homes, with the fear of another sudden earthquake that could demolish their homes.

Taylor, Matthew. "Tens of Thousands of Puerto Ricans Still without Electricity, Water, Days after Earthquake." Tens of Thousands of Puerto Ricans Still without Electricity, Water, Days after Earthquake, World Socialist Web Site Wsws.org Published by the International Committee of the Fourth International (ICFI), 25 Jan. 2020. www.wsws.org/en/articles/2020/01/10/puer-j10.html

This article provided supplementary information about the earthquakes that devastated the island. After the large 6.4 earthquake, the island was faced with many casualties, such as loss of clean water and electricity. Many of the important power plants in the island reside in the south, so many of these power plants were affected. The article claims, “At least two thirds of the island’s population remained without electricity as of Thursday, and 250,000 without clean water.” This article also touches on the alleged corruption issues on the island, and the inadequate funds from the government for emergency relief.

Sifferlin, Alexandra. “Cilantro: More Than An Herb, It Can Purify Water Too.” Time, Time, 12 Sept. 2013, healthland.time.com/2013/09/12/cilantro-more-than-an-herb-it-can-purify-water-too/.

This source delves into the effective use of cilantro as a filtering agent. The research conducted by Schauer and undergraduate students, proved the prominence of cilantro as a bio absorbent material. This research team also analyzed how the common filtering agent, charcoal, was more expensive and not as available and easy to harvest, in comparison with cilantro. The article claims, “..the researchers reported success in removing lead and nickel with their cilantro filters …” Schuaer also claims “...a handful of cilantro will nearly cleanse a pitcher full of highly contaminated water of its lead content.” It is apparent that cilantro is a favorable plant that can be utilized to extract heavy metals from contaminated water.

Hauck, Grace. “Magnitude 5.9 Earthquake Rocks Puerto Rico and Causes Landslide in Peñuelas.” USA Today, Gannett Satellite Information Network, 23 Jan. 2020. www.usatoday.com/story/news/world/2020/01/11/puerto-rico-earthquake-6-0-magnitude-quake-causes-damage-ponce/4441511002/.

This source contains information about the recurring seismic activity in Puerto Rico, which started in late December of 2019. The article focuses on the 5.9 earthquake that instilled fear throughout many municipalities on the island. Prior to the 5.9 earthquake, there was a 6.4 earthquake that hit PR, resulting in the vast majority of the island to lose power, demolished structures in the south, and one death. The southern coast of Puerto Rico was essentially covered by a seismic cloud, causing more than 950 earthquakes. These frequent earthquakes caused residents whose homes were close to the epicenter regions of the earthquakes to resort to sleeping in tents outside of their homes or shelters in their respective communities.

Panditharatne, Mekela. “New Data: 2 Million Puerto Ricans Risk Water Contamination.” NRDC, 3 Jan. 2020, www.nrdc.org/experts/mekela-panditharatne/over-2-million-puerto-ricans-risk-bacteria-water.

After Hurricane Maria, the island was struck with numerous amounts of damage, leaving most of its residents without access to clean water. This signified that water contamination was imminent after the natural disaster. The article claims, “The tests performed by the Puerto Rico Department of Health confirmed that several cities in Puerto Rico are at risk of bacterial contamination in their water supply, in the aftermath of Hurricane Maria.” This portrays the vitality of being aware of ‘easily-accessible water filtrations systems that can provide potable water’. The tests and research performed concerning the water supply in Puerto Rico shows how in times of natural disasters, regions like Puerto Rico, can be drastically affected and cause their water to be contaminated with bacteria, such as E. coli. and coliforms. More than half of civilians in Puerto Rico faced the risk of bacterial contamination in their water after Hurricane Maria devastated the island.

Chodosh, Sara. “Activated Bamboo Charcoal”. April 2017. POPSCI.com. December 16, 2017.

Bamboo charcoal works efficiently in purifying water and making it taste good. It can keep your water fresh for about a month, until you need to clean or replace it. It does not use any electric or solar power, although it could be harder to find for some people than for others.

Green, Tony. “Water Filters Remove Impurities”. August 6, 2017. January 16, 2018.

Coconut shells are a good cleansing agent for water. They filter through activated carbon, which eliminates contaminants within the water. Most activated carbon is coal or charcoal.

Parker, K.T. “ Natural Materials Used for Water Filtration”. April 24, 2017. Sciencing. January 17, 2018.

Many different types of natural materials are used to filter and clean water. These materials include sand, oysters, plants, charcoal, and coconut. These are resources that are renewable and easy to find.

Werner, Carol. “ Renewable Energy Fact Sheet”. May 2006. Environmental and Energy Study Institute. January 17, 2018.

A solar water heater, which consists of a solar collector and a storage tank, can be used to heat water more efficiently and cheaper than an electric heater. There are many benefits to using a solar water heater, including money saving and environmentally friendly usage. Storing water can be a highly effective way to conserve and reuse natural resources. Rainwater and runoff can be decontaminated and used as drinking water. Greywater can be filtered and used as lawn irrigation.

News Week.com. “Puerto Rico’ Drinking Water Is Spreading Disease Due To Animal Urine And Hazardous Waste”. October 2017

Linley Sanders tells us about how there have been many cases of Leptospirosis. Kids have also been drinking from streams that have animal urine which is what causes Leptospirosis, since most people lack clear water. Illnesses will increase and water purification is not a long term solution.

All About Water Filters.com. “11 Unbelievable Ways To Filter Water With Plants”

The Article “11 Unbelievable Ways to Filter Water With Plants” told us about how to do filters with plants and fruit peelings. All these filters work effectively based on this article. The one that was most interesting was the fruit peeling because it was done with something that a lot of people have.

Experts in the field

Colon, Enrique. Ramey Unit School. Personal Interview. January 10, 2018.

Mr. Colon is a computer teacher at Ramey Unit School. Our prototype design included using coconut charcoal, and he informed us that he had previously worked with making coconut charcoal for his own use. He worked alongside with us in creating the coconut charcoal, and explaining the benefits of using it.

Koslow, Drew. Ridge to Reef. Personal phone interview. January 18, 2018.

Drew Koslow is a 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.

McFarland, Amy. Ramey Unit School. Personal interview. January 16, 2016.

Mrs. McFarland is a fifth grade teacher at our school. She and her husband handed out water filters after the hurricane. She helped us by telling us what the filters were made of and what was inside. She gave us information on what role each part of the filter played.

Rivera, Ruby. Ridge to Reef. Personal interview. November 18, 2018.

Ruby Rivera is a 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.

Roettger, Herald. Ridge to Reef. Expert in the Field, Science. November 19, 2018.

Herald Roettger is a MA Science teacher and has worked with the Surfrider Foundation in making water tests of water collected from local beaches near us. He provided us with the procedures in testing the water we would cooled from our filtration systems.

Roettger, Richard. Teacher at Ramey Unit School. Expert in the field

Richard Roettger is a High School teacher at Ramey Unit School. He is currently working with another group for the Globe Science Fair, and, along with his group, are working on studying and testing the effectiveness of several different water filters.

Sassar, David. Civil Engineer, Expert in the Field. January 21, 2018.

Mr. Sasscer visited our classroom to observe our presentations and give us feedback about being an engineer.

Zapata, Yesmin

Yesmin Zapata is a Community Scope Coordinator, who works in Costa Salud, in Rincon, Puerto Rico. She was able to provide us with feedback of our prototype design, along with a brief description of her role in the community.