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Determining sources of nitrate in the semi-arid Rio Grande using nitrogen and oxygen isotopes

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ABSTRACT

The Rio Grande, a semi-arid river in the American Southwest, is a major source of surface water for agriculture and municipal purposes in New Mexico and western Texas. In addition to increasing salinity, considerable increases in nitrate (NO_3^-) concentrations have been observed in the semi-arid portion of the Rio Grande. It is possible that elevated water salinity inhibits denitrification on irrigated fields and, thus fails to mediate the excess nutrient load from anthropogenic activities. Therefore, the two major goals of this study were to i) characterize and quantify major NO_3^- sources, and ii) assess whether elevated water salinity affects microbial denitrification in the watershed. In fall 2014 and summer 2015, the Rio Grande surface water, irrigation drains, precipitation (urban runoff), and municipal waste effluents were sampled between Elephant Butte, New Mexico and Tornillo, Texas (~260 km distance) for chemical and stable isotope analyses. The highest NO_3^- concentrations, up to ~70-140 mg/L, were observed in waste effluents and agricultural drains irrigated with the reclaimed city water. Conversely, NO_3^- concentrations in the river and agricultural drains were significantly lower (<1-10 mg/L) in the areas farther away from urban centers. Two major NO_3^- sources were identified using isotope tracers: fertilizers, with low $\delta^{15}N$ and high $\delta^{18}O$ (average +0.6 and +18.3 ‰, respectively), and waste water effluents from cities, with high $\delta^{15}N$ and low $\delta^{18}O$ (average +10.5 and -5.1 ‰, respectively). According to nitrogen isotope mass balance constraint, the contribution of waste effluent-derived NO_3^- was the smallest in upstream locations, between Elephant Butte and Las Cruces, and accounted for up to 0-25 % (±10 %) compared to the fertilizer-derived NO_3^-. Further downstream near big urban centers, the effluent contributions increased and accounted for up to 70-100 % between Las Cruces and El Paso. The highest effluent-derived NO_3^- contributions of 90-100 % were measured in the agricultural district located below El Paso where the reclaimed city water is commonly used for irrigation. Elevated salinity does not appear to limit microbial