Evaluating the Effects of Reclaimed Water on the Chemical and Physical Properties of Soil: Implications of Ion Deficiency on Soil Conductivity and Crop Development

Background

Agriculture plays a critical role in Arizona's economy and accounts for a large share of the state's water supply. One way Arizona supplies irrigation water without depleting rivers or the aquifer is by using reclaimed water. Reclaimed water is treated to a level just below potable drinking water standards. The purification process can substantially reduce the concentration of dissolved solutes and ions in water, creating an ion-deficient environment. The removal of these minerals can alter the chemistry within the soil and impact its health and structure. This study has two main goals: to evaluate how reclaimed water can leach nutrients from the soil, which significantly affects crop development, and to assess whether reclaimed water compromises soil infiltration. Previous studies have examined the impact of reclaimed water on crops, but have focused on how the salinity changes the soil texture. Additional studies have also focused on ion deficiencies resulting from reclaimed water use, but have examined their effects on marine life rather than on agriculture.

Objective/Hypothesis

This study will help inform sustainable irrigation practices and improved long-term soil health management. In Arizona, reclaimed water is designated for agricultural irrigation and groundwater recharge to the aquifer. Most of the water is used for irrigation, as an alternative to freshwater, given Arizona's significant number of agricultural centers. Although reclaimed water supports water conservation goals, its altered ionic composition may create soil ion imbalances that affect nutrient availability and infiltration capacity. Long-term use without evaluating the effects encourages soil degradation and reduced crop productivity. Evaluating these effects allows for better planning for climate-resilient agriculture and groundwater management strategies.

The objectives of this study are to examine how reclaimed water affects the soil's chemistry and physical properties. This is done by doing two different analyses:

1. The first analysis examines how ion concentrations in water have changed before and after irrigation. Through this, you can evaluate the amount of ions/minerals leached from the soil, which can be qualitatively evaluated through crop growth.
    a. Hypothesis: The consistent use of reclaimed water for irrigated soils will stunt the growth of the crops through the leaching of ions.
2. The next analysis examines how chemical leaching from the soil affects infiltration rates.
    a. Hypothesis: Ion depletion will alter soil structure and reduce infiltration rates over time

Methods

<u>Experimental Design</u>

The lab will be a soil column plant experiment. The crop used is cherry bell radishes. This experiment is expected to last at least a month (The reported growing time for the crop is 22 days). During this time, four sample types will be irrigated. Two of the samples will be pots containing the crop, with one irrigated with reclaimed water and the other with potable water. The other two samples will be pots containing no crop, but one will be irrigated with reclaimed water and the other with potable water. The potable water will be used as a control against the reclaimed water. Additionally, the pots containing no plants will be used as controls for the planted pots.

From these labs, the chemistry of both the reclaimed and potable water will be analyzed before watering and after water has drained through the crop. The amount of water added will be measured, as will the amount that drained through.

Statistical Analysis planned

Several figures are planned to find trends of the chemical and physical changes in the soil:

- A plot of the cumulative volume of water collected vs time. This will be used to evaluate infiltration rates between the various samples.
- A plot of ET calculated from planted and non-planted samples vs. time. A water budget will be used to evaluate soil/plant ET reactions to reclaimed water vs potable water.
- A cumulative sum of various leached ions (Mg, Na, Cl) over time for reclaimed water. This will indicate if there is a preference for a specific ion to be leached in reclaimed water.
- A cumulative sum of leached ions (Mg, Na, Cl) over time for potable water. This will be used as a control against the reclaimed water chart.

Example Key Figure

This is a conceptual image of the setup for the plant samples. The pots need to be at least 4 inches in diameter and 4 inches deep to accommodate the growing bulb and roots. The plant pot will be placed in a 600 ml beaker to collect drainage.

Timeline and milestones

The summaries below are the expected deliverables of the milestones at the end of the month.
February: Completion of the experimental design and baseline sampling
March: Begin planting, irrigation, and weekly analysis
April: Continued irrigation and weekly analysis
Early May: Harvest and finish lab analysis
Late May: Statistical Analysis of results and begin writing paper