# Irrigation loads salts on agricultural soils of dryland: anthropogenic impact on the Critical Zone

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The soils of western Texas and southern New Mexico near the U.S.-Mexico border are highly cultivated. On this dryland, flood irrigation is necessary but contributes greatly to soil degradation. Indeed, our elemental flux calculation estimates that irrigation using water from the Rio Grande River loads 200 gNa/m$^2$ and 100 gNa/m$^2$ annually. Here, we characterized soil and pore water samples in agricultural fields of this dryland to quantify the salt loading within soils and to investigate the dominant controlling factors.

The saturation indexes calculated from soil water chemistry demonstrated that these waters were oversaturated with respect to calcite in soils, but only slightly unsaturated with respect to halite and gypsum. Fluid electrical conductivity (EC) in soils, converted from bulk soil EC, increased at the onset of each irrigation event, suggesting gradual increase of major ion concentrations such as $Na^+$ and $Cl^-$ in the soil waters. This is probably due to both dissolution of pre-existing evaporate salts and loss of water through evapotranspiration. Thus, it is expected that with continuous loss of water, soil waters will eventually become saturated with respect to evaporate minerals and halite and gypsum begin to precipitate in the soils. For example, up to 0.5 wt% of halite was observed in our study sites.

Soil waters were saturated for calcite even at the onset of irrigation and should become more oversaturated over time. Indeed, calcite was detected in these soils by powdered XRD and quantified by elemental carbon analysis (~10 wt% of calcite). U-isotope derived ages of pedogenic carbonates in the agricultural soils were much lower than those in the natural sites nearby. Thus the presence of recently accumulated new carbonates (due to irrigation loading) significantly lowered the average age of previously and naturally formed old carbonates in soils.

Majority of soils have sodicity greater than 13 and salinity greater than the crop's tolerance levels. In summary, we illustrated that flood irrigation loaded salts onto the agricultural soils in drylands, deteriorting soil quality and modifying global elemental cycles and the critical zone.