# Aguarico

Ramey Unit School
Aguadilla, Puerto Rico

## Improving the Drinking Water Quality After Hurricane Maria using Natural Resources

March 1, 2018

Environmental Problems and Solutions

# Abstract

**According to a survey taken on our school about one month after Maria hit, only about 51% of the students from kindergarten to twelfth grade had electricity, and 83% had running water, though most of the tap water was contaminated and people were recommended not to drink it. These victims were required to take desperate measures to gain food or drinking water, like taking it from streams or drinking from the tap, which was still contaminated due to the shutdown of city purification systems because there was no power.**

**About three months after the storm, a significant amount of people still did not have reliable electricity or potable water. Water purification systems did not function properly due to this lack of power. Citizens from many areas such as Dorado, located on the north shore, were limited to to water provided by toxic Superfund cleanup sites. Times when water was guaranteed safe to drink were rare.**

**As a result of the lack of safe drinking water, many people, including our own friends and families, were forced to drink hazardous, unsafe 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, which is common in many streams and rivers. Because there were hardly any proper medical facilities, this became a major crisis among many Puerto Ricans. All of our team members have experienced the struggle of getting reliable potable water. Based on these events, our team confirmed the urgency of this problem and were motivated to investigate a possible solution to help our local community.**

**Water contamination is not a new issue in Puerto Rico. In fact, even before the hurricane, the island was referred to for, "the most contaminated water in the United States. In 2015, 70% of Puerto Rico's population received water that violated federal health standards. Water contamination is a critical problem that Puerto Ricans, after the hurricane more than ever. After identifying this problem, our team constructed the following problem statement: 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 this hypothesis: 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.**

# Problem Statement/ Hypothesis

**Problem Statement:**

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.*

**Hypothesis:**

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.

# Testing Methods/ Procedures

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

- Coconut charcoal
- Coconut husks
- Sand

After constructing our various prototypes, we ran the water through the devices, and tested the water samples for E.coli, Enterococcus, Coliforms, Dissolved Oxygen, Conductivity, PH, and Temperature

# We First Analyzed and Organized our testing materials and 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 |

The results of our first test included running tap water (AAA) and irrigation water from the Guajataca watershed through our filters 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 |

Our second prototype included sterilizing all of our filtration materials, and transferring our filtration materials 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 |

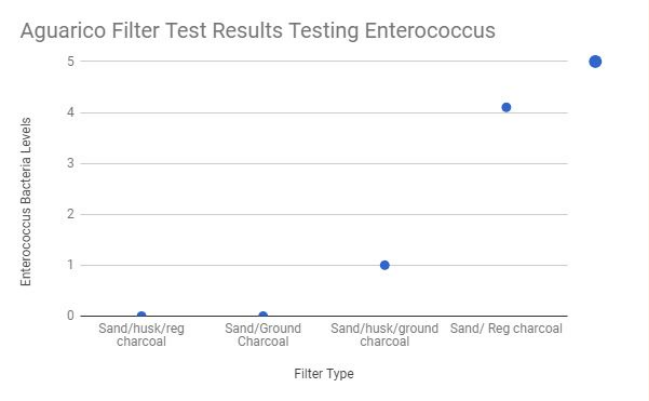
Our final test was conducted by testing four different filters, as shown below.  According to the table, the sand/husk/regular charcoal proves to filter the water most effectively, and maintains EPA safe drinking levels.

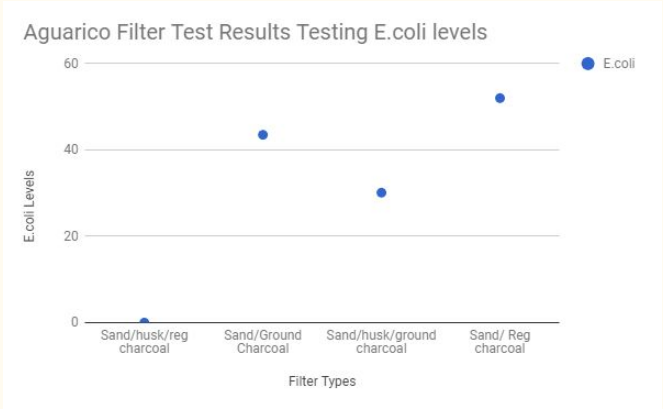
| Aguarico Filter Test Results from Feb 27 | | | | |
|---|---|---|---|---|
| | | | | |
| Sample Source | | | | |
| **Irrigation** | | | | |
| | | | | |
| Sand/husk/reg charcoal | | 0 | 0 | 0 |
| Sand/Ground Charcoal | | 0 | 30.7 | 43.5 |
| Sand/husk/ground charcoal | | 1 | 49.6 | 30.1 |
| Sand/ Reg charcoal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

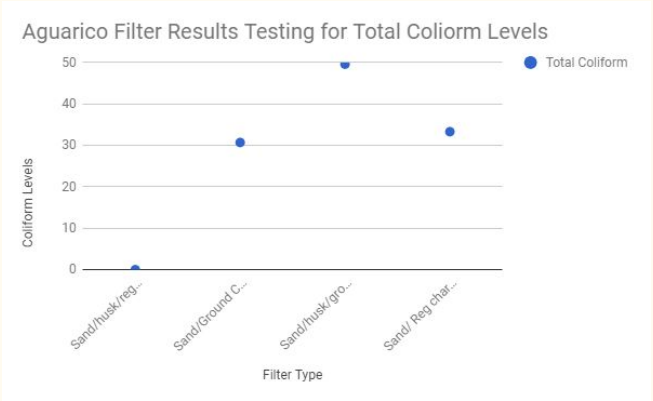
This final chart demonstrates the results for our final water filter test results:

| 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 | | |

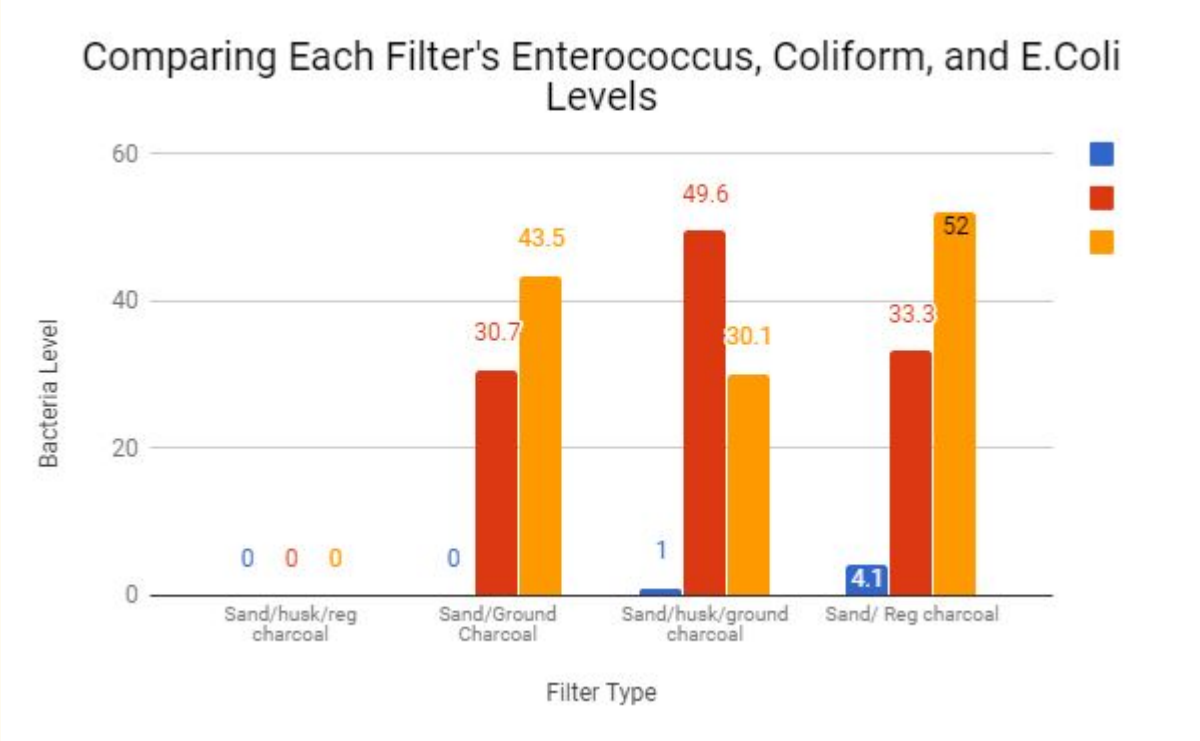
# The following chats compare the four different filter results in the amount of Enterococcus, coliform, and E.coli levels found present in the water



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 from both city (AAA) and  contaminated irrigation water samples. Aguarico faced many problems during the process of our experiment, and our results show that we were able to get over challenges and continue working and refining. The results from our final trial were the best and most significant.  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.

# Sources of error

During the process of our project, 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.