Comment on “A Reservoir of Nitrate Beneath Desert Soils”

Walvoord et al. (1) reported a large nitrate pool located deep (>1 m) beneath desert soils. Two aspects of this work were particularly surprising: the large pool size, estimated to be up to ~10^4 kilograms of nitrogen per hectare, as nitrate (kg N ha⁻¹); and the shape of the nitrate profiles, which resembled the conservative solute-accumulation profiles of Cl⁻ more than typical nutrient depletion profiles. In view of independent data and additional issues discussed below, however, we question the generality of these results.

Soil nitrate values can vary greatly over short temporal and spatial scales. We recently investigated 16 desert soil profiles to 10 m depth in paired grassland and woody sites at the Jornada and Sevilleta long-term ecological research stations (2). Analyses of eight Chihuahuan Desert cores at Jornada showed nitrate values that ranged from ~4 μg N g⁻¹ of soil near the surface to ~0.1 μg N g⁻¹ in subsurface soils (Fig. 1). The observed values were consistent with data from surface soils in other desert studies [e.g., (3–8)] and were an order of magnitude lower than the Chihuahuan Desert values reported in (1). Our total pool estimates to 10 m depth, at 50 to 100 kg N ha⁻¹, were also substantially lower.

The shape of the nitrate profiles was the second surprising result in (1). Our Jornada nitrate data followed the pattern of nutrient depletion profiles (9) and bore no resemblance to Cl⁻ profiles at the site (Fig. 1). The one clear difference between the two nitrate profiles we studied—the smaller nitrate pool in the top meter of soil in the grassland compared to the shrubland, which is dominated by the nitrogen-fixing honey mesquite, Prosopis glandulosa (Fig. 1)—was most likely biological.

Soil nitrate concentrations from Sevilleta were of similar magnitude and profile shape to those at Jornada (Fig. 2). The nitrate concentrations for Sevilleta soils were also an order of magnitude lower than values in (1), with total pool estimates of only 60 to 90 kg N ha⁻¹ to 10 m depth. A lack of correspondence between the shape of the NO₃⁻ curve and the Cl⁻ peak at ~2 to 3 m depth was particularly clear at Sevilleta (Fig. 2).

Vegetation and the timing of precipitation—whether rainfall occurs primarily in the growing season—may play important roles in determining the variability of nitrate at depth. In the Chihuahuan desert, P. glandulosa often grows roots to 5 or 10 m (2, 10), as deep as or deeper than the NO₃⁻ and Cl⁻ peaks observed in the Chihuahuan data of (1). Direct evidence of nutrient uptake from at least 3 to 4 m depth by P. glandulosa and the grass Bouteloua eriopoda has been shown at Jornada (2). We speculate that the large variability in nitrate concentrations and profile shapes in the soil cores studied in (1) may be partly caused by plant activity. We further speculate that the possible uptake of nitrate in such deep pools could aid the success of invasive woody shrubs in deserts, a mechanism that to our knowledge has not been considered previously.

The nitrate values we observed and the questions raised above do not
negate the results of (1). However, the nitrate reservoir proposed for desert soils is large—up to 13,600 kg N ha$^{-1}$, far larger than values in agricultural soils (11). The extrapolation of these results to 16% of global vadose-zone nitrate and 71% of warm desert nitrate is questionable. Until confirmation of a large deep-soil nitrate pool exists generally, such regional and global extrapolations must be treated with caution.

R. B. Jackson
S. T. Berthrong
C. W. Cook
E. G. Jobbágy
R. L. McCulley
Department of Biology and Nicholas School of the Environment and Earth Sciences
Duke University
Durham, NC 27708–0340, USA

*To whom correspondence should be addressed. E-mail: jackson@duke.edu

References and Notes

3 December 2003; accepted 12 February 2004