Targeting Water Pollution and Hydroelectricity Potential Within Low-Income Areas

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Targeting Water Pollution and Hydroelectricity Potential Within Low-Income Areas

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Abstract

In recent years efforts towards combating pollution have risen yet not enough is being done to combat these issues on a more local level. Low-income communities often have the fear of environmental gentrification when clean-up efforts are made and often are forced to remain in polluted areas. Aquatic pollution and environmental gentrification need to be addressed further. In this project, the goals were to design and construct a device that is able to produce a substantial amount of electricity (~20V or more) and efficiently filter water. The device showed improvement in infiltration test factors (total dissolved solids, electrical conductivity, and pH). Currently, only the filtration aspect has been tested and further testing and modification are in motion to better filtration and test electricity production.

Acknowledgements

I would like to thank Mr. David Eisenberg for his constant assistance, feedback, and understanding. I would also like to thank Mr. Paulino Gomez and Ms. Reyna Gomez for providing support throughout this project.

Biographical Outline

Name: Jacquelyn Gomez

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Academic Achievements

- 2nd Place winner in the 73rd Annual Prince George's Area Science Fair (2021) Senior Division in the Environmental Engineering category
- First Place Certificate recipient the American Institute of Aeronautics and Astronautics (AIAA)- National Capital Section

Activities

- National Honors Society
- Italian Honors Society
- Science National Honors Society
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- SYPE Youth at Work
- PGCMLS Volunteer

Advice to Class of 2021

- Enjoy the small moments you have

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Chapter One

The Problem and Its Setting

Aquatic pollution is one of the biggest environmental issues at the moment. The issue has received large amounts of publicity and social media attention yet not enough is being done to combat these issues on a more local level. Whenever such issues of pollution are touched upon locally there is a lack of focus on the impact on communities. Environmental clean-up is meant to benefit local communities however many fail to recognize the negative impacts on communities that may come along with these cleanup efforts. Once a polluted area gets cleaned up the property value and cost of living rise. This is known as environmental gentrification and often evicts residents who can no longer afford these new finances. Nothing is in place to give back to these communities that are threatened by environmental gentrification. Both aquatic pollution and environmental gentrification are issues that need to address.

Background of Study

Through the research on the local effects of these environmental issues, the Anacostia River's trend of pollution had become evident. The Anacostia River has been deemed unsafe to swim and fish in; only receiving a passing grade—a D— within the last two years. The *2020 State of Anacostia River Report Card* shows a decreasing level of dissolved oxygen, 60% fecal matter—100% would mean safe to swim in— and 52% water clarity averages a 63% overall grade (The Anacostia Watershed Society, 2020). With efforts towards combating the river's pollution, local low-income communities along the river have stated resistance towards these efforts in fear of environmental gentrification which would raise property value in those areas. As local governments and organizations work towards cleaning up the environment their efforts and the resulting improvements are primarily seen in wealthier communities at first, while the low-income environments, like the Anacostia area, continued to suffer for more years (Craig, 2019). This research clearly highlights the ongoing issues in both local pollution and social-economic issues.

Statement of Problem

The Anacostia River is an example of a local polluted issue. For decades the river maintained an F grade until 2018. The issue of the Anacostia River is still being fought currently. There have been efforts to clean up the Anacostia River but not enough has been and no solutions/efforts have addressed the communities. The installation of trash traps and environmental law introduction are examples of current efforts and there has been progressed evident by the river's grade increase, but it is not enough. Local low-come communities have discussed their fear and resistance to these projects because of the seemingly inevitable environmental generation that would evict them from their current area of residence. Hyrdroelectity often offers financial relief and can be applied to both small and large scales. In order to combat these issues, the following research question was proposed: can a device be designed and constructed to produce a substantial amount of electricity (~20V or more) and efficiently filter water?

Engineering Goals

For the device to be deemed successful it would have to accomplish the following: decrease the TDS by ~25% or more, decrease EC by at least ~15%, produce a substantial amount of electricity measured in dc voltage 15-20V minimum, have a pH of 6.5-8.5 and overall the device should have an end result of cleaner water (visually cleaner) after going through the device and produce hydroelectricity. Hypothetically –and at a larger scale– the device is meant to be placed along the Anacostia River**.** It would collect trash within water wheel barrels and as the wheel turns it would produce hydroelectricity for local communities to use without disturbing wildlife.

Variables

Independent Variables

Varying water samples (i.e. filter clean water, polluted water from the Anacostia River, self-made contaminated water)

Dependent Variables

Water quality factors: pH value, TDS, EC. For testing electricity production: DC Voltage

Control

The control variable was clean pre-filtered water.

Regulated Conditions

- Varying water sample 3-5 gallons per testing
- 10 trails per water sample. 30 trails total
- Phase one of testing focused on water quality testing
- Phase two of testing focused on electricity production
- Tested outdoors

Assumptions

- All devices used for testing provided accurate results
- Prototype in the theoretical application would not disturb wildlife
- Both quality filtration and production of hydroelectricity occurred at the same time during the final stage
- Minor temperature changes due to outdoor testing did not have effects on the end filtration results

Limitations

- Testing and building are done to scale
- Tested on days with similar outdoor temperatures
- No natural river flow will be used

Statistical Analysis

Comparison of before and after data collection for water quality factors was used and displayed within a bar graph. A line graph was used for electricity production data.

Summary

There is a large focus on aquatic pollution but a lack of focus on the effects of those environmental issues on a local level. The Anacostia River has constantly had an issue with pollution with a decade of F streak grade and a D grade in recent years. While these issues get worked on locally people fail to recognize the effects clean-up projects have on local low-income areas. Cleaner environments mean a high cost of living which low-income communities cannot afford. The goal of this project is to create a device that would combat all listed issues above: cleaning up the aquatic pollution and giving back to the local communities through hydroelectricity production as a form of financial allivation. Varying water type was the project's independent variable. The dependent variables were pH value, TDS, and EC well as a test of electricity production in D.C Voltage. It was assumed that devices used for testing gave accurate data. The device was scaled down and factors such as river flow are unable to be reproduced. To display data comparison bar graphs and line graphs are used. For the device to be successful it would have had to lower TDS, EC, keep pH in a 6.5-8.5 range and produce 15-20V.

Definition of Terms and Abbreviations

1. EC- electrical conductivity
2. Environmental Gentrification- The process of cleaning up pollution and having greener applications that raises property value attracting richer residents ultimately increasing the cost of living in these areas.
3. TDS- Total dissolved solids

Chapter Two

The Review of Related Literature

For years local aquatic pollution in low-income areas has been neglected not only because of the local government's lack of efforts but also because of residents who fear losing their home to environmental gentrification. In recent years, however, D.C and Maryland areas have increased their efforts towards improving local environments, and this includes the Anacostia River. Despite these current efforts the Anacostia River continues to suffer from poor health, and the fear of environmental gentrification is still embedded into local communities. More polluted areas have a lower cost of living, but once these areas become clean, investors ultimately increase the cost of living, evicting residents who can no longer afford these higher finances.

Nothing is in place to give back to these communities that are threatened by environmental gentrification. The goal of clean-up efforts is to improve the area's reputation, but the effect on the local communities are overlooked. If one hopes to truly improve the local environments they must not only focus on clean-up efforts and devices but also focus on the communities that have suffered from these dirty environments. Continuous aquatic pollution and environmental gentrification are two issues that need to be addressed. Throughout the research and construction, the device was made with the intention of combatting the Anacostia River's issues. The goal of the device was to produce a substantial amount of electricity (~20V or more) and efficiently filter water.

Anacostia Background

The Anacostia River is divided into three branches: MD Branch, Upper D.C, and Lower D.C. For years, the river had been deemed too dangerous to swim and fish in, receiving failing grades till 2018, when the river got its first D grade (The Anacostia Watershed Society, 2020). The Anacostia River has struggled with pollution for decades and still does. Back in the Civil War, the river was a prime dumping ground for toxins, and today, it is often the victim of illegal dumping. Runoff poses as one of the greater threats to the improvement in the Anacostia River. The soil surrounding the river is embedded with numerous toxins such as Hg, Pb, and Zn (Harrisa, A et al., 2018). During heavy rainfall, those metals along with other toxins from suburban, urban and rural areas, and the occurrence of COS all contribute to the river's depleting health (Harrisa, A et al., 2018). The Anacostia Watershed data showed notable declines in river health during years of heavy rainfall (The Anacostia Watershed Society, 2020). The implantation of the Clean Water Act 1972 had encouraged the promotion of a healthier environment especially rivers. It had allowed for a protected/moderated environment i.e forest, lakes, rivers on more local levels. However, these environmental improvements were only seen in wealthier communities at first, while the low-income environments, like the Anacostia area, continued to suffer for more years (Craig, 2019).

Environmental Gentrification

The effects of environmental gentrification are a major concern for local communities in the DMV area. (Fenston, J, 2019). Low-income areas find themselves in difficult situations having to choose between cleaner living areas or financial stability. Many rather deal with the scattered trash and unsafe river than being eventually kicked out of their homes. Many ignore these unsafe environments for the sake of affordability. The Anacostia River itself acts as a dividing line between different income areas (Craig, 2019). Many clean-up efforts have one sole goal: cleaning up the environment. Cleaning up the environment is meant to benefit communities living in that environment but ironically those communities are completely disregarded especially low-income communities. Many clean-up projects concern and benefit the area's reputation and not the communities. A study of economic displacement had shown that a $1,000 increase in Brooklyn's per capita income during a period of time when "green" areas and devices were being implemented (Maantay, J et al. 2020). Such studies illustrate the advantage given to those of higher socioeconomic status and the complete disregard of lower ones.

Current Status of the Anacostia River and Surrounding Area

In recent years, the Anacostia River has seen improvement due to the Watershed's efforts, environmental laws, volunteer projects, clean-up projects, and use of technologies. The Anacostia area worked with the EPA and was able to make arrangements with local businesses to ensure they control their pollution output (Craig, 2019). Other laws such as the 5 ₡ Plastic Bag aimed to reduce the public's pollution output. Such efforts allow for the river's AWS annual assessment to reflect improvement. AWS test DO (dissolved oxygen), fecal matter %, chlorophyll A, SAV, and more (The Anacostia Watershed Society, 2020). DO is an important factor in river health but often suffered due to toxins getting into the river either by Combined Sewer Overflow (CSO), illegal dumping, and etc.CSO contains high DO levels. Although CSO does have these high levels of DO, CSO ends up prolonging decomposition within the water and enabled low DO levels overall (The Anacostia Watershed Society, 2020). Currently, the river has a D grade but has improved from last year's report card. As more efforts have been made to clean up, the fear grows amongst the low-income communities that live along the river. Once industrial D.C cleans up, residents assume these minority areas will belong to the wealthy (Fenston, J. 2019)

Hydroelectricity Background

Renewable energy had only recently been applied as a source of mass-energy in recent decades. The turbine is an essential part of the hydro wheel– the more traditional way to create hydroelectric power— and was invented in 1849, going by the Francis turbine. The turbine allowed for more industrial use but the hydro wheel had existed prior. Used by the Greeks to grind flour centuries before and has progressed to have a more modern use. The key to the electric generator was founded by Michael Faraday who used magnets and copper wire to produce electricity. The magnetic field was the energy that pulled electrons out of their orbit, producing that electricity Faraday saw (Discover our Shared Heritage Travel Itinerary Series, 2017). The first hydroelectric power plant for larger-scale production was established in 1887 in San Bernardino, California which led to 15% of the U.S power be produced by hydroelectric. Currently, the U.S power is composed of 6.6% hydroelectric power, a decrease from 1887's hydroelectric usage. Other countries have developed more sufficient hydroelectric production and usages. Norway's power is composed of about 90% hydroelectricity. Overall the world uses about 16% hydroelectric power derived from numerous devices such as industrial hydroelectric plants and small-scale generators (Balkhair, K. et al. 2017). In Maryland, less than 2% of the electricity used is produced by hydroelectric, and overall renewable energy only produced less than 5% of total electricity in 2017-2018 (Pepco An Exelon Company. 2018).

Hydroelectricity Applications

With the development of hydroelectric power, it has been applied in numerous ways. There are different types of hydroelectric production. The water wheel is less seen in urban settings but in villages, smaller towns, or for personal use. The water wheel is one of the most commonly used hydroelectricity devices that utilize the "fall" of water to produce electricity. Hydroelectricity and its related devices are still evolving to become more efficient and useful in more urban areas. One research team aims to increase the electric output of small-scale hydropower which would make the devices more cost-efficient and more accessible to other demographics (Balkhair, K. et al. 2017). A different research team aims to see if hydropower can be implemented into gas stations as a charging method for electric cars (Balacco, G. et al. 2018).

Urban Setting

Hydroelectricity is not common in urban settings. The usages of hydroelectricity are often found in more rural areas. However, these hydroelectric plants see the effects of urbanization and climate changes. Through multiple testings, researchers found out how these changes gravely affect the efficiency of generators and hydroelectric production. Despite hydroelectric power being often used in rural settings, these effects impact the urban areas more. One research project planned to use hydropower in gas stations

(Balacco, G. et al. 2018). Others are combating aquatic pollution found in urban bodies of water caused by chemical runoff and CSO overflow (Carpenter, K. et al., 2016). It is recognized that the lack of space creates difficulty in the usages of other commonly used filtration devices in these cities. The threat of climate change also has grand effects on renewable energy sources creating difficulties for hydroelectric plants. (Majumder, P et al. 2018).

Current Applied Methods in Combating Pollution

One major contributor to the healthier Anacostia River is the implantation of trash traps along the river. Trash traps allow for the gathering of illegal dumping and littering which have been a notable issue for the river. Trash traps are often located near river drainage and have been proven efficient in the Anacostia River. Research shows the efficiency of different waste traps and the wheel axis waste traps are proven to be extremely strong and effective in drainage areas (Nurul A. N, 2019). It accommodates well in different environmental factors and has good potential in our local areas if they are not already implanted. Another device utilizes already working green devices for filtration purposes that are meant to be used in smaller areas of cities (Chua, G.X et al. 2020).

Summary

The Anacostia River had suffered decades of pollution and it was only in recent years the river has begun to see improvements and that is due to multiple efforts such as environmental laws, volunteer projects, clean-up projects, and the use of technologies. While the local environment improves fear remains among low-income communities.

That fear is being displaced by environmental gentrification. Currently, the Ancoatia river has a D grade and AWS had hoped to see continuous improvement. Currently, toxic sediment, CSO, and heavy rainfall threaten the river on a chemical level. Laws and associations with the EPA had shown a more governmental effort to improve the river. The DMV and surrounding Anacostia communities, mainly low-income, fear being evicted due to rising living costs. The rise in property value and cost of living due to environmental clean-up efforts is environmental gentrification. There were studies showing the raise of capital per income in places with green accommodation. One common renewable energy is hydroelectricity. Hydroelectricity went from a minor role in old civilization to a large part in humanity's efforts to be greener. About 16% of the world uses hydroelectricity and in Maryland, only 1.1% of electricity comes from hydroelectric power. Hydroelectricity is not only used for a population's power usage but there are future devices that plan to be used for personal use (i.e small generators) and gas station fuel for electric cars. Devices such as trash traps are currently being used in the Anacostia River and more research is being put into other filtration devices for urban areas. There are current efforts in improving low-income polluted areas but not as much effort in protecting these low-income communities themselves. Acknowledging the negative impacts of environmental gentrification is essential to seeking solutions to protect these communities from displacement.

Terms and Abbreviations

1. AWS: Anacostia Watershed
2. CSO: Combined Sewage Overflow

3. DMV: D.C, Maryland, Virginia
4. DO: Dissolved Oxygen
5. EC: Electrical Conductivity
6. Environmental Gentrification: The process of cleaning up pollution and having greener applications that raises property value attracting richer residents ultimately increasing the cost of living in these areas.
7. EPA: Environmental Protection Agency
8. TDS: Total Dissolved Solids

Chapter Three

Method

Environmental clean-up projects only give back a cleaner environment and nothing more. If one can not afford the rising property value and higher cost of living in those newly cleaner environments they are evicted out of their homes. The main goal of this project was to designed and constructed to produce a substantial amount of electricity (~20V or more) and efficiently filter water. The device is a modeled water wheel that both cleansed the said body of water/water sample and produced hydroelectricity for its hypothetical community. The device is catered to the Anacostia River and the local communities that surround it. The model will be a scaled-down version of the device that is meant to help these communities but perform its main functions(cleaning water and producing electricity). For the device to be deemed successful it would have had to accomplish the following engineering goals: decrease water's total dissolved solids (TDS) by ~25%, decrease electrical conductivity (EC) by ~15%, have a pH of 6.5-8.5, and produce 15-20V.

Materials

1. Fish Tank of 10 Gallons 14.5in L✕ 8.7in W✕ 9.7in H
2. 2-5 Gallons of Water Sample
    a. Varying samples for testing
    b. Controlled filter water, Anacostia river water, self-made contaminated water
3. 2 Circular wooden circles 8 inches diameter 1 inch thick

4. 8 Wooden slabs 3in L x 0.5in W x 0.5in H
5. Mini Turbine 6V
6. Digital multimeter
7. Wood glue
8. Superglue
9. Plastic Angled Container 5in✕7in✕3in
10. Duct tape
11. Mesh net 14.5in L x 9.7in H
12. DS Meter Digital Water Tester 3in1 (test for TDS, EC, and Temperature)
13. pH stripes
14. Plastic pipe 5inL x 1nW x 1inH ; 1in diameter
15. Hand saw
16. Ruler
17. Protractor
18. Drill
19. Wooden cylinder container 3in L x 3in W x3in H

Procedures for Assembly

Construction wooden wheel

1. Attach wooden cylinder to the middle of 1 wooden circle
2. Cut wooden planks into 8 slabs 3 inches long
3. Attach wooden slabs to the wooden cylinder at 45° apart or 2.5 inches away

4. Glue 2nd wooden circle to the other side of the wooden cylinder
5. Drill hole into a wooden wheel
6. Attach turning axis
7. Attach turbines
8. Test mobility of the wheel

   Set up fish tank portion

9. Drill hole into the fish tank about 3 inches above the bottom on the smaller side
10. Attach the plastic pipe to where the hole was drilled
11. Trim mesh filter if needed (to 14.5in L x 9.7in H)
12. Attach mesh filter at about ⅞ mark in the fish tank
13. Drill hole about ⅔ mark on the longer side

    Finish constructing device

14. Attach water wheel axis to the 2nd drill hole
15. Remove turbine and then reattach turbine on the outside of the fish tank
16. Place container slightly under the plastic pipe
17. Prepare for testing

Data Collection and Analysis

Data collection was essential to determining the effectiveness of our model and the conditions the model catered to— whether physical trash will is solely combatted or able to combat toxins too. Data collection comes from three devices: a 3 in 1 TDS Meter Digital Water Tester (testing for TDS and EC,), and pH strips, and a digital multimeter (testing for dc voltages of hydroelectric production). Phase one of testing focussed solely on water quality factors. At the start of each trial, the raw water samples (Controlled filter water, Anacostia river water, or self-made contaminated water) are tested with each device and written down (sample # before filtration). After each sample had gone through the device water quality factors are and recorded as sample # after filtration. The conclusion of water quality factor testing proceeded with phase two which had focussed on hydroelectric production. The pre-filtered was ran through the device for five minutes and during each minute mark, voltage outage was measured with a digital multimeter and recorded. All written data will be displayed on a comparison bar graph separated with before and after data of said sample displayed. Four graphs were created graphs.

Summary

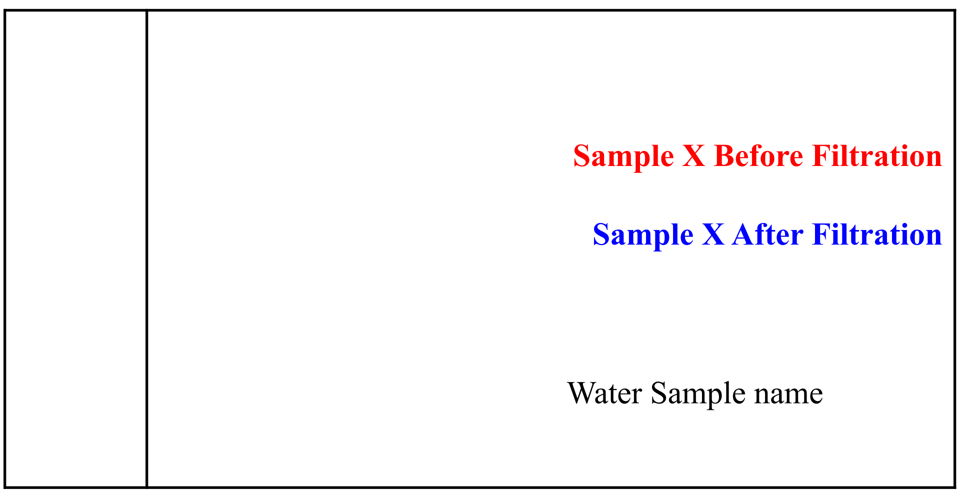
The main purpose of this project was to create a model of a device that would be implanted in bodies of water, focused on the Anacostia River and the MD/DC area. The research question was: Can a device be designed and constructed to produce a substantial amount of electricity (~20V or more) and efficiently filter water? The device was designed to collect trash, clean the river, and as the water wheel model rotates it shall produce and provide electricity to its local communities. Providing electricity also provides some financial relief to the communities who need it and would suffer financially due to environmental gentrification. The device described in this paper is a model that would hypothetically aid the Anacostia River. It is tailored to the river's needs and issues with the goal of testing out the device's features/goals in a scaled-down version. The device is assembled in about 17 steps testing commenced. What was tested and aided in determining the device's efficiency is EC, pH, TDS, and voltage output.

Each sample was tested for the three water quality factors prior to go through the device being labeled *sample # before filtration* on the graph. As the device is active, watts were measured. After the water had gone through the device, the 5 factors will be tested and labeled *sample # after filtration* on graphs. Graphs were looked at and compared to see the efficiency of the model under different water type conditions and will indicate whether a scaled-up/similar device could aid the local Anacostia River communities.

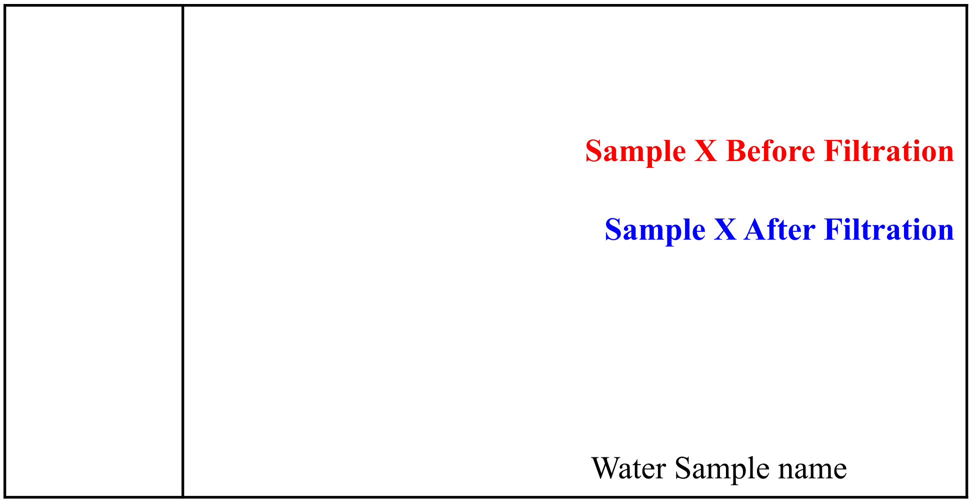
Prepared Data Tables and Graphs

Comparison Bar Graphs

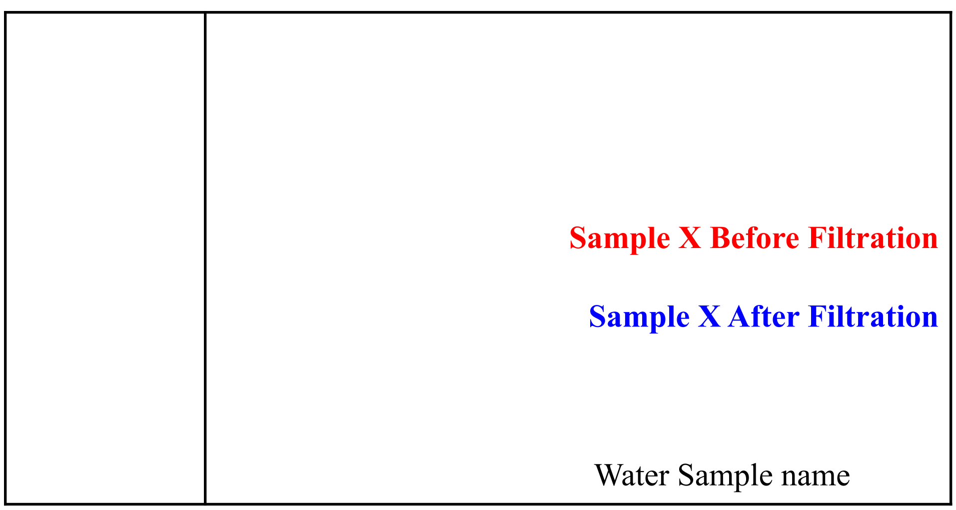
[Name of Water Samples Being Tested and EC]



[Name of Water Samples Being Tested and pH]



[Name of Water Samples Being Tested and TDS]



Line Graph

[DC Volatage Production]

	Minutes

Chapter Four

The Finding

Environmental clean-up is meant to benefit local communities the most however many fail to realize the negative community impacts that may come along with these cleanup efforts. Low-income areas suffer from both large amounts of pollution and the threat of environmental gentrification. Once a polluted area gets cleaned up the property value and cost of living rise, evicting those who can longer afford these new finances. Those with a low-income background often have no other choice but to remain in polluted areas. The Anacostia River has a trend of low-quality water and those surrounding low-income communities fear future environmental gentrification. There are efforts towards cleansing the river but there is not as much focus on these surrounding communities. At the moment no device both alleviates pollution and future financial stress.

Data

Data collection occurred in the residential areas of Adelphi, Maryland. Testing materials include DS Meter Digital Water Tester 3in1, pH Stripes, and a Digital Multimeter. Testing factors for water quality were: TDS (measured in ppm), EC (measured in µS/cm), and pH (measured by pH value). Testing factors for electricity production were: DC voltage. For all trials, –10 trails per water sample– data was collected prior to filtration and after filtration in order to study the device's effects.

EC had shown the least significant differences between before and after filtration with only an average decrease of 8% µS/cm. TDS had shown the most significant improvements between before and after filtration phases with an average decrease of 18% ppm. pH remained in ideal ranges for the pre-filtered water sample and the Anacostia River water sample. In both the before and after filtration phases for the self-made contaminated water pH levels were 4-5 (acidic). The average hydroelectricity production was 3.7V. Some trials had required retesting due to device complications. Trails that faced complications due to device complications were not accounted for in the displayed data collections.

$$\text{Average of Tested Factor} = \frac{\text{Sum of raw data of [Tested Factor] from the 10 trails}}{10}$$

Before and After Data of Water Test Factors: Pre-Filtered Water (Avg)

	EC (µS/cm)	**TDS (ppm)**	**pH**
Before Filtration	221 µS/cm	108 ppm	6.8
After Filtration	217 µS/cm	108 ppm	7

Table 1: Averages of all three water quality test factors (ED, TDS, pH) before and after filtration for the Pre-Filtered Water trails.

Before and After Data of Water Test Factors: Self-Made Contaminated Water (Avg)

	EC (µS/cm)	**TDS (ppm)**	**pH**
Before Filtration	417 µS/cm	313 ppm	4
After Filtration	360µS/cm	256 ppm	5

Table 2: Averages of the three water quality test factors (ED, TDS, pH) before and after filtration for the Self-Made Contaminated Water trails.

Before and After Data of Water Test Factors: Anacostia River Water (Avg)

	EC (µS/cm)	**TDS (ppm)**	**pH**
Before Filtration	457 µS/cm	567 ppm	8
After Filtration	414 µS/cm	468 ppm	7.5

Table 3: Averages of the three water quality test factors (ED, TDS, pH) before and after filtration for the Anacostia River Water trails.

Hydroelectricity Production (Avg)

Minute(s)	**Voltage Output**
0	0
1	4.32
2	4.12
3	3.47
4	3.25
5	3.78

Table 4: Averages of hydroelectricity voltage production over the course of 5 minutes using pre-filtered water. Used to create **Figure 4.**

Data Analysis

The two biggest goals of this device are to both filter water and produce electricity. The water filtration portion of the device showed potential with a majority of trials showing small improvements in each tested factor–TDS, EC, pH. Although improvements were not large, the device shows a lot of potentials. EC showed the least significant change between before and after filtration phases with an average decrease of 8% µS/cm. TDS shows the most significant changes. TDS on average had a decrease of 18% ppm. Most pH from the trails was in an ideal range (6.5-8) except for the Self-Made Contaminated Water before and after filtration phases. There was an improvement in the Self-Made Contaminated Water before and after filtration phases from 4 to 5 pH but the pH is still too acidic to be deemed safe. More work needs to be done to get that sample into the ideal range. Hydroelectricity production did not satisfy the goal of 15V-20V being produced on average. The average production of voltages was 3.97 V.

Water Quality Test: EC Averages Before and After Filtration (rounded Avg)

	Before Filtration	**After Filtration**
Pre Filtered Water	221 µS/cm	217 µS/cm
Self-Made Contaminated Water	417 µS/cm	360 µS/cm
Anacostia River Water	457 µS/cm	414 µS/cm

Table 5: Averages of before and after filtration data collections of EC for all three water sample trails. This data was used in the creation of **Figure 1.**

Water Quality Test: TDS Averages Before and After Filtration (rounded Avg)

	Before Filtration	**After Filtration**
Pre Filtered Water	108 ppm	108 ppm
Self-Made Contaminated Water	313 ppm	256 ppm
Anacostia River Water	567 ppm	468 ppm

Table 6: Averages of before and after filtration data collections of TDS for all three water sample trails. This data was used in the creation of **Figure 2.**

Water Quality Test: pH Averages Before and After Filtration (rounded Avg)

	Before Filtration	**After Filtration**
Pre Filtered Water	6.8	7
Self-Made Contaminated Water	4	5
Anacostia River Water	8	7.5

Table 7: Averages of before and after filtration data collections of pH for all three water sample trails. This data was used in the creation of **Figure 3.**

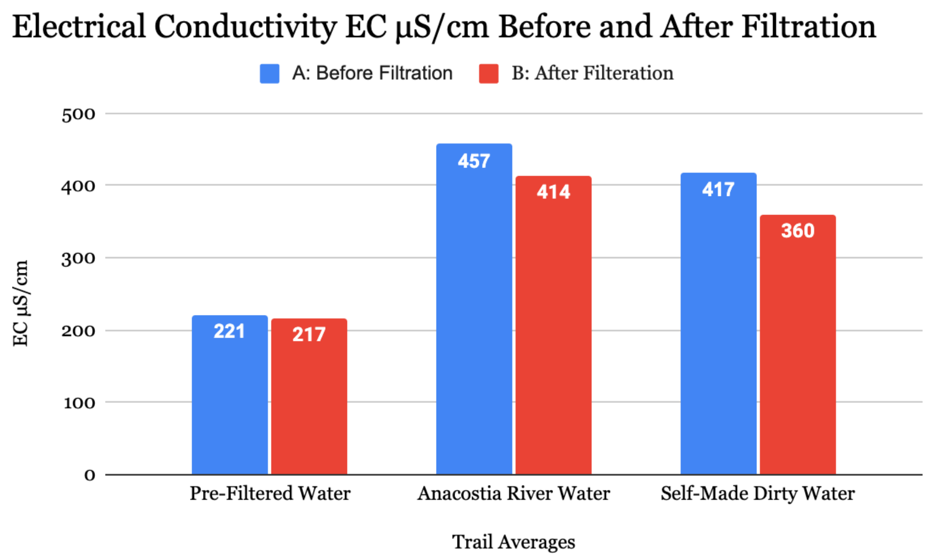


Figure 1: Data from **Table 5** in a visual representation. The representation is meant to display the device's effectiveness in decreasing EC after filtration data collection. The engineering goal is to decrease EC between before and after filtration data by at least 15%.

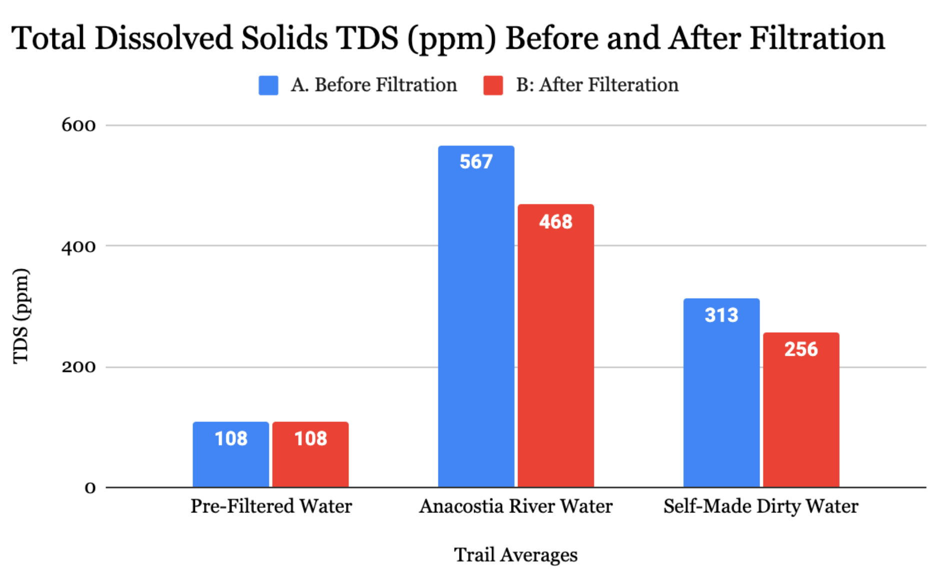


Figure 2: Data from **Table 6** in a visual representation. The representation is meant to display the device's effectiveness in decreasing TDS after filtration data collection. The engineering goal of the device was to decrease TDS between before and after filtration data by at least 25%.

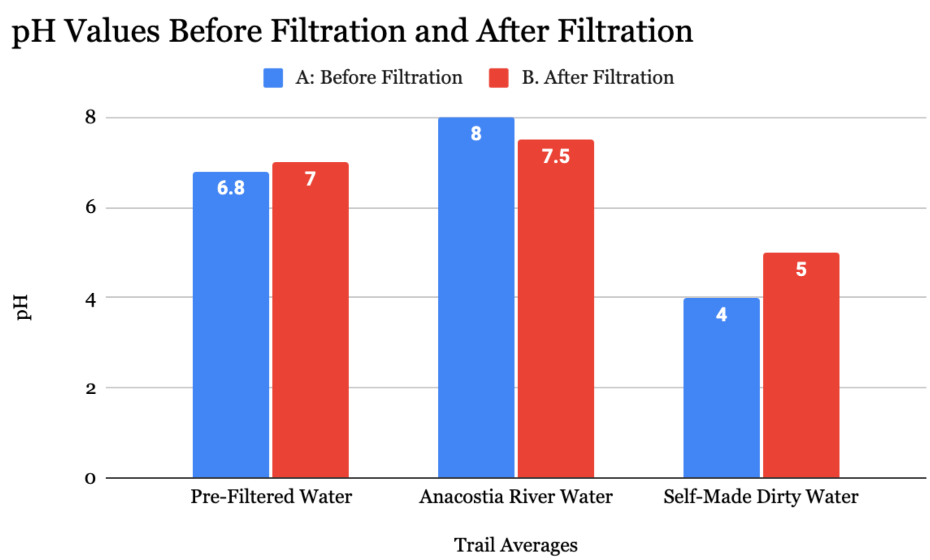


Figure 3: Data from **Table 7** in a visual representation. The representation is meant to display the device's effectiveness in pH as the engineering goal of the device was to have after filtration data to be in the 6.5-8.5 range.

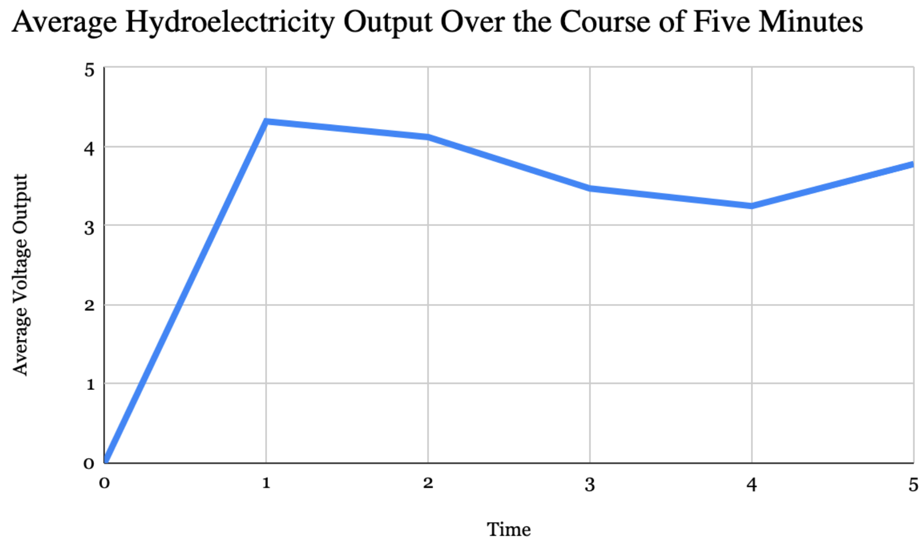


Figure 4: Data from **Table 4** in a visual representation. The representation is meant to display the average hydroelectric production in voltages. 15V-20V were not produced, not satisfying the outlines engineering goal.

Summary

The device being tested is meant to both alleviate the environmental and socio-economic struggles low-income communities endure. The target environment is meant to be the Anacostia River and surrounding areas. Data collection had all occurred in the residential area of Adelphi, Maryland. Factors being tested include TDS (ppm), EC (μS/cm), pH. Devices used in this phase of testing which focuses on the filtration aspect of the device were: DS Meter Digital Water Tester 3in1 and pH Stripes. The next phase of testing will include the measurements of produced electricity from the water wheel using a digital multimeter in amps. Data displayed are all averages of 30 trails–10 trails per water sample. Tables in the data section are all average data collections of the three water testing factors (EC, TDS, pH) before and after going through the device. Each singular table is dedicated to one of the tested water samples– Pre filtered water, self-made contaminated water, Anacostia River water. Tables in the data analysis section were used to create the three figures/graphs. Figures are displayed in before and after comparison bar graphs. Both figures and tables in the data analysis section pertain to a singular water testing factor and display the data collection of that tested factor amongst the three samples before and after going through the device. Data collection showed little difference in EC data between before and after with an average decrease of 18% ppm. TDS showed the most significant difference in data before and after with a decrease of 8% µS/cm. pH data was all in the ideal range(6.5-8.5) except in the self-made contaminated water sample (4-5) which was too acidic to be deemed safe. Hydroelectricity production was 3.7V on average. Most data did not satisfy the engineering goals but each category had some type of improvement showing potential in the device.

Terms and Abbreviations

1. Avg: Average
2. Amps: Unit of measurement for electronic currents
3. EC: Electrical Conductivity (water)
4. Ppm: Parts per Million
5. TDS: Total Dissolved Solids
6. µS/cm: Microsiemens per Centimeter
7. V: Voltage

Chapter Five

Conclusions

Summary

The primary goal throughout this research project is to design and test a proposed device that would efficiently cleanse water and produce a substantial amount of electricity. While environmental clean-up efforts are meant to be beneficial they can displace low-income communities as property value and cost of living rise. Due to this displacement caused by environmental gentrification low-income communities are trapped in a cycle, forced to remain in polluted areas for financial stability. The proposed device hypothetically would provide some financial relief through the production of hydroelectricity and would cleanse water as well. The main components of the device were the wooden water wheel, turbine, and mesh filter. The engineering goals were to decrease the TDS by ~25% or more, decrease EC by at least ~15%, produce water in the pH levels of 6.5-8.5, and produce a substantial amount of electricity (15-20V minimum). In order to test the device, 30 trials were run, with 10 trials per water sample. The tested factors were TDS, EC, pH, and dc voltage. Data were collected prior to the device running to after to create compression charts and graphs.

Conclusion and Discussion

The two primary goals of this device are to both filter water and produce electricity. The water filtration portion of the device shows potential with a majority of trials showing small improvements in each tested factor–TDS, EC, pH. Although improvements were not large, the device shows a lot of potentials. EC showed the least significant change between the before and after phases. EC is typically monitored for longer periods of time so the lack of change in results makes sense as testing occurred immediately after a trial finished. EC overall showed a decrease of 8% on average, not satisfying the outlined engineering goal. TDS shows the most significant changes. The combination of the mesh filter and the water wheel collecting trash during rotation had shown large removal of visible trash. However, the device was less efficient when dealing with smaller scaled contaminants. Overall TDS on average decreased about 18%, not satisfying the 25% goal but shows potential and room for innovations. Most pH data from the trails were in an ideal range (6.5-8) except for Self-Made Dirty Water before and after. Despite not being in ideal ranges there was an improvement in Self-Made Contaminated Water before and after from pH 4 to pH 5. In this first phase of testing the model shows potential as all three water factors showed improvements from before and after filtration. Phase two of testing included the addition of the turbine and bailey to test hydroelectricity efficiency. The average voltage production was 3.72V which did not satisfy the outlined 15V-20V goal. The unsuccessful accomplishment of the hydroelectricity portion could be due to the issues with the water wheel's axis. Although no factors satisfied the outlined engineering goals the indication of improvement in the tested factors is important to recognize. The data indicated that there is potential for further study into this type of device.

Recommendations

Since the device's results did not accomplish the engineering reflections and modifications to design are necessary. The addition of a turbine to the device will change the data results and allow for the electrical production of the device to be tested. As phase two of testing commences there should be an improvement in water quality factors as the turbine would result in more efficient rotations of the water wheel. Other possible modifications to this device include the closing of large gaps within the mesh filter, looser water wheel axis, plastic attached container to collect trash, etc. Data from future testing should show greater improvement in the three water factors as well as the production of hydroelectricity. The testing method for EC would also change to gather more efficient data. With these changes, it is hoped that in the future the device would both efficiently cleanse water and provide a significant amount of electricity in order to benefit low-income communities.

Future Implications

This research highlights a commonly ignored issue within the sustainable and environmental fields. While important efficient methods towards combating environmental issues are crucial so is recognizing the effects such methods have on surrounding communities. There is a large difference between the environments of different social classes and the fear of environmental gentrification is imbibed into the lower class more than anyone. This current device does have its strong points faults. Value can be found in the successes and failures of research. There are numerous different methods that could be used to approach the environmental and social issues of pollution. Further research on this device could be extremely valuable in terms of providing a strong solution for low-income communities. It provides valuable data on the effects water wheels have in the filtration aspect and if utilized correctly holds immense potential. Highlighting and working on the issue of pollution and environmental generation could allow others to recognize the societal issues with environmental clean-up efforts leading to other innovations towards the issue.

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This website provides recent information about the state of the Anacostia River. It provides improvements over the years, downfalls, graphs, and data water cleanse factors like TDS and pH

Pepco An Exelon Company. (2018). *Maryland Environmental Fuel Source Information. pepco.com.* https://www.pepco.com/MyAccount/MyBillUsage/Documents/Pepco%20MD%20Fuel%20Mix%20Insert_10.18_ADAcomp.pdf

The website offers information on the fuel usage of the Maryland electric company, Pepco. This will aid in identifying the usages of renewable energy currently and how the devices could aid in a rise in renewable energy.