Hydroponics: River Redefined

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Abstract

In 2018, it was estimated that 821 million people in the world were undernourished and according to the UN, only one in every three people has access to safe drinking water. This is a major issue and it can be attributed mainly to poor agricultural practices. 92 percent of the World's freshwater is used for farming food and raising livestock and it is estimated that around 50 percent of that water is wasted due to evaporation and runoff caused by overwatering. This poses a question; How can we improve agricultural practices? This is a loaded question because there are so many different possibilities, but what if we could grow food and filter water at the same time? My problem statement is as follows; Due to poor agricultural practices many people are suffering from food and water scarcity. I think a solution to this problem lies in hydroponics and natural water purifiers. During the course of this project, I created and developed a system that grows plants and filters river water all in one 6-gallon. Different methods of filtering water were tested during growth cycles each amounting to seven days. At the beginning and end of each cycle, the water quality of river water was measured as well as measurements of each plant's height. From trial and error, a system that efficiently filters river water while growing a sustainable food source was created. This project has the potential to help families who face food insecurity and countries with poor agriculture practices.

Hydroponics: River Redefined

Hydroponics is a method of growing plants without any soil, while plants sits in a bedding or growth media, the roots grow down into water mixed with a nutrient solution. Hydroponics systems are very easy to control and manipulate because there are so many types of systems. Not only are hydroponics systems versatile, they can also be placed virtually anywhere as long as the plants are receiving sunlight. Food scarcity is a major problem in our World, while some people can throw out leftovers, others hardly have enough food for the table, this is because of poor farming practices. Today's agricultural practices are wasteful and inefficient, 92 percent of the World's freshwater is used for farming food and raising livestock and it is estimated that around 50 percent of that water is wasted due to evaporation and runoff caused by overwatering. Our drinking water is wasted while about 1 in every three people don't even have clean drinking water. For my project, I hope to create a hydroponics system that grows food and filters water naturally with plants and rocks.

Background

Hydroponics is a way to grow plants without using a lot of space or any soil. The plant's roots in a hydroponic system are submerged in nutrient rich water, while the rest of the plant is exposed to air. Usually a system will consist of a reservoir, nutrient pump, timer, air pump and stone, and a grow bed. The most common type of plants grown in a hydroponics system are leafy plants such as lettuce or spinach. While humans push forward into the world, cut down forests and construct new buildings, land suitable for growing plants is diminishing. Hydroponics is the next way to grow food without using land, also you can place a hydroponics system anywhere. There are many advantages to hydroponics, here they are. 1. You can grow anywhere, 2. Uses 20 times less water than soil-based gardening. 3. Your environment is sterile, which means no pesticides, 4.you'll use 20% less space for growing. 5. The system water can be reused, allowing you to conserve water, 6. Harvesting is easier, and 7.you can grow year-round if indoors. Even though there are many advantages to a hydroponics system, there are also disadvantages. 1. Putting together a hydroponic system isn't cheap, 2. Constant monitoring is required, 3. Hydroponic systems are vulnerable to power outages, 4. In the event of a power outage that outlasts your generators you will be manually watering your garden, 5. Micro-organisms that are water-based can creep in rather easily, 6. Growing a hydroponic garden demands technical expertise, 7. Production is limited compared to field conditions, 8. If a disease appears, all plants in the system will be affected, 9. Without soil to serve as a buffer if the system fails plant death will occur rapidly. When growing plants in a hydroponic systems bedding is key to how the plants thrive. Bedding holds the plants up and allows the roots to grow in the water. Some growth mediums include Rockwool, grow rock, coco fiber, perlite, vermiculite, oasis cubes, and floral foam, and grow stone, river rock, pine shavings, and composted materials. Nutrient pumps pump a chemical solution into the water that helps the plant grow. The chemicals in the solution are usually used to clean out the tank or to give the plant nitrate. Nitrate is usually found in soil or droppings from animals.

Types of Hydroponics Systems

1. Deepwater Culture (DWC), also known as the reservoir method, is by far the easiest method for growing plants with hydroponics. In a Deepwater Culture hydroponic system, the roots are suspended in a nutrient solution. An aquarium air pump oxygenates the nutrient solution, this keeps the roots of the plants from drowning. Remember to prevent light from penetrating your system, as this can cause algae to grow.

2. Nutrient Film Technique, or NFT, is a type of hydroponic system where a flow of nutrient solution runs over the plants roots. This type of system is on a slight tilt so that the nutrient solution will flow with the force of gravity.

3. Wicking is one of the easiest and lowest costing methods of hydroponics. When using the wicking method, a material, such as cotton, that is surrounded bedding with one end of the wick material placed in the nutrient solution. The solution is then sucked up to the roots of the plant.

4. An ebb & flow hydroponics system, also known as a flood and drain system, is a great system for growing plants with hydroponics. This type of system functions by flooding the growing area with the nutrient solution at specific intervals. The nutrient solution then slowly drains back into the reservoir

5. A hydroponic drip system is rather simple. A drip system works by providing a slow feed of nutrient solution to the hydroponics medium, this waters the plants.

-Recycled Growth Media

Two years ago, for my experiment I created a recycled growth media that yielded more plants than two other store-bought medias. This new media was created with used paper towels, paper, pencil shavings, cardboard, and tissues. This media will be used in this year's experiment.

-Filtering Water Naturally with Rocks and Mint

Impurities can almost be strained from water by using rocks and sand. By creating layers of rocks, pebbles, coarse sand, and fine sand, water can pass through this "filter" and impurities can be removed. The oils in mint can remove impurities, bacteria, and algae from water.

Materials and Methods

The materials for this project are as follows: 6-gallon translucent or semi-translucent drink pitcher, river rocks, aquarium gravel (without paint or dyes), medium grain sand, fine grain sand, soybean seeds, peppermint seeds, food-grade peppermint oil, two embroidery hoops a half inch less in circumference than the circumference of the drink pitcher, paper towels, window screening, drinking water test strips, wooden dowels, two-part epoxy, and river water.

To begin creating the filter and growth system, you must prep the drink pitcher. First, wash out the pitcher. Then, measure the diameter and height of the pitcher. Divide the pitcher into three parts by marking lines on the inside of the pitcher at 1/3 and 2/3 of the pitcher's height. (So, if the pitcher was 27 inches tall, marks would be made at 9 and 18 inches from the base of the pitcher.) Using the pitcher's diameter, mark and cut the wooden dowels to match. Using a two-part epoxy, secure the first dowel horizontally at the first mark previously created then at the second. Next, cut four two-inch pieces from a wooden dowel. Secure those pieces of wood opposite from the larger dowels you previously fastened to the pitcher. *(refer to figure 1.)* Last, add nine drops of peppermint extract to the bottom of the pitcher.

Now that the pitcher is prepped, it is time to create the plant bed and filter. Stretch the window screening across each embroidery hoop and tighten the hoops until the screening is taught. Place the first screen into the pitcher laying it atop the first set of wooden dowels. Place a thin layer of paper towels over this screen. Then place 10 soybeans onto the paper towel along with mint seeds. *(refer to figure 2.)* Next, place the second embroidery hoop onto the second set of dowels. *(refer to figure 3.)* Line that same embroidery hoop with another thin layer of paper towels. Last, layer river rocks, aquarium rocks, medium-grain sand, and fine-grain sand onto the embroidery hoop in that order. *(refer to figure 4.)* Your system is ready for experimentation.

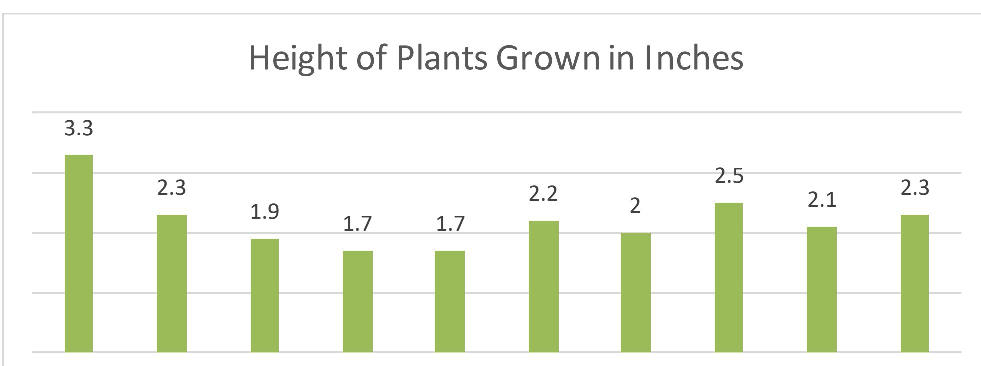
For the first trail, collect three liters of river water (I used water from the Little Miami River) and use a water test strip to measure the quality of the water. Jot down your measurements. For two weeks, pour water into the pitcher as if you are watering plants. After two weeks, test the quality of the water again. Empty and rinse out the pitcher. Make sure to measure the heights each soybean grew and jot them down. Reassemble the system with new paper towels but reuse the rocks and sand.

The second trial consists of two parts. First, boil three litters of river water and measure the quality of that water with water test strips. Then, repeat all the steps in the first trial but save 1 litter of the water you've filtered. Add three drops of peppermint oil to the water and measure the quality after two days. Last, add three more drops to the water and measure again after two days.

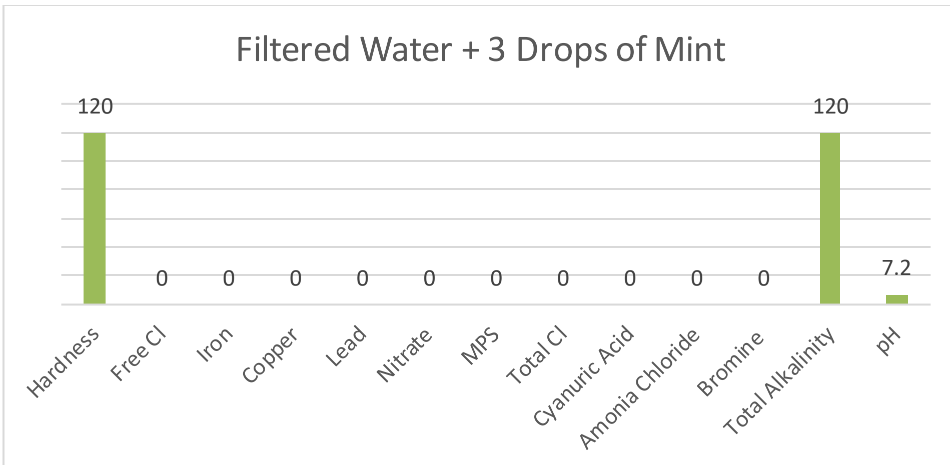
For this experiment to yield optimal results, I recommend you place the filter and growth system underneath or near a window with direct sunlight.

Results

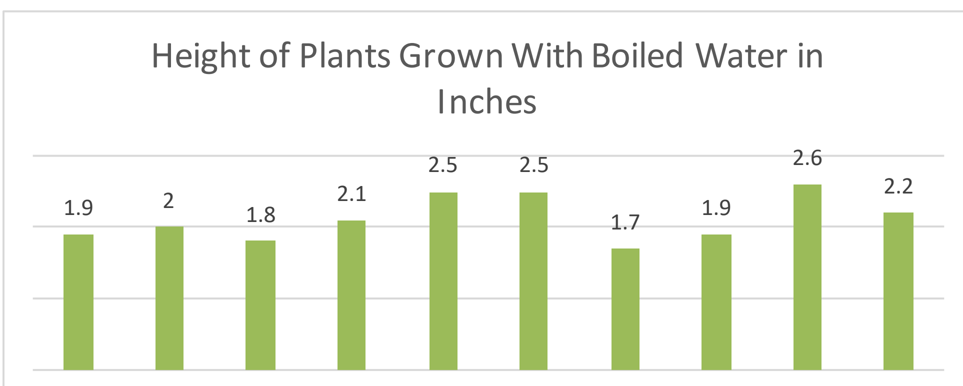
After the first round of testing, which lasted two weeks, the average height of the soybeans grown was 2.2 inches. 100% of the soybeans sprouted however, 0% of the mint planted grew.



In regard to the water quality, the total hardness was 0, total alkalinity was 120, and the pH was measured at 8.2. All the measurements above fall into the recommended range of drinking water. The chart below shows zero, chlorine, iron, copper, lead, nitrate MPS, cyanuric acid, ammonia chloride, or bromine. During this trial the water filtered was taken directly from a river and turned into safe drinking water while growing healthy plants, so I consider this trial a success.

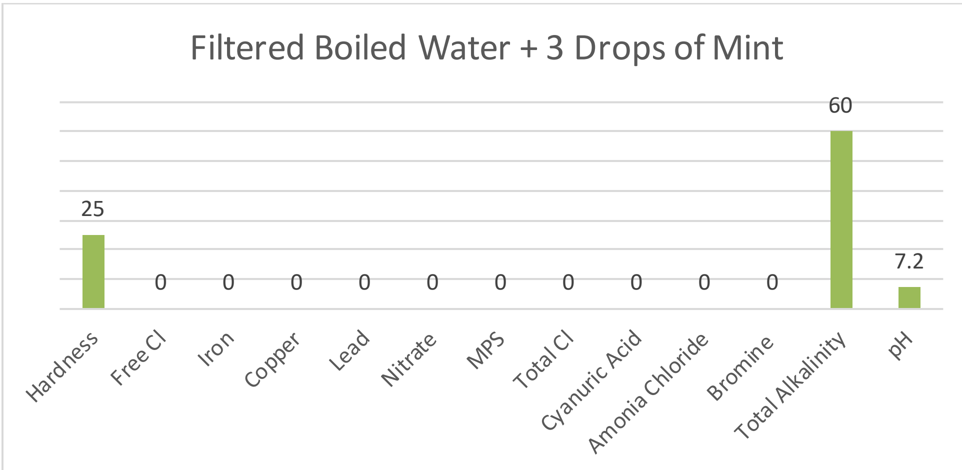


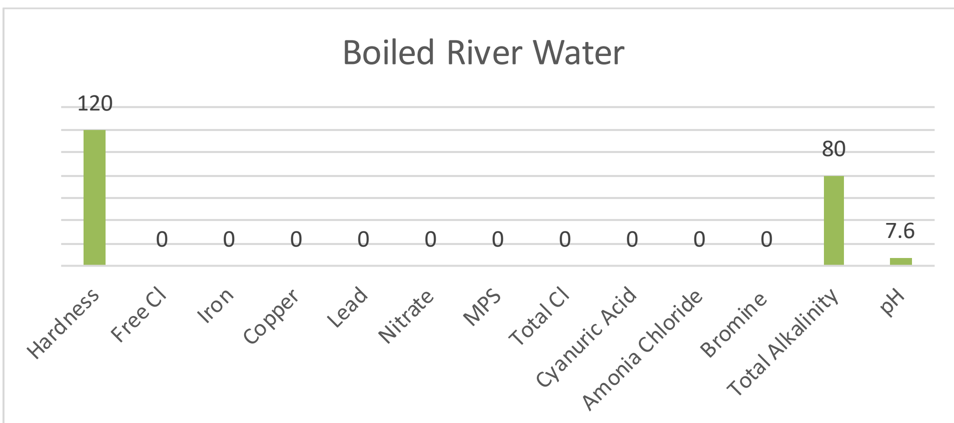
The second trial consists of three parts: running boiled water through the system with three drops of peppermint oil, six drops, and then nine. Because the plants are not exposed to the



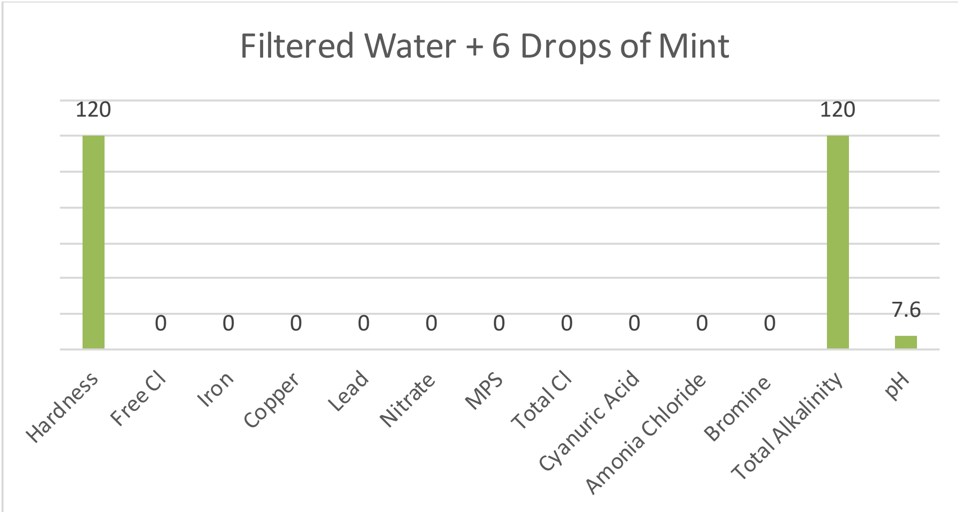
peppermint oil, there is only one set of plant measurements. The average height of the soybeans in this trail is 2.12 inches which is only slightly shorter than the previous trial.

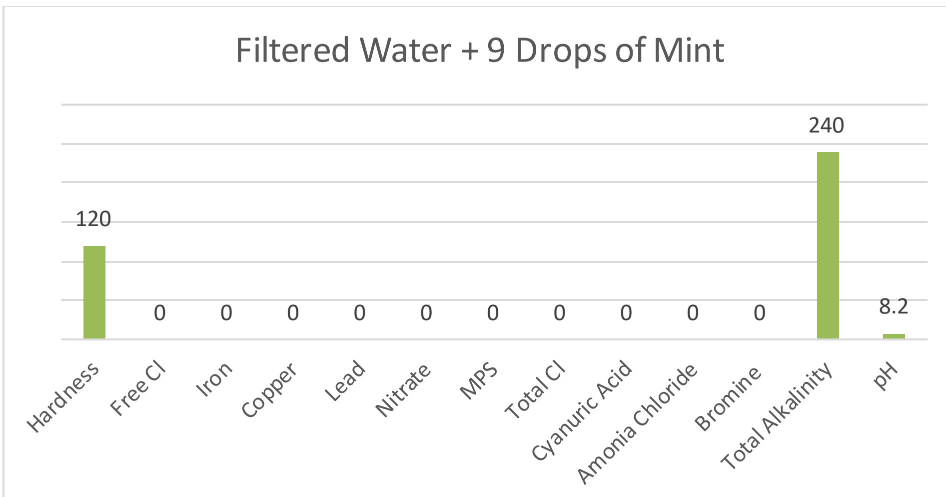
The filtered water from this trail is also safe to drink; the total hardness measured 25, the total alkalinity was 60, and the pH was 7.2. These results are better than the previous trial because the pH is more stable: not too high, not too low. In regards to alkalinity, both measurements from trial 1 and 2 fall into a safe range. As you can see, chlorine, iron, copper, lead, nitrate, MPS, cyanuric acid, ammonia chloride, and bromine, all measure at 0. Compared to the water quality of boiled river water before filtration, hardness, pH and total alkalinity all lowered.





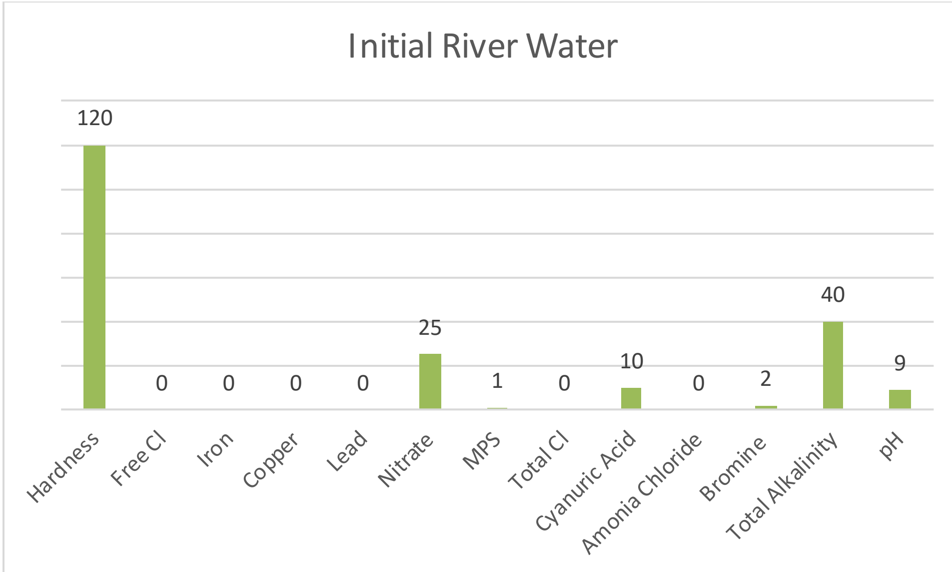
The water measurements of the second and third part of the second trial are show below.





As you can see above, the results of both trials are fairly similar, they both share the same hardness. However, when the amount of peppermint oil in the water increased, so did the pH and total alkalinity. In the trial with 6 drops of mint oil per litter, the pH measured at 7.6. In the last trial with 9 drops of peppermint oil per liter, the pH was 8.6. The total alkalinity also increased from 120 to 240 between the two trials. In both these trials the drinking water is safe to drink.

Overall, I would consider the whole experiment and all its parts a success. Compared to the original measurements of the water I tested there was a significant improvement in water quality. Below are the original measurements from the unfiltered river water.



As expected, there was no chlorine, iron, copper, or lead in the river water. However, there was nitrate, cyanuric acid and bromine found in the water, all of which make it unsafe to drink. Nitrate comes from human and animal waste so consuming any nitrates could cause illness. Cyanuric acid is often found in drinking water however, too much can be dangerous. Lastly, bromine is sometimes added to rivers and lakes by environmental proception agencies, but nor public water supplies. Bromine can cause vomiting and gastrointestinal sickness when consumed by humans. On the note of plant growth, I am somewhat disappointed but not surprised. The average height of the sprouts after 7 days was 2.16 inches.

Discussion and Conclusions

At the end of this experiment, I concluded that it is very well possible to create a system that filters water and grows plants hydroponically. Compared to the result of my experiment last year, the plants grew an average of 2.44 inches shorter than plants grown in a traditional hydroponic system. This could be for several reasons: the plants were grown without any nutrient solution, the plants were grown in a drip system rather than a deep-water culture system, and lastly, because the plants were with river water. Usually, plants grown in a hydroponics system are watered with a diluted nitrate bases nutrient solution. Because nitrate is not safe for human consumption and the same water used to water the bean sprouts was filtered, I chose not to include a nutrient solution in this experiment. In the previous two years of my experimentation, I have grown plants in a deep-water culture system, meaning the roots of the plants are suspended into water. However, this year I experimented with a drip system so, water would filter through the rock and sand trap I made then reach the plants. I believe that because the roots of the plants were not suspended in water or grown with a nutrient solution, the average height of the plants was shorter than the previous year. Lastly, in previous years I have grown plants with filtered water rather than river water, this may have also affected plant growth.

Between the first two trials, the average difference in plant height was only .08 inches. The plants grown with river water that had not been boiled beforehand grew an average of 2.2 inches, while the plants grown with boiled river water grew an average of 2.12 inches. While this height difference is small, I still believe it is notable. The initial river water collected included trace amounts of nitrate; the same substance found in many hydroponics fertilizers. My hypothesis is that when the river water was boiled, the nitrate levels in the water dropped. So, plants grown with the safer water also experienced lack of nutrients compared to the first trial.

In both the first and second trial, nine drops of peppermint oil were added to the water, or, three drops per litter. While the filtered water from both trails were safe to drink, the hardness and total alkalinity measurements from the second trial using boiled water, were both lower than the measurements in the first trial. So, I decided to continue testing with this water. As peppermint oil was added to the water, the pH and total alkalinity levels rose while the hardness remained constant. So, three drops of peppermint oil per liter produced the best results of water quality. Again, all the water was safe to drink however, the measurements of pH and total alkalinity rose to the extreme end of safe water drinking range. Because the measurements of water from the trial with boiled water and three drops of peppermint oil fell in the middle range of safe water, it's the most safe.

During all the trials, not a single mint seed sprouted. I had hoped that the mint plants would grow so the system could be self-sustaining however, that was not the case. I researched this problem further only to find that mint grows best in deep water culture systems.

If I was to repeat this experiment I would change several things; I would use metal dowels and embroidery hoops rather than wooden ones, I would test the water quality after growing plants with nitrate solution mixed in the water, I would fasten the dowels to the inside of the tank more securely, and lastly I would use a different growth media. During the project I noticed my wooden materials were beginning to rot. To combat this problem, I could exchange all the wooden dowels and embroidery hoops for ones made of metal. Secondly, I would test the water quality and plant growth using a nitrate solution. If the peppermint extract removed the nitrate from the river water, it may be able to remove the nitrate added to the water by the solution. Another engineering flaw I noticed, is that the dowels I fastened to the inside of the tank began to come loose. A solution to this issue could be to drill into the tank and dowels to fasten them in the system more securely. Lastly, I would use a different growth media to grow the soybeans and mint, so the mint would have better growth.

Overall, I consider this project a success because even though the mint plants did not grow, I filtered river water while growing a viable food source. In my opinion, this is a major feat because it all occurred in a 6-gallon water pitcher. The system I created is portable and versatile. The system could be placed virtually anywhere, the only restraint would be climate. If the surrounding areas are too cold the plants would not sprout, and the water would freeze. If the climate was too hot, the plants could dry out. This system could also be modified to feed a large amount of people as long as the materials used are strong. I am very hopeful this experiment could help families who face food insecurity, or countries that don't have efficient agricultural practices.

Acknowledgment

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Figures

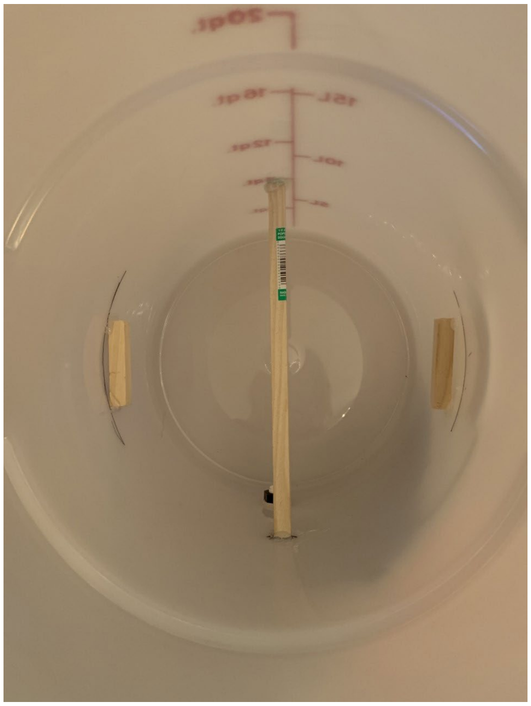

Figure 1.

Figure 2.

Figure 3.

Figure 4.