The effects of precipitation, potable water, and greywater on *petunia nana compacta*

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Abstract

This study focuses on the effects of potable water, rainwater, and greywater on dwarf petunia seeds and the effect of these sources by measuring germination, height of stems, and sprouted leaves with prior information helping to understand how the pHs and salinity of water can affect saplings. In this experiment, there was the challenge of obtaining rainwater in Arizona. There was also the requirement of an indoor space with ample sunlight and containers to separate the seeds to ensure that every group was treated the same way with the same optimal temperatures. This question has been touched on with bacteria samples in stem roots and the testing of pHs in water to see how those affect the growth of plants, the experiment capitalizes on Arizona's hard tap water, rare precipitation, and greywater from a household washing machine. This experiment has given more in-depth results of the properties of greywater and its large benefits of use in the growth of dwarf petunia seeds, demonstrating an average of 0.696 centimeters of growth and 8 total germinated seeds, significantly more than potable water and rainwater results. There was one trial to the experiment that lasted four weeks, while spending months researching how the different metals and bacteria in water can affect how the plant grows and changes on a cellular level, causing it to be more responsive in germination and overall growth. This research is promoting sustainable water reusage, especially in states like Arizona and Wyoming where water is on a shortage and can instead be reused for more efficient methods.

Question and Variables

The driving question observed in this study is: How does the source of water affect the growth of petunias?

The independent variable that was tested in this study was the source of water. This includes Tap (potable) water, rainwater, or grey water. The dependent variable being addressed was plant

growth. Growth was measured in terms of vertical growth by centimeters and number of leaves visible on the plant. Rainwater was hypothesized to produce the most sprouts, leaves and overall average growth out of the three test groups.

Background Research

Planet Earth is in a scenario of rapidly declining access to natural resources, significantly, water. Fresh water makes up approximately 3 % of global water supply, and less than 0.5% is currently available for human consumption. This makes sustainable methods of reuse necessary to preserve our precious planet. This is an issue that has already been undertaken by many researchers, experts, and scientists that we will be studying in our SARSEF project for this year. In the past, the researchers investigating this topic used various methods to gather information about this topic. The first source conducted an experiment using a model made to collect rainwater from an urban environment. The article titled "A Framework for Creating Sustainable Rainwater Harvesting and Reuse Strategies for Urban Landscape Irrigation in a Changing Climate", the authors discussed their research on the rainwater collection system. They gathered data specific to the climate of Austin, Texas, and used those findings to create a system tailored to the temperature and rainfall of the area. They found that basins and other collection and filtration methods used in the model were highly efficient. Another study, "Circular Economy of Water: Rainwater Harvesting (RWH) and Reuse Solutions" found similar results to the increase in water quality. In this specific experiment, they found that rainwater that had gone through the designed filtration devices had better quality than household tap water using parameters of salinity, turbidity, pH, and oxidation reduction to determine purity of water.

The previous two mentioned studies examined rainwater specifically, with the next project titled: "The Impact of Plant Growth-Promoting Bacteria on the Functional and Thermodynamic Traits of *Aptenia Cordifolia* and *Carpobrotus Edulis* under Recycled Water Irrigation in External Green Wall Conditions" which took to testing reused water and its effect on plant growth. While this study included research with bacteria, we are not including bacteria in our study. However, it still presented valuable results, with the people conducting the experiment finding that using wastewater, or reused water, aided plant growth significantly under the parameters of plant biomass, root mass, number of flowers, and other variables to determine the growth of the specimen. Interestingly, these results also yielded that using wastewater increased the tested plant's ability to utilize water more efficiently. The next project, titled: "Water Quality Characteristics of Municipal Wastewater Treatment Plants and the Prospect of Reclaimed Water Utilization in Lower-Middle Income and Water-Scarce Areas: A Case Study of Puyang" investigated the issue of water scarcity in China. In the study, they thoroughly tested various wastewater treatment sites around Puyang. What they found was that each of the sites met standards of water quality and cleanliness to be used. The most important thing they found was that each one could produce much more water than their current production parameters showed.

Our fifth source discussed water scarcity, which is an ongoing global issue. The article: “Rainwater Harvesting and Treatment: State of the Art and Perspectives” expands on this idea of water availability and cleanliness. This piece compiled multiple sources of research from other rainwater studies and a description of how technology has grown, providing a descriptive analysis of the changes in modern ideas proposed to rainwater treatment. They explain the benefits of rainwater harvesting (RWH) as well; “RWH provides several benefits to the local environment. It can provide a non-potable water source, reducing demand from distribution systems. Moreover, it mitigates urban floods, reduces water pollution (reducing the activation of combined sewer overflows) and preserves high-quality water sources”(Raimondi et al. 2023). The authors found that water scarcity has vastly increased, and while rainwater solutions have gained significant traction since they were first proposed, more can be done for both our environment and us.

These five sources of research-based botany are extremely important because of their potential to have a high impact and increased reusage of unfiltered water sources. Using this data, we could use wastewater- for this study specifically grey water from laundry- to grow plants rather than filtered water, which filters the bacteria into its stem naturally. This is useful information because humans have struggled through an unnatural drought due to the exponential growth of our societies with an increasing need for sources that provide clean drinking water. Plants are also good for the environment because they have high albedo, and reduce the absorption of the sun’s radiation, reducing the impacts of global warming. On top of that, plants are natural carbon sinks that produce oxygen in return, reducing pollution in an area, and the overall carbon that resides in the atmosphere, trapping the ultraviolet radiation. Even more so, plants and trees are a natural source of vegetation and lumber for humans, allowing us to manufacture more goods, and continue to feed our expanding population.

This is important to our society because of the increased plant growth of using wastewater/greywater and rainwater on plants rather than filtered water. By being able to grow more plants faster, we can increase the number of fruits and vegetables that are grown altogether without using as much land as it normally takes. This directly affects our society by decreasing the prices of food in stores, and promoting less use of GMOs, which is both healthier and cheaper for us. We are also increasing access to filtered water by reusing wastewater, which reduces the risk of cancer and diseases transmitted primarily through dirty water, like cholera and dysentery. By utilizing these sources and testing a plant’s ability to use different sources of water for a higher efficiency rating, we can decrease the overall stress of water scarcity that raises prices and increase the amount of clean water availability.

Materials List

1. 500 ml pots were used to hold the plants and soil. Twelve individual pots in total were used.

2. Soil purchased from a home goods store was used to fill pots and grow plants. Approximately 500 ml of soil was used in each pot.

3. Plastic measuring cups were used to measure the individual amount of water added to each plant during each round of watering.

4. Water basin used to drain laundry grey water from laundry washing machine.

5. 2 large plastic buckets were used, one that collected rainwater and one that collected water from a spicket coming from the laundry water basin.

6. 84 total petunia seeds were used to grow the plants observed in the experiment, 28 for each of the three test groups..

7. Rainwater was used to water the rainwater sample group.

8. Tap water was used to water the tap water sample group.

9. Grey water was used to water the grey water sample group..

Experimental Procedure

1. Rainwater was collected using a large bucket during a rainstorm and stored in the bucket with a lid.

2. Grey water was collected in a large bucket that was drained from a laundry machine stored in the bucket with a lid.

3. 12 small pots with volumes of 500 ml were selected and filled completely with identical soil from a store-bought soil bag.

4. 7 petunia seeds were added to each pot and were buried two centimeters deep in the soil and were recovered with soil.

5. The pots were placed indoors on a table near a window to receive equal sunlight.

6. The 28 plant samples were divided into groups of 7 plants over 4 pots and labeled with pieces of paper on the pots of each sample group.

7. 100 ml of rainwater was measured using a measuring cup and poured into the soil of each of the 4 rainwater sample pots.

8. 100 ml of grey water was measured using a measuring cup and poured into the soil of each of the 4 grey water sample pots.

9. 100 ml of tap water was measured using a measuring cup and poured into the soil of each of the 4 tap water sample pots.

10. Steps 7 through 9 were repeated once every 2 days.

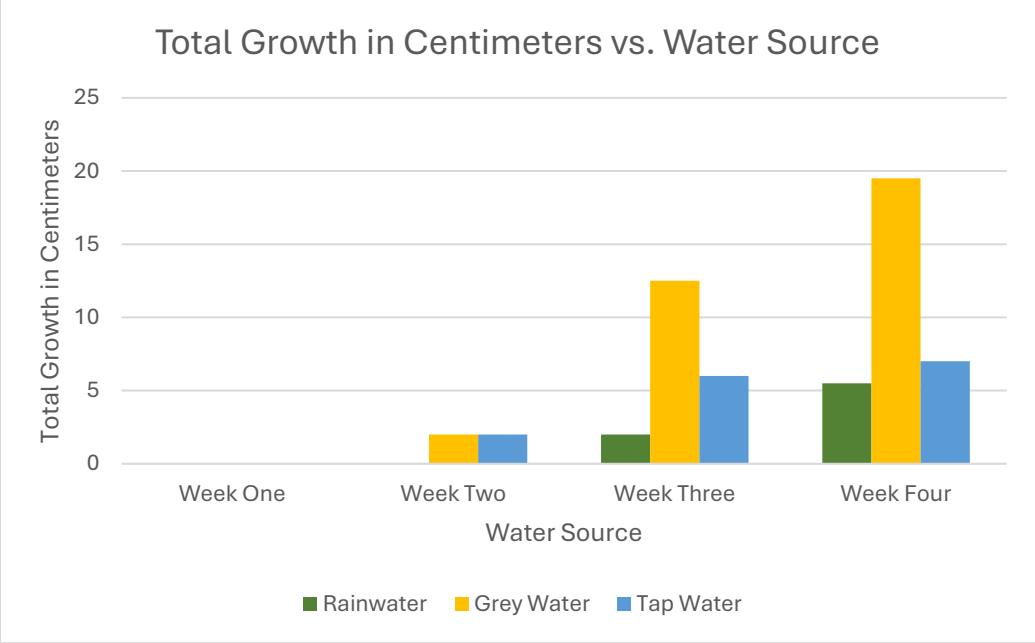
11. Vertical growth in centimeters and leaves and flowers on each plant was measured every 7 days.

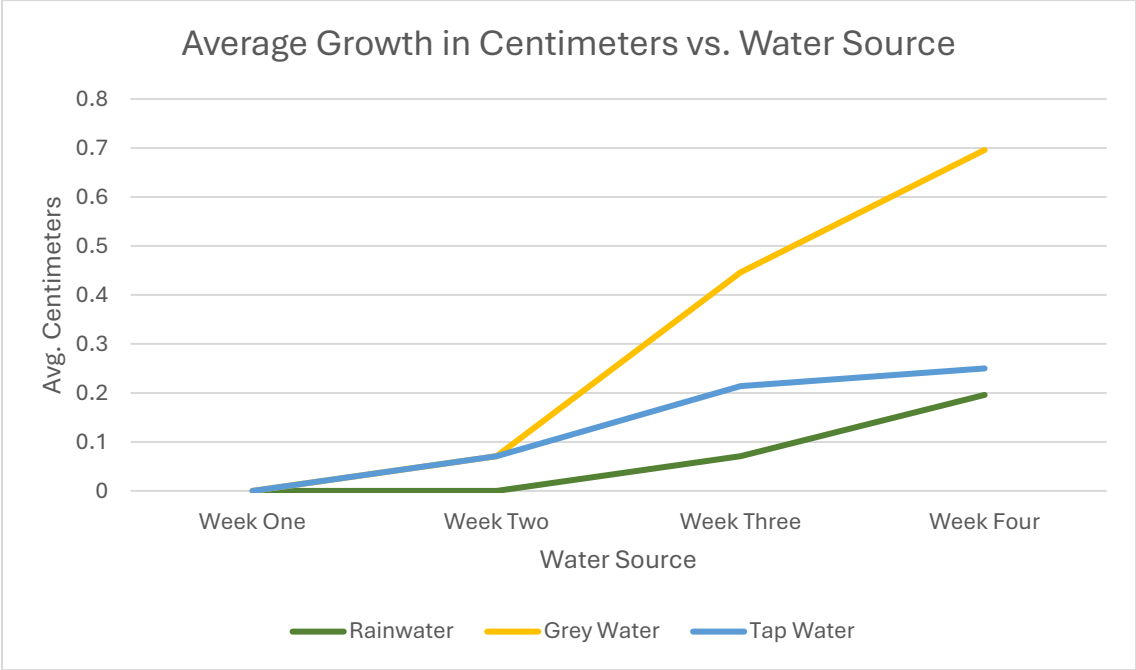
12. Step 11 was repeated for a total of 4 weeks.

13. A data table consisting of water sources and corresponding plant growth was made to compare data.

NOTE: The original design was specified for 10 weeks of data collection but was revised and shorted to 4 weeks of data collection.

Data and Results





Greywater samples have the greatest average growth between twenty-eight seeds, in centimeters. At the conclusion of the study, greywater had an average growth of 0.696cm. The control group – tap water – has a lower average of growth by week four with an average of 0.25cm. Rainwater sprouts had an overall lower average height of 0.196cm and had less seedlings. Each group increased in average overtime.

Conclusion

The greywater was the best water source determined by the results of the study. It provided the fastest germination and greatest average growth out of the three tested water sources. Rainwater indicated the slowest and least average growth over the test groups, and tap water had the second-best average growth. These results negated the hypotheses, which stated that rainwater would have the greatest overall growth.

Grey water and tap water yielded germinated sprouts after 2 weeks of the study and increased over time. Rainwater test groups only sprouted after 3 weeks of the testing period. Grey water had an average of 0.696 cm after the duration of the study and had 8 total sprouts and 16 leaves. Tap water had an average of 0.25 cm's with three sprouts and 6 leaves. Rainwater had an average of 0.196 cm, three total sprouts and 5 total leaves. The study sought to measure the overall growth in vertical centimeters and number of leaves, so grey water can be deemed the best water source based on these criteria, since its number of leaves and average vertical growth were both the greatest.

Minerals and bacteria may have been in grey water that benefited the seeds and the sprouts of petunia. The pH of the rainwater may not have fallen in the range of optimal growth of petunias, causing lower average growth and preventing germination. Similarly, tap water may have been too hard or contain small amounts of chemicals damaging to seeds.

Future research

There are many possibilities for generating more results pertaining to this study's concepts. Since only one species of plant was used, future studies that compare the results of *petunia nana compacta* to that of other common garden flowers, herbs and vegetable plants using the same water sources would provide generalizable results. Similarly, recreating this study with more trials would test the reliability of the data.

To test the scientific reasoning behind the data, testing water pH, mineral content, salinity, and other quality measurements could optimize the value of the results. Learning the property differences between the water sources would help create the desired understanding of how sustainable sources benefit or harm gardening and agriculture.

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