Sustainable Water Options for Houseplants

Background

Issues of environmental sustainability have become a major focus for me, and I often think of how I could live as sustainably as possible. I recently questioned if I could water my houseplants more sustainably. I have always watered plants with city/tap water and the plants grow well, so tap water seems like a fine choice. Yet upon closer examination, I discovered that the process of filtering and recycling tap water is a huge consumer of energy, and is not environmentally healthy nor helpful. In 2017, the United States emitted a total of 6.5 billion tons of greenhouse gases, with the use of electric power contributing 28% (Center for Climate and Energy Solutions). Water and wastewater treatment plants' utilization of pumps, motors, and other equipment account for about 3–4% of electric energy use, leading to their emitting more than 45 million tons of greenhouse gases every year (U.S. Environmental Protection Agency, 1). Another matter concerning tap water is that of safety. The tap water in my city contains small traces of the harmful chemicals cyanide, arsenic, lead, chlorine, fluoride, radium, sulfate, and the bacteria Escherichia coli (E. coli) (Birmingham Water Works Board).

Learning more about my tap water led me to my initial question of: What are safer and more sustainable water options? Rainwater is the safest and most sustainable alternate option. Rainwater is a mixed electrolyte that is composed of ions and nitrogenous compounds that are not harmful to humans nor plants (Carroll, 2). Using rainwater as one's primary source of water is possible for some people, but not all. For areas where drought is an issue, there must be yet another alternate option, and this could be greywater and dark greywater. Greywater is defined as "wastewater without any contributions from toilet water," this includes wastewater from sinks, dishwashers, bathtubs, and showers (Oteng-Peprah). Some sources classify kitchen sink wastewater as greywater too, but others classify it as dark greywater due to the greater variety of substances that are washed down kitchen sinks. This paper will designate between the two, referring to kitchen wastewater as "dark greywater". Greywater and dark greywater are sustainable water options because they reuse water, thus keeping that water from going to a wastewater treatment plant. However, greywater and dark greywater are not safe for humans to drink unless they have gone through a complicated filtration process. But what about for plants? This led me to my research question: *To what extent do rainwater, greywater, and dark greywater affect the growth Brassica rapa (Wisconsin Fast Plants), as measured with biomass, compared to tap water?* The independent variable is the type of water used; the dependent variable is the biomasses of the plants; and the control variables are the time the plants were given to grow and their growing location. I hypothesize that plants grown with tap water and rainwater will have more flowers and greater biomasses than plants grown with greywater and dark greywater. I have successfully grown plants with tap water, and rainwater is the original water source for plants, so I believe those plants will be healthier. On the other hand, I suspect that plants grown with greywater and dark greywater will have lower biomasses and less flowers because of the uncertainty of their safeness. I suspect this because of the potential harmful components of both of these water samples. For example, the dark greywater sample could include salt and/or vinegar, which are both harmful to a plant's growth.

Procedure

I collected unfiltered tap water from my kitchen sink. I collected rainwater using a rain barrel. To avoid doing complicated and possibly incorrect plumbing work, I created replications of greywater and dark greywater. To create the greywater, I combined what is regularly washed down my bathroom sink in a day. To do this, I brushed my teeth three times over a bucket, let all the water I used fall into the bucket, washed my hands three times over the bucket, and squirted about 0.5 fluid oz. of contact solution into the bucket. To replicate dark greywater, I washed my family's dirty dishes over a bucket to collect what is regularly washed down the kitchen sink: dish soap, unfiltered tap water, and food particles. The food particles I was able to identify that entered my dark greywater were flour, butter, and tomato soup. I used a mesh strainer to remove any chunks of food. I had 32 ounces of each type of water.

I grew 20 Wisconsin Fast Plants seeds. To sprout them, I prepared four bowls with a paper towel soaked with one type of water: one with tap water, one with rainwater, one with greywater, and one with dark greywater. Then, I placed five seeds in each, and left them on my kitchen counter for 27 hours. After 27 hours, 17 of the 20 seeds had germinated (two of dark greywater and one of greywater did not). Next I prepared four pots of vermiculite. I labelled the containers with the type of water the seeds within them were grown with. Then, I planted the five seeds into their corresponding pots outside in direct sun. Concerning the three seeds that did not sprout, I replaced them with other seeds in their respective germination bowls because I wanted five seeds for each sample. I watered the seeds with 10 oz. of their water. I watered the plants with 5 oz. of water every 4 days, since this is how long it took for the vermiculite to dry out. I observed their growth and took notes on appearance and speed of growth. On the 30th day of their growth, two of the plants formed flowers, and I removed all the plants from their pots and weighed each of them using a mass scale. I recorded their weights and then laid them on top of the vermiculite in their pots. I repeated this process for 6 more consecutive days until the weights did not change the last two days (days 35 and 36). There are no ethical concerns within this experiment. As for safety concerns, the subjects of my experiment were not at risk, but the greywater and dark greywater may have been unsafe for me to touch.

Results

Table 1: Raw Data of Dry Biomasses (in grams)

	Mass (g)	Mass (mg)	Mass (g)	Mass (g)	Mass (g)
Tap water	0.03	0.01	0.02	N/A	N/A
Rainwater	0.05	0.02	0.01	0.02	N/A
Greywater	0.01	0.01	0.01	0.02	0.01
Dark greywater	0.01	N/A	N/A	N/A	N/A

Each "N/A" in Table 1 stands for the plants that died.

I calculated the average dry biomass for each group, and the following is a sample from the greywater group:

$$(0.01 + 0.01 + 0.01 + 0.02 + 0.01)/5 = 0.012 \text{ g average}$$

Figure 1: Average Dry Biomasses for Each Group (mg)

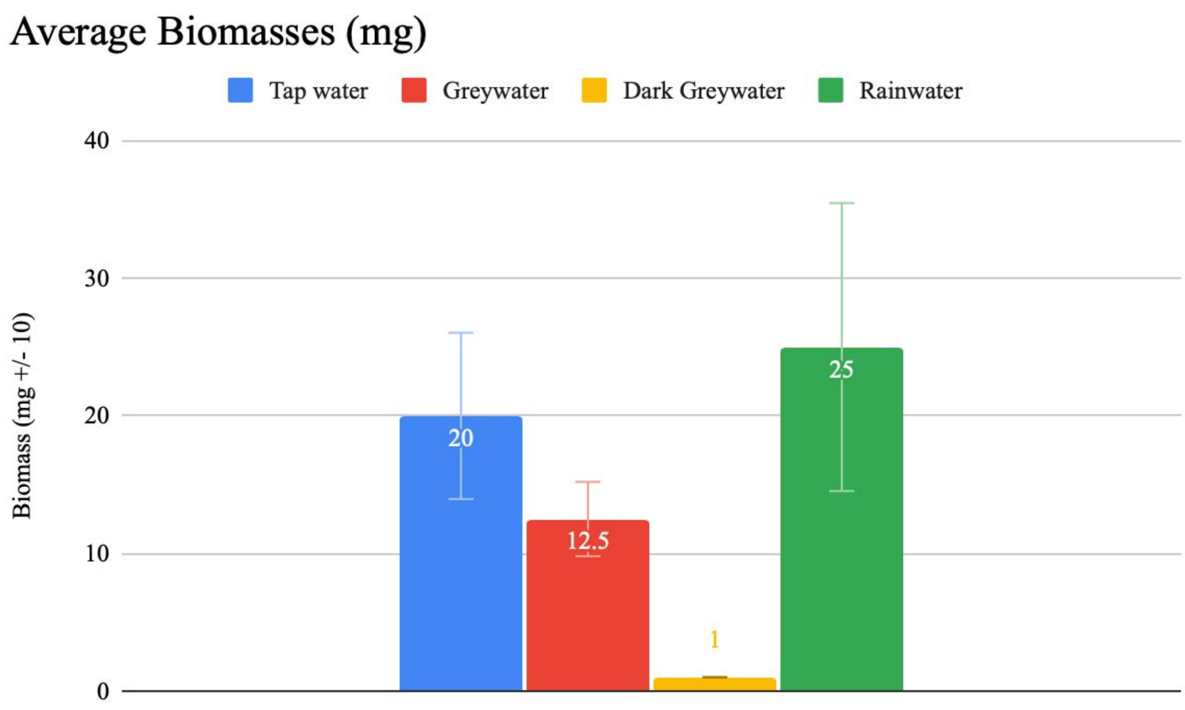

Figure 1 presents the calculated average dry biomasses for the plants of each water type on the final day they were weighed. I converted the values from grams to milligrams in order for the error bars to present clearer. Error bars represent calculated 95% confidence intervals.

I conducted an ANOVA test because I needed to test for a significant difference between the means of four different groups. For the test, my null hypothesis is that there is no significant difference between the average dry biomasses of each group of plants. My alternate hypothesis is that there is a significant difference between the average dry biomasses of each group. It is important to note that for my statistical test and analysis, I had to remove the one value from dark greywater because it was a sample size of only one, and therefore a true average value could not be established, and it can not contribute to the ANOVA test.

Through the results of the test, I found that F (1.47) is less than F critical value (4.26), which means I accept the null hypothesis, meaning that there is no significant difference between the average biomasses of each group of plants that were watered with different types of water.

Conclusion

The results of the ANOVA test suggest that the overall growth of the Wisconsin Fast Plant is not dependent on the type of water used, since there was no significant difference between the average dry biomasses of tap water, rainwater, and greywater. The exception to this, of course, is dark greywater, since four of the five plants watered with this water sample died. The results of the ANOVA test are supported by Figure 1, which shows greywater's error bar overlapping with those of tap water and rainwater, suggesting that there is little variance among the three groups.

Both tap water and rainwater flowered on day 30 of their growth, but neither greywater nor dark greywater did. However, it is crucial for me to note that on day 30 when I removed all the plants to weigh them, three of greywater's five plants were budding, and the one dark greywater plant was too. I believe that if they had been given about 3 more days to grow, then they would have also flowered. It is also important to note the similarities in the data. On the final day they were weighed, all four groups of plants had at least one weight of 0.01g, and three of the four had at least one weight of 0.02g (see Table 1). This suggests that all four groups of plants had similar levels of growth and health. However, since dark greywater had the lowest average biomass and four of its five plants died, it could be inferred that this watering source was the least healthy for plants, yet this will be discussed further in the next section.

Evaluation of Investigation

I identified a couple sources of error within my experiment. The recommended growing temperature for these plants is 65˚F to 78˚F, so I grew them outside with temperatures ranging from 60˚F to 80˚F. About two weeks into their growth, the temperature at night dropped to around 50˚F. After that, I brought them into my house and their growth continued and ended inside. Secondly, three weeks into the experiment all the plants should have been flowering, yet they were small and not even budding. Because of this, I decided to introduce a grow light with two bulbs being 10 watt, 600 lumen bulbs. The extra light and warmer temperatures inside both seemed to increase the speed of their growth, because two of the plants bloomed only a week later. For this experiment, I aimed to have the plants' growth setting remain constant and be a control variable. Their setting did change, which may have likely stunted their growth, yet it was still a control variable in that all the plants received the same conditions. For repeating this experiment, I would make sure to keep the growth conditions constant by growing them in the same location with the same light source(s) for the duration of the experiment. A limitation I experienced in this experiment was with my mass scale; if I repeated this experiment I would use a scale that could provide more precise measurements.

An important factor to consider for this experiment is the possibility for dark greywater and greywater to be more or less successful (for producing healthy plants) watering options depending on their contents. For example, the plants grown with dark greywater in this study may have produced more plants with greater biomassses if the dark greywater sample used had not had tomato soup in it, which may have been too acidic for the plants. Additionally, the greywater plants may have been more or less productive without contact solution in the sample. To extend this study, I would grow one type of plant with samples of different variations of dark greywater and greywater. For example, I would collect dark greywater samples from my kitchen sink on different days so that one may have bits of green beans in it while another may have bits of coffee grounds in it. It is not realistic to expect one person's dark greywater and greywater samples to remain exactly the same over time, so if through further experiments multiple dark greywater and greywater samples could be shown to be successful for growing plants, it could be established that they are indeed sustainable and effective switches to make for watering houseplants.

Works Cited

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