Using flow-through column experiments to study dynamics of CO_2 emissions and calcite accumulation in flood-irrigated sediments

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Intensive evapotranspiration drives the oversaturation of calcite in irrigaiton waters used for agricultural soils along the Rio Grande valley, leading to the precipitation of pedogenic calcite and emission of abiotic CO_2. The kinetics and controls of this chemical reaction have been investigated by field studies, parameters including texture and irrigation water intensity and chemistry are identified as important variables. Flow-through column experiments can help elucidate basic responses of such complex and dynamical systems, especially for future scenarios of different climatic conditions and irrigation water chemistry. Here we designed columns packed with sediment layers of contrasting texture and permeability and irrigated by water of different salinity. Nested CO_2, O_2, and EC/soil moisture sensors were used to monitor the water movement, investigate the evolution of soil water chemistry, and capture the CO_2 production and movement as a result of flood-irrigation. Without biological processes, CO_2 in soils is entirely abiotic; therefore, its emission is only reflective of precipitation reaction. In addition, daily CO_2 efflux data were collected from the columns, as a function of irrigation events, to directly measure CO_2 emission. Results from the column experiments identified soil moisture content to be the most important parameter, controlling both CO_2 production and phyiscal transport. During initial flooding with ponded water, CO_2 is simultaneously compressed in the top sand layer and pushed to the deeper clay layer. As drying through evaporation occurs, water is no longer ponded and sediment pores open, facilitating the release of trapped CO_2. Eventually, oversaturation of remaining soil water results in calcite precipitation and CO_2 production, diffusion and emission. This study highlights that measurable CO_2 fluxes from the column experiments are in agreement with what is observed in field studies and in reactive transport modelling.