Quantifying anthropogenic contributions to century-scale groundwater salinity changes, San Joaquin Valley, California, USA

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HIGHLIGHTS

• Changes in TDS and major ions in groundwater were evaluated over the last century in the San Joaquin Valley (SJV).
• TDS has increased in most parts of the SJV and increases are mainly associated with agricultural practices.
• In the eastern SJV, increases in bicarbonate, nitrate, and sulfate in recharge were the main contributors to increased TDS.
• Bicarbonate is primarily the result of dissolution of primary minerals during the agricultural growing season.
• Nitrate and sulfate are mainly derived from applications of fertilizers and soil amendments for agriculture.

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ABSTRACT

Total dissolved solids (TDS) concentrations in groundwater tapped for beneficial uses (drinking water, irrigation, freshwater industrial) have increased on average by about 100 mg/L over the last 100 years in the San Joaquin Valley, California (SJV). During this period land use in the SJV changed from natural vegetation and dryland agriculture to dominantly irrigated agriculture with growing urban areas. Century-scale salinity trends were evaluated by comparing TDS concentrations and major ion compositions of groundwater from wells sampled in 1910 (Historic) to data from wells sampled in 1993–2015 (Modern). TDS concentrations in subregions of the SJV, the southern (SSJV), western (WSJV), northeastern (NESJV), and southeastern (SESJV) were calculated using a cell-declustering method. TDS concentrations increased in all regions, with the greatest increases found in the SSJV and SESJV. Evaluation of the Modern data from the NESJV and SESJV found higher TDS concentrations in recently recharged (post-1950) groundwater from shallow (<50 m) wells surrounded predominantly by agricultural land uses, while premodern (pre-1950) groundwater from deeper wells, and recently recharged groundwater from wells surrounded by mainly urban, natural, and mixed land uses had lower TDS concentrations, approaching the TDS concentrations in the Historic groundwater. For the NESJV and SESJV, inverse geochemical modeling with PHREEQC indicated that weathering of primary silicate minerals accounted for the majority of the increase in TDS concentrations, contributing more than nitrate from fertilizers and sulfate from soil amendments combined. Bicarbonate showed the greatest increase among major ions, resulting from enhanced silicate weathering due to recharge of irrigation water enriched in CO₂ during the growing season. The results of this study demonstrate...