

Nitrate Isotope Analysis of Tunnel Drainage Water and Nitrate Source End Members in the Twin Falls Canal Co. Irrigation Tract, Southern Idaho

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Objective:

The purpose of this study is to determine the nitrate ^{15}N and ^{18}O fractionation characteristics of shallow groundwater and of unamended and fertilizer- or manure-amended soil end members for Twin Falls Canal Co. Irrigation Tract in southern Idaho.

Methods:

Sampling Tunnel Drainage Water. We revisited and sampled 10 of the original 15 tunnel and tile-well network drains evaluated by Carter et al. (1971) across the TFCC tract. The 10 drains (**Table 1**) were stratified by area to ensure complete coverage of the study lands. Water samples were also collected at the Milner Dam pool (42°31'38" N, 114°02'14" W), which supplies water to the irrigation canals that convey the water downslope across the tract. Water samples for nutrient and isotope analysis were collected in 2003 through 2007 once per month during the April to November irrigation season and on alternate months in the off season. Nutrient concentrations in these samples were analyzed and reported in a companion paper (Lentz et al., 2018). We sampled water (125 mL) from flows issuing directly from the tunnel or tile drain outlet and stored it on ice until transported to the lab. Particulates present in water samples collected from tunnel drains, the Milner pool, and percolate from the laboratory experiment (see: Source and End Member Analysis) were removed by passing the liquid through a nitrate-free 0.45- μm filter. Of the sediment-free water sample, 20 mL was frozen in a scintillation vial for nitrate ^{15}N and ^{18}O isotope analysis.

Source and End Member Analysis. A 0-30 cm depth sample of Portneuf silt loam was collected, ambient nitrate was removed by extraction with RO water, air dried, and sieved through a 2-mm screen. One of three amendment treatments was mixed with 125 g of soil: 1) 0.04 g total N as freeze-dried manure (where total manure N = 1.63% and assuming 40% of manure N is available, 6.74 g manure, dry wt.); 2) 0.04 g N as urea fertilizer (0.1 g); or 3) no amendment.

The treated soil was packed into 13-cm long by 4-cm diameter PVC cylinders with nylon cloth (50 μm mesh) bottoms in three lifts to achieve a dry bulk density of about 1.15 Mg m^{-3} . Extra soil columns prepared for each treatment were used to determine soil pore volumes and track soil $\text{NO}_3\text{-N}$ concentrations during incubation.

We wet the soil in each cylinder to 55% water filled pore space (WFPS) using RO water and incubated at 22° C. Soil water contents were adjusted to 55% WFPS weekly. All soil columns were leached after six months incubation, ensuring that the accumulated $\text{NO}_3\text{-N}$ included an ample proportion of input N that had cycled through the soil system. For leaching, RO water was applied to the column's nylon cloth shielded soil surface at a rate of 6.0 mL h^{-1} (4.8 mm h^{-1}) until one pore volume of soil percolate was collected from each soil column. Samples of the accumulated water were prepared for $\delta^{15}\text{N-NO}_3$ and $\delta^{18}\text{O-NO}_3$ analysis. A 25 mL subsample of the leachate was filtered (as for tunnel water samples) and frozen in a 20-mL scintillation vial.

Water samples were shipped frozen on dry ice to the Marine Chemistry and Geochemistry Laboratory

at Woods Hole Oceanographic Institution (Woods Hole, MA) for nitrate isotope analysis. The laboratory employed the microbial denitrifier method (McIlvin and Casciotti, 2011) and Gas Isotope Ratio Mass Spectrometry (Finnigan DeltaPLUS XP, Waltham, MA) to measure $\delta^{15}\text{N-NO}_3$ and $\delta^{18}\text{O-NO}_3$ (Eqns. 1 and 2). The standard isotopic ratio for N was atmospheric N_2 (AIR) while that for O was the Vienna standard mean ocean water (VSMOW). Because the computed ratio is small, the value is multiplied by 1000 and reported per mil (‰):

$$\delta^{15}\text{N-NO}_3 (\text{‰}) = \left\{ \left[\frac{(^{15}\text{N}/^{14}\text{N})_{\text{sample}}}{(^{15}\text{N}/^{14}\text{N})_{\text{AIR}}} - 1 \right] \cdot 1000 \right\} \quad [1]$$

$$\delta^{18}\text{O-NO}_3 (\text{‰}) = \left\{ \left[\frac{(^{18}\text{O}/^{16}\text{O})_{\text{sample}}}{(^{18}\text{O}/^{16}\text{O})_{\text{VSMOW}}} - 1 \right] \cdot 1000 \right\} \quad [2]$$

where the sample N and O isotopes were determined from the nitrate in the water. Measurement precision was 0.1 to 0.2‰ for both $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ (McIlvin and Casciotti, 2011).

Results:

Tunnel water nitrate $\delta^{15}\text{N-NO}_3$ values ranged from +4.6‰ to +7.8‰ and $\delta^{18}\text{O-NO}_3$ ranged from -4.5‰ to -7.6‰ (**Fig. 1**). Nitrate stable isotope compositions of Group-I tunnel waters and tunnel tile drain waters (Group II) were enriched compared to the control soil and deep groundwater endmembers (**Fig. 1**), with the Group II tile drain waters being intermediate between the Group-I and the control soil and deep groundwater (**Fig. 1**).

References:

Lentz, R.D.; Carter, D.L.; Haye, S.V., 2018. Changes in groundwater quality and agriculture in forty years on the Twin Falls irrigation tract in southern Idaho. *J. Soil Water Cons.* (In Print).

Carter, D. L.; Bondurant, J. A.; Robbins, C.W., 1971. Water-soluble NO_3 -nitrogen, PO_4 -phosphorus and total salt balances on a large irrigation tract. *Soil Sci. Soc. Am. Proc.* 35 (2), 331-335. (Available online at: <http://eprints.nwisrl.ars.usda.gov/258/1/285.pdf> Verified 19 July 2017.)

McIlvin, M.R.; Casciotti, K.L., 2011. Technical updates to the bacterial method for nitrate isotopic analyses. *Anal. Chem.*, 83, 1850-1856.

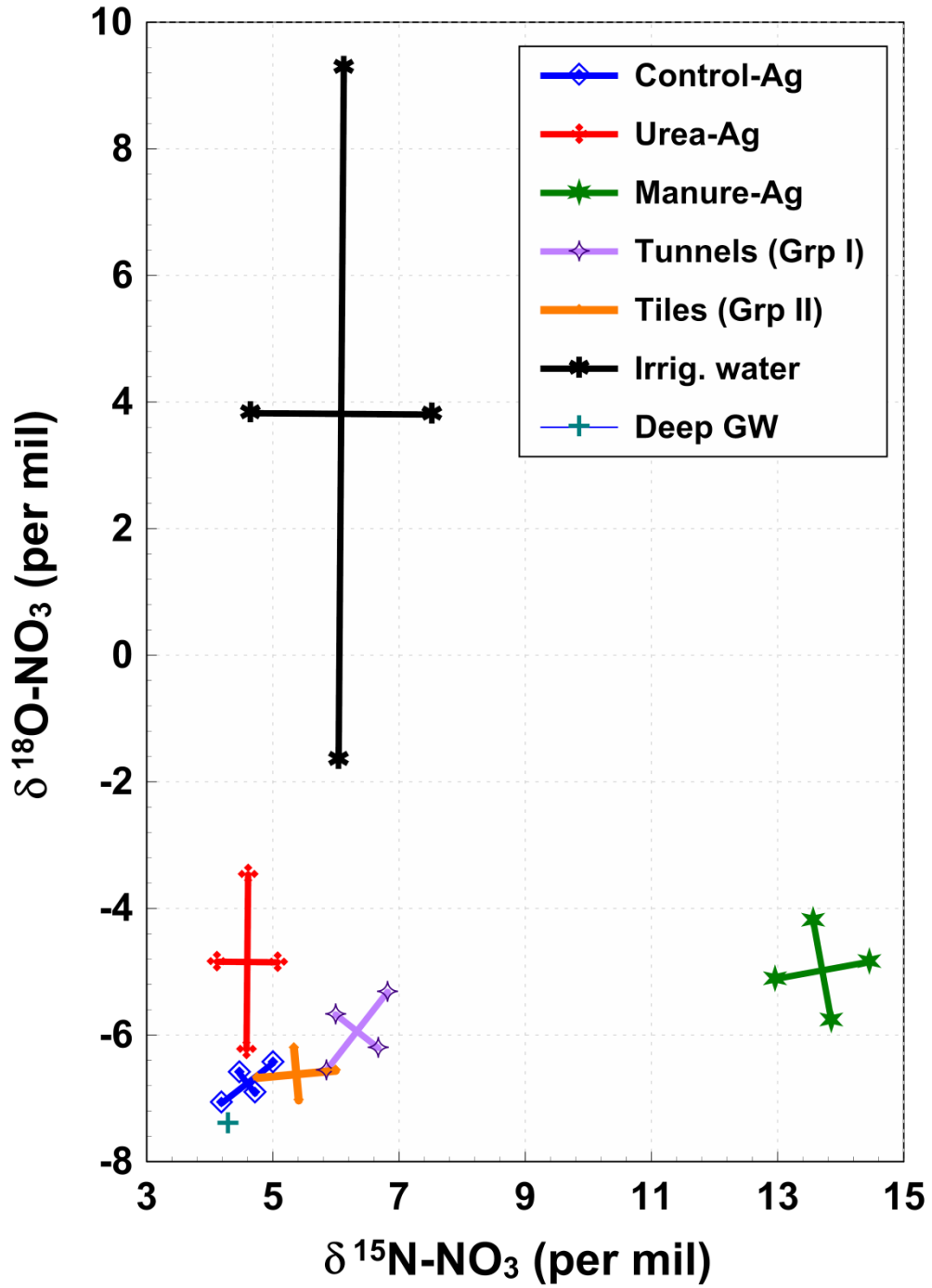


Fig. 1. Distribution of nitrate isotope compositions in water from non-treated (control), urea- or manure-amended soils (end-member analysis), and shallow groundwater sampled from tunnel drains (Group I) vs. tile drain waters (Group II, Hankins and Walters), and the nitrate isotope composition of deep ground water (Deep GW). The error bars are the means \pm 1 standard deviation obtained parallel and perpendicular to the direction of greatest variation for each data set. (The alignment and variance associated with $\delta^{15}\text{N-NO}_3$ and $\delta^{18}\text{O-NO}_3$ values for each group were calculated by rotating the coordinate axes relative to the long axis of the data points).