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Impact of Reclaimed Water on Photosynthetic Performance in Green Bark Ceanothus (Ceanothus spinosus)

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Abstract

The sprinkled water on the campus of Pepperdine University is primarily reclaimed water from sinks, toilets and showers on campus. The water is treated with micro bacteria and sand rocks to remove larger particles, smaller nitrogen containing compounds, excess nutrients and human pathogens. The Mediterranean weather in Southern California is characterized by dry summers, and watering plants by reclaimed water helps relieve the water stress in the community. However, the reclaimed water might distort the normal physiology of native plants on campus. We hypothesize that because nitrogen containing compounds cannot be efficiently removed by micro bacteria, higher nitrogen content in the reclaimed water results in fewer nodules and a decrease in photosynthetic rates.

We randomly placed twelve pots of Ceanothus spinosus into two groups and treated them with reclaimed water or distilled water. They were watered every three days (twice a week). We measured the rate of photosynthesis, stomatal conductance, and electron transport rate weekly. By the end of the third week, we pulled out the roots of each pot and counted the number of nodules on their roots. When we pulled out the roots at the end of the third week, we did not find any nodules in either group. From the data, we can only conclude that there is no difference in the nodulation or photosynthetic rates between plants treated with reclaimed water and ones treated with distilled water. Therefore watering plants with reclaimed water does not harm the natural vegetation, and can be encouraged for use in areas with stressful water conditions.

Introduction

Pepperdine University in Malibu, California is situated in a landscape that is irrigated with reclaimed water. Reclaimed water is not allowed to be deposited in the ocean and therefore this provides a unique opportunity for research from the sewage systems on campus and reused to decrease water consumption and reduce costs. Naturally this water is not safe for consumption by animals or humans. This begins the question, can we continue to use this water without harming the local plant life? The reclaimed water used is recycled from bathrooms, kitchens and other facilities on campus. As a result, the water is contaminated with many chemicals present in shampoo, soap and detergents. Furthermore there are also organic compounds from humans found in the area. On campus, there are plants that carry out nitrogen fixation in nodules on their roots. The number of nodules on the root varies depending on the nitrogen concentration and water found in the soil. Nitrogen present in reclaimed water may increase the nitrogen concentration in the soil, which may then eliminate the need for nodules in the root of the plant. In addition, there may be a decline in productivity and efficiency of the plant in its photosynthetic processes as well as other normal functions.

In our conducted experiment, our hypothesis is that Ceanothus spinosus will have fewer nodules on the plant when given reclaimed water in comparison to distilled water. This is due to the higher nitrogen concentration present in reclaimed water. Our method of testing is to irrigate twelve plants with either reclaimed or distilled water twice a week for three weeks. At the end of the three weeks we will uproot the plants and count the number of nodules on the plant. We will also measure photosynthesis rate, electron transport rate and stomatal conductance of the plants every week to observe if there are any significant differences due to the type of water. This is important because if the reclaimed water is damaging plant ecosystems, then it will further damage the rest of the ecosystem, for example the animals that are eating the plants. If this is the case, water treatment facilities should find other ways to use the water appropriately. Additionally, reducing the amount of nitrogen in plants could diminish the nutritional benefits of consuming plants.

Materials and Methods

In order to test our hypothesis, we set out to control all outside variables with the independent variable being type of water given. First, twelve young C. spinosus plants were bought from the Theodore Payne Foundation in one-gallon pots. These plants were numbered one through twelve, then, randomly assigned distilled or reclaimed water for the length of the experiment. Also, a mark was placed 10 cm from the tip of a growing line on each plant with a pen. All of the plants were kept in a wired area outside of the Stauffer Greenhouse on Pepperdine University's Malibu campus. This was to control for sunlight received, water or dew accumulated, and weather effects such as wind or humidity. Twice per week, they were given 250 ml of water. The "distilled" group was given water from a filtered spout in the plant biology laboratory, while the "reclaimed" group was given water transferred from Alumni Pond on campus. The pond holds a large collection of filtered sewage and runoff that is used to irrigate Pepperdine's landscape. Thus, it was a natural choice for a source of reclaimed water. After two weeks, we began to take measurements using the LI-6400XT gas-exchange system. Four measurements of photosynthesis, stomatal conductance, and electron transport rate levels were recorded. Often, the leaves were too small to cover the entire area provided by the gas-exchange system. Such leaves were removed and labeled the measurements were taken. Then their areas were determined with a light area machine in the student projects lab on campus. The areas were used to normalize our data so that leaves with unequal areas can be compared statistically. At the conclusion of the project, the plants were uprooted in search of nodules. Growth was recorded from the 10 cm mark, and the roots were separated from the stems and leaves. The plants were dried in an oven for two days at 60°C, then the mass of each root and stem system was recorded individually using an electronic balance. All data was collected in a field notebook and inputted for statistical analysis.

Results

Figure 1. Comparison of the average values of photosynthesis (measured in μmol CO₂/m²/s) of 6 C. spinosus plants given reclaimed water and 6 C. spinosus plants given distilled water. Data gathered at Pepperdine University's Malibu campus in the month of November 2013 with a Li-6400XT gas exchange system. Data points n = 4, standard error bars are included with 1 SE.

Figure 2. Comparison of the average values of stomatal conductance (measured in mmol H₂O/m²/s) of 6 C. spinosus plants given reclaimed water and 6 C. spinosus plants given distilled water. Data gathered at Pepperdine University's Malibu campus in the month of November 2013 with a Li-6400XT gas exchange system. N = 4, standard error bars included with 1 SE.

Figure 3. Comparison of the average values in electron transport rate in 6 C. spinosus plants given reclaimed water and 6 C. spinosus plants given distilled water. Data gathered at Pepperdine University's Malibu campus in the month of November 2013 with a Li-6400XT gas exchange system. N = 3, standard error bars included with 1 SE.

Table 1. Comparison of roots and shoots on 12 specimens of Ceanothus spinosus, 6 given reclaimed water and 6 given distilled water. Measurements are in grams and were taken in the Bio Chemistry lab at Pepperdine University. Numbers given are mean values plus or minus 1 SE, n = 6. There was no significant difference between treatments by Student's t-test, P > 0.05.

Discussion

At the conclusion of our data collection, we examined the roots of our potted C. spinosus plants to discover that none had nodules. We speculate that this is due to the fertilizer present in the soil provided by the Theodore Payne Foundation. The nitrogenous soil may have overcome any difference provided by the reclaimed water. In addition, after analysis of our normalized data, we found that there was no significant difference in the photosynthetic rate, stomatal conductance, or electron transport rate between C. spinosus plants watered with reclaimed versus distilled water. With such a brief period to collect data on our young plants, there was a smaller amount of information in line with our hypothesis that we hoped for. It has been proven, however, that full saturation of the soil prevents accumulation of salt; this would explain our lack of a significant difference. Still, this does not discount the fact that we saw trends in the data over the length of our experiment. We observed that the plants given reclaimed water were more efficient on average; their photosynthetic rates, stomatal conductance, and electron transport rates were all higher. This suggests that the nutrients provided in the reclaimed water may have come to benefit the young C. spinosus plants by replacing the need to fixate them. Also, we saw that as time went on, the photosynthetic rate, stomatal conductance, and electron transport rate of every plant rose. We suspect that this phenomenon is due to the fact that our plants were very young. Mature plants have much more stable rates. Thus, in continuation of this research project, we would study mature C. spinosus plants in their natural soil over a more significant period of time.

Conclusion

Implications of our study confirm that using reclaimed water to irrigate plants is not harmful and therefore the use of recycled water on campuses over the United States is more sustainable and a beneficial way of utilizing reclaimed water. Companies or companies using purified water to irrigate plant ecosystems would cut costs and reduce water consumption by recycling their used water and, as a result, be more sustainable. However, before any action is taken, it should be taken into consideration that our experiment was conducted for only three weeks. This short amount of time may not have been sufficient for accurate results to be found. Further research that could be conducted would be to continue the entire experiment for at least two months, to provide more accurate results.

References


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