

Improving Point of Use Water Treatment Technology

Austerity Measures and Water Quality and Access in Puerto Rico

A Thesis Prospectus

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Access to safe, potable water is a problem people all over the world face. According to the World Health Organization (WHO), one in three people globally do not have access to safe drinking water (*1 in 3 People Globally Do Not Have Access to Safe Drinking Water – UNICEF, WHO, 2019*). Poor water quality can result in the transmission of diseases such as cholera, dysentery, and hepatitis A. WHO estimated 829,000 people die each year from diseases related to poor drinking water (*Drinking-Water, 2019*). The Center for Disease Control and Prevention (CDC) determined that the United States has one of the safest drinking water supplies in the world, providing over 286 million people with access to safe drinking water from their tap (*Water-Related Diseases and Contaminants in Public Water Systems, 2014*). In communities that have non-functioning water treatment systems or these systems are unavailable, people may rely on point-of-use water treatment (POUWT).

One such POUWT technology includes the MadiDrop+. The MadiDrop+ is a ceramic tablet that releases silver to deactivate bacteria. However, silver alone does not meet the WHO standards for POUWT technologies. My capstone team is working with PhD students in Professor James Smith's lab to make a more effective MadiDrop+ tablet that will release both silver and copper. Copper not only kills bacteria, but also has an antiviral effect on enteric viruses (Bosch et al., 1993). Along with this, my team will also be working on testing the effects of different POUWT technologies, such as the MadiDrop+ and copper, on mosquitoes to minimize health concerns related to the spread of vector-borne diseases.

Since my capstone research project focuses on water quality and treatment, my STS research paper will focus on access to clean, potable water in Puerto Rico. My research will focus on how the United States and its austerity measures taken in Puerto Rico have led to inadequate water supply. I will also examine how Puerto Ricans have pushed back against and resisted austerity measures. This research will employ the hydropolitics framework and social movements and mobilized publics framework. Puerto Rico was chosen as a case study since poor water quality and inadequate access to water, especially in the aftermath of Hurricane Maria, is caused by the history of austerity and violence on part of the United States government.

Technical Topic

Billions of people around the world do not have access to clean water. Insufficient supply of water treatment systems including piped water systems leads to an increase in the spread of waterborne illnesses. WHO estimates that water contamination causes 485,000 diarrhoeal deaths per year (*Drinking-Water*, 2019). Communities that lack access to a centralized water treatment and distribution system may heavily rely on decentralized, point-of-use water treatment. Examples of POUWT include boiling water, chemical disinfection, and filtration. The MadiDrop+ (MD+) is one example of a POUWT that chemically disinfects water. MD+ is a ceramic tablet that releases silver ions into water to deactivate pathogens. It has proven to deactivate 99.99% of bacteria (Hill et al., 2020). Although the MD+ is able to deactivate bacteria, it does not meet WHO standards for POUWT technologies. Adding copper to the MD+ would make it a better POUWT technology as copper has an antiviral effect on enteric viruses, and copper and silver together can synergistically disinfect disease-causing microorganisms (Soliman et al., 2020). One objective of my capstone project is to effectively get copper into the MD+ and have the MD+ discharge copper ions for over 365 days.

Along with water quality issues, many of the communities that rely on POUWT may require home storage of water which attracts mosquitoes. Mosquito larvae hatch when submerged in water. This poses health concerns as mosquitoes contribute to vector-borne diseases such as dengue fever. In parallel with our experiments with the MD+, my capstone team will also explore the effects of commercialized POUWT technologies on mosquitoes. Prior research has shown copper potentially has an effect on mosquito larvae (Reza & Ilmiawati, 2020). Since our experiments with the MD+ focus on getting copper into the MD+, we will test different concentrations of copper on mosquitoes. We plan on also experimenting with solutions of copper and silver to test their synergistic effects on mosquitoes. The team will work collectively on all tasks throughout the technical project. Team members perform similar tasks within the lab for each experiment, rotating the time when each member will go into the lab. The data will be collected through shared documents for all members to see and contribute to.

Finally, the team will work on developing a life-cycle assessment (LCA) of the MadiDrop+ using OpenLCA to determine the impacts of this POUWT technology on the environment. Research regarding the sustainability of ceramic point-of-use water treatment filters will be used to aid the development of our LCA (Ren et al., 2013). The overall goal of these experiments both with the MD+ and mosquitoes is to work towards

having more effective POUWT available to the communities that depend on them that not only address waterborne illnesses, but also vector-borne illnesses.

STS Topic

Although the CDC determined that the United States has one of the best and safest supplies of drinking water, this is not the case for the country's colonies. The maintenance of the United States' imperialist agenda has left its colonies struggling to access quality water. My STS research will focus on how the United States and its austerity measures taken in Puerto Rico have led to inadequate water supply in the archipelago, and how Puerto Ricans have been opposing this austerity. The hydropolitics and social movements and mobilized publics frameworks will be employed throughout this research.

The United States was attracted to Puerto Rico as it was seen as economically valuable as an outlet for excess manufactured goods and as a naval station in the Caribbean (Brás, 2011). Therefore, in 1898, the United States invaded and colonized Puerto Rico during the Spanish-American War. During the early years of the U.S. occupation of Puerto Rico, the archipelago's economy was mainly focused in agriculture. However, through what is known as "Operation Bootstrap," Puerto Rico's economy shifted to favor industrialization and manufacturing (Ayala, 1996). This industrialization of the Puerto Rican economy favored U.S. interests and its imperialist agenda as it allowed for federal tax exemptions in Puerto Rico for outside investors and the creation of an exclusively U.S. market (Morales, 2019). This modernization coupled with the U.S. demanding resource colonization brought about environmental problems, such as air and water pollution, and the commodification of the archipelago's water and waterscapes (Anazagasty-Rodríguez, 2021). Anazagasty-Rodríguez's article "Colonial Waterscapes: The Water Issue in Puerto Rico" in *The River Rail: Puerto Rico* will be used for this research to provide a basis on the history of U.S. colonialism and capitalism and how they have contributed to the insufficient water resources within the archipelago.

The shift of the economy during Operation Bootstrap created an overdependence on external investment which has led to the current day debt crisis (Morales, 2019). This debt crisis led to the implementation of austerity measures like the passing of the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA) that allowed for the island to enter into a bankruptcy process. PROMESA, in turn, established the Fiscal Oversight Management Board (FOMB), colloquially known as La Junta. La Junta controls Puerto Rico's budgetary proposals and expenditure allocations. The control board's focus

on paying off the debt has led to less money and resources being used for ensuring clean water is being dispersed adequately throughout the archipelago (Lloréns & Stanchich, 2019). The control board pushes for privatization of Puerto Rico's Aqueduct and Sewer Authority (PRASA), a currently public corporation, due to the fiscal crisis devastating the archipelago (Anazagasty-Rodríguez, 2021).

Having base knowledge of U.S. colonialism and austerity measures within Puerto Rico provided by the cited articles, this research paper will further explore how this history of austerity has affected Puerto Rico's water supply. This paper will examine how U.S. military interest in Puerto Rico, stemming from the United States' original interest in colonizing the country, has deteriorated the quality of the water throughout the archipelago. The effects of the pharmaceutical industry within the country, brought about by the industrialization of Puerto Rico's economy through Operation Bootstrap, on water quality will also be explored throughout this research paper. Focusing on the aftermath of Hurricane Maria, this research will also examine how the colonial relationship between the United States and Puerto Rico exacerbated the environmental conditions and lack of clean water during this period. The role of the fiscal control board will be studied with relation to its effects on water quality and resources in the archipelago. García-López's article "The Multiple Layers of Environmental Injustice in Contexts of (Un)natural Disasters: The Case of Puerto Rico Post-Hurricane Maria" will be used in this paper to explore water issues after the hurricane. Morales's *Fantasy Island* will also be utilized to provide information on the industries brought into Puerto Rico that have had an effect on the environment, and information on the effects of La Junta in Puerto Rico. A hydropolitics framework will be employed to guide this study. Hydropolitics is the politics of water and allocating water resources within a society. Hydropolitics employed as a framework will not only help navigate water conflicts and understand the interactions of actors in water conflicts, but also examine the power relations and complexities involved in water issues (Bréthaut et al., 2021).

After examining austerity measures and their effect on water in Puerto Rico, this paper will then focus on Puerto Ricans' opposition to such austerity measures in the archipelago. The work of Puerto Rican journalist Bianca Graulau will be used as a starting point to navigate the social movements in Puerto Rico. This will be guided through the social movements and mobilized publics framework. Social movements and mobilized publics as a framework examines social movements, why they occur, how they develop, and the political, social, and cultural implications of such movements (Sen & Avci, 2016). This framework would allow for the exploration of how social movements in Puerto Rico developed to counteract the austerity measures that are discussed through hydropolitics.

Next Steps

Both the technical capstone and STS research projects will be complete by May 2022. Below is an outline of overall objectives and their respective completion time frames.

- Capstone technical project
 - September 2021 - define team project scope and objectives; complete lab safety assessments; begin sampling the MD+ to test for silver and copper levels
 - October 2021 - continue sampling for the MD+; prepare for mosquito experiments by completing calculations of copper concentrations; submit mid-semester progress report
 - November 2021 - conducting experiments in the lab for MD+ and mosquitoes; continue sampling for the MD+
 - December 2021 - organize data from Fall 2021 experiments
 - January 2022 - begin research for LCA
 - February 2022 - continue experiments in the lab; continue LCA research; start creating LCA; begin writing technical report
 - March 2022 - compile all lab data; finish LCA; write technical report
 - April 2022 - team review of technical project
 - May 2022 - submit final technical report
- STS research project
 - October 2021 - submit prospectus draft to advisors, complete peer review
 - November 2021 - submit final prospectus to advisor for approval
 - December 2021 - research the impacts of pharmaceutical companies and U.S. military on Puerto Rico's water quality, and privatization of water sources and waterscapes in Puerto Rico
 - January 2022 - continue research on pharmaceuticals, U.S. military, and waterscapes; research social movements in Puerto Rico against austerity measures, especially movements focused on the environment and water
 - February 2022 - submit draft of research paper
 - March 2022 - modify research paper draft and write final version
 - April 2022 - submit final draft of thesis portfolio

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