Combining Uranium and Boron Isotope Ratios to Trace Anthropogenic Salinity Inputs to the Rio Grande River in Southwest USA

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The Rio Grande is an important source of irrigation water in the arid to semi-arid southwest US. High salinity in the Rio Grande in this region, similar to many other arid land rivers, has affected soil quality and crop productivity. Salinity contributions to Rio Grande may come from anthropogenic (agriculture practices, urban activities) and natural (groundwater upwelling, chemical weathering) sources. In this study, we combine two novel anthropogenic isotope tracers (U and B) to identify and quantify the salinity sources. U isotope tracer is indicative of agriculture-sourced salinity due to the presence of U in phosphorous fertilizers and B isotope tracer is powerful in resolving urban sourced salinity due to its presence in urban wastewater. From 2015 to 2016, we collected monthly river samples at 15 sites along a 200-km stretch of the Rio Grande from Elephant Butte Reservoir, NM to El Paso, TX, as well as irrigation canals, city drains, wastewater effluents, and groundwater in this region. High TDS values in these water samples in general correlate well with their high B and U concentrations. Our results show that the deep groundwater end-member has distinctively high ($^{234}U/^{238}U$) and $\delta^{11}B$ ratios; the agricultural water end-member has distinctively low ($^{234}U/^{238}U$) and intermediate $\delta^{11}B$ ratios; the urban water end-member has distinctively low $\delta^{11}B$ ratios and intermediate ($^{234}U/^{238}U$) ratios. Major ion chemistry, ($^{234}U/^{238}U$) and $\delta^{11}B$ ratios in the Rio Grande river water reveal multiple and variable salinity inputs from geological, agricultural, and urban sources. High TDS values, high ($^{234}U/^{238}U$) and $\delta^{11}B$ values suggest that natural upwelling of groundwater is significant in the Rio Grande near Elephant Butte. Rio Grande waters from the Mesilla Valley region have characteristic lower ($^{234}U/^{238}U$) values, possibly sourced from fertilizers that are extensively used in the region. Agricultural practices during flood irrigation also intensify evaporation of Rio Grande surface water and significantly increase water salinity. Stable O and H isotope ratios indicate signatures of evaporation as well as multiple water sources due to agricultural practices and groundwater pumping. $\delta^{11}B$ values in Rio Grande river near cities such as El Paso and Las Cruces suggest mixing of anthropogenic salinity end-members such as treated city wastewater.