Using Reclaimed Water for Irrigation

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Introduction

Drought and water shortages are becoming an unavoidable crisis in arid regions. Reclaimed water is seen as a good alternative to higher quality well water. However, citrus and avocado growers are concerned that elevated concentrations of boron, salts, and surfactants in reclaimed water could adversely affect their orchards.

Reclaimed water can decrease saturated hydraulic conductivity in the soil due to it's higher concentration of dissolved salts and sodium.

Sodium reduces hydraulic conductivity by swelling and dispersing clay particles in the soil thus reducing the water-conducting pores. Reduced water infiltration may cause ponding, root rot, and damage to crops.

The scientific literature contains conflicting reports on the "permissible limits of boron" recommended for "sensitive crops" such as citrus and avocadoes.

The purpose of these laboratory experiments was to determine the affect of reclaimed water on saturated hydraulic conductivity and re-evaluate the guidelines for irrigation with respect to boron concentrations in soils cropped to citrus (Riverside, CA).

"Safe" Concentrations of Boron

Conflicting Reports

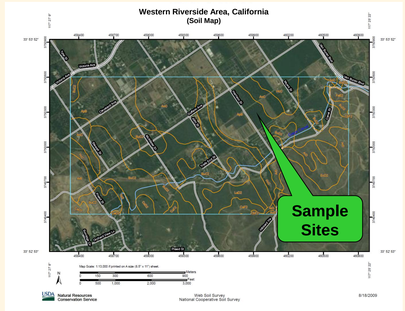
- Boron concentrations of 0.7 mg/ L in irrigation water is "Safe for all crops in California."
  California State Water Resources Control Board, 1984 (Pettygrove and Asano, 1984)
- 0.33 mg/ L "permissible limits of boron" in irrigation water recommended for "sensitive crops," which include citrus and avocado.
  U.S. Salinity Laboratory (USSL Staff, 1954, page 81)

Reason for the Boron Confusion

Irrigation Water ≠ Soil Water

Soils have a high adsorption capacity for boron ⇨ Delayed build-up of boron in the soil solution

Sampling Sites



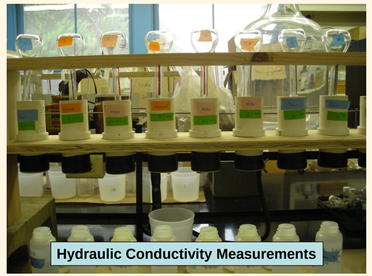
Methods

Three Water Treatments:

Water Quality	Gage Canal (Control)	50/50 (reclaimed/ control)	Reclaimed
EC (mS/cm)	0.67	0.85	1.0
pH	7.4	7.8	7.9
Alk (mEq/L)	4.1	3.7	3.5
SAR	0.76	1.3	2.0
Boron (mg/L)	0.07	0.21	0.35

Three Soil Depths

Depth	% Clay	% Silt	% Sand	Column g/cm³	% OM
0-20 cm	23	33	44	1.54	2.0
40-60 cm	27	42	31	1.61	1.5



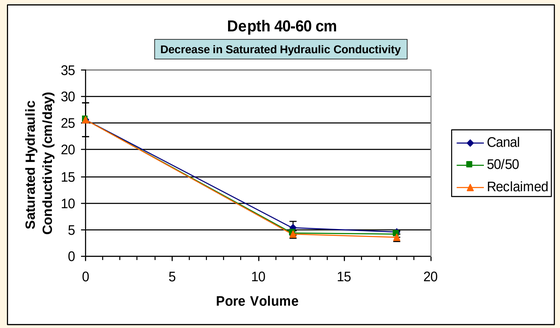
Soil Series: Arlington Loam

Experimental Design

- 2 mm sieved repacked soil columns
- Water applied in 100 mL increments
- Drying cycles of 24 hours between applications
- Saturated hydraulic conductivity with Darcy's Law Constant Head
- Plant available boron concentrations determined by hot water extraction

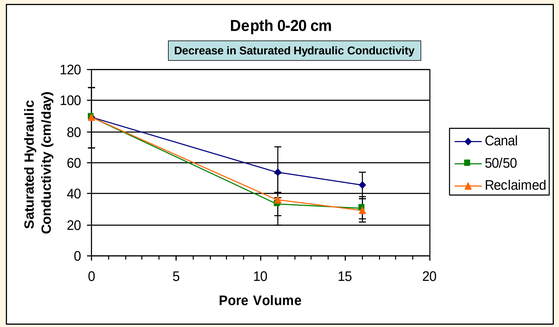
Saturated Hydraulic Conductivity

Lower Horizon



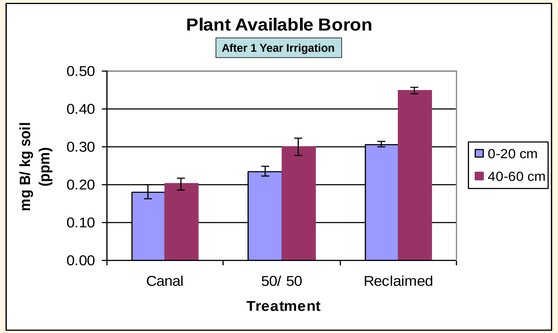
No significant difference in saturated hydraulic conductivity was observed among all treatments in lower horizons.

Surface Horizon Most Affected



Saturated hydraulic conductivity for the 50/50 and the reclaimed water treatments decreased by 16-18% compared to the control.

Boron



Depth 0-20 cm (23%clay)

Plant available boron concentrations for the 50/50 and the reclaimed water treatments increased by 30% and 70% compared to the control.

Depth 40-60 cm (27% clay)

Plant available boron concentrations for the 50/50 and the reclaimed water treatments increased by 49% and 123% compared to the control.

Conclusion

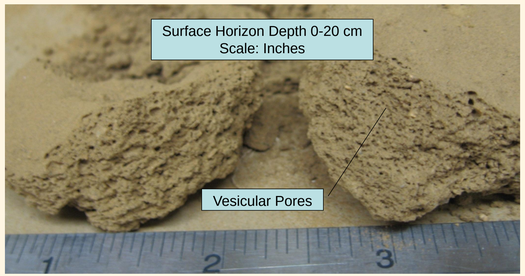
Saturated Hydraulic Conductivity

- Surface horizon, depth 0-20 cm, showed the greatest overall reduction in saturated hydraulic conductivity for the reclaimed and 50/50 treatments.
- All treatments showed a significant decrease in saturated hydraulic conductivity which may be due to formation of vesicular pores (see below).
- These results suggests that farmers might have to change their irrigation practices or add gypsum to the soil if they use reclaimed water for irrigation.

Boron Concentrations

- After one year of irrigation (1.5 m water), plant available boron concentrations in the soils were significantly higher (30 – 123% increase) than the canal water control.
- Lower horizon, depth 40-60 cm, showed the largest increase (123%) in plant available boron concentrations in the soil for the reclaimed water treatment.
- Although still under the toxic threshold for citrus (0.7 ppm boron) after one year of irrigation, the reclaimed water results suggests a possible boron toxicity may occur during the second year of irrigation.
- A multi-year irrigation study is needed to re-evaluate the guidelines for irrigation with respect to boron concentrations in soils cropped to sensitive crops such as citrus.

Future Directions



- A reduction in saturated hydraulic conductivity was seen in all treatments which may be due to formation of vesicular pores over one year.
- Future research will focus on how vesicular pores form in these soils and if reclaimed water accelerates formation of the vesicular pores.
- A multi-year boron irrigation study is underway.
- Explore mitigation and potential remediation techniques to help establish guidelines for sustainable reclaimed water irrigation practices.

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