Geophysical Research Abstracts
Vol. 18, EGU2016-5714, 2016
EGU General Assembly 2016

Root-Zone Redox Dynamics – In Search for the Cause of Damage to Treated-Wastewater Irrigated Orchards in Clay Soils

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Treated wastewater (TW) has become a common source of water for agriculture. However recent findings raise concern regarding its use: a marked decrease (up to 40%) in yield appeared in orchards irrigated with TW compared with fresh water (FW) irrigated orchards. These detrimental effects appeared predominantly in orchards cultivated in clay soils. The association of the damage with clay soils rather than sandy soils led us to hypothesize that the damage is linked to soil aeration problems. We suspected that in clay soils, high sodium adsorption ratio (SAR) and high levels of organic material, both typical of TW, may jointly lead to an extreme decrease in soil oxygen levels, so as to shift soil reduction-oxidation (redox) state down to levels that are known to damage plants. Two-year continuous measurement of redox potential, pH, water tension, and oxygen were conducted in the root-zone (20-35 cm depth) of avocado trees planted in clay soil and irrigated with either TW or FW. Soil solution composition was sampled periodically in-situ and mineral composition was sampled in tree leaves and woody organs biannually.

In dry periods the pe+pH values indicated oxic conditions (pe+pH>14), and the fluctuations in redox values were small in both TW and FW plots. Decreases in soil water tension following irrigation or rain were followed by drops in soil oxygen and pe+pH values. TW irrigated plots had significantly lower minimum pe+pH values compared with FW-irrigated plots, the most significant differences occurred during the irrigation season rather than the rain season. A linear correlation appeared between irrigation volume and reduction severity in TW-irrigated plots, but not in the FW plots, indicating a direct link to the irrigation regime in TW-irrigated plots. The minimum pe+pH values measured in the TW plots are indicative of suboxic conditions (9<pe+pH<14) which are conductive of Fe and Mn reductive–dissolution. However, Fe and Mn levels in the soil solution and in the tree samples were not elevated in the TW plots. A possible explanation for these contradicting findings may be the short duration of the reducing conditions.

We will present a model linking the measured soil redox-potential with soil water tension and oxygen concentration levels. The consequences of our findings to plant health will be discussed, and future research prospects will be shown. We believe that our findings will contribute to the development of better management practices that will enable more sustainable use of TW, an essential resource in the world today.