Title: **Nitrogen Isotope Monitoring at Unsewered Subdivisions**

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Background/Need: On-site septic tank, soil absorption systems which serve unsewered subdivisions may cause nitrate levels in groundwater to exceed the national drinking water standard of 10 mg/L of nitrate. Previous studies indicate that nitrogen from lawn fertilizer and septic tank, soil absorption systems cause nitrate contamination of ground water beneath and on the downgradient side of the six subdivisions. One other possible source of nitrate is agricultural fertilizer used on upgradient cultivated land. Nitrate from feedlots, barnyards, and septic tanks have been distinguished from natural soil nitrate on the basis of their δ^{15} N. It is unclear, however, if δ^{15} N can be used to reliably distinguish these nitrate sources from agricultural fertilizer sources in Wisconsin's groundwater.

Objectives: To evaluate the possibility of drinking water well contamination by agricultural sources in private water-supply wells in six subdivisions in Wisconsin.

Methods: Four of the subdivisions are located in Eau Claire County and two in LaCrosse County in west-central Wisconsin. The subdivisions are situated on sand and loamy sand soil on glacial outwash or river terrace deposits with soil slopes of 0 to 6 percent. All wells in Sandy Knolls, Oak Park, Briarwood and Lowes Creek subdivisions terminate in a water-table aquifer composed of sandy sediment. One exception is a well in Lowes Creek subdivision which terminates in sandstone under the sandy sediment. In Pine Grove-Deer Park subdivision, 21 wells terminate in the upper sandy sediment, 17 wells in sandstone under the sandy sediment, and one well in granite under the sandy sediment.

To reduce ambiguity in the analysis, five of the six subdivisions selected are located in areas with little to no upgradient agricultural activity or other known sources of nitrate.

Water samples were collected from inside or outside faucets of homes in each of the six subdivisions using standard procedures. The wells selected for sampling had previously recorded values of nitrate in excess of 10 mg/L or were wells of highest nitrate within the subdivision. A larger number of samples were collected in Sandy Knolls, Oak Park, and Mill Run subdivisions where a larger number of private-water supply wells exceed 10 mg/L nitrate.

Results and Discussion: Thirty-eight samples were collected for δ^{15}N and nitrate analyses:two in Lowes Creek subdivision, nine in Oak Park subdivision, five in Pine Grove-Deer Park subdivision, three in Briarwood subdivision, eight in Sandy Knolls subdivision, and eleven in Mill Run Subdivision. The mean δ^{15}N for all measurements is 6.2 $\pm$ 1.6 and the mean nitrate value for all measurements is 10.6 mg/L + 4.3 mg/L. The correlation coefficient between δ^{15}N versus nitrate for each well is 0.10 which is <90% significant by the t-Test.

The following observations may be made by comparing the data with published $\delta^{15}N$ data:
1. Fertilizer has a range of $\delta^{15}N$ lower than animal waste with no overlap of the range of values. However, septic tank waste may have a wider range of $\delta^{15}N$ which may overlap slightly with the higher $\delta^{15}N$ values for fertilizer.
2. Unfertilized soil has a range of $\delta^{15}N$ isotope values generally between the range of values for fertilizer and animal waste.
3. Groundwater beneath fertilized sites reported in the literature have higher $\delta^{15}N$ than the fertilizer used at the surface. This increase in $\delta^{15}N$ may be due to fractionation processes that occur within the soil during infiltration.
4. Cultivated land in West Texas has a wide range of $\delta^{15}N$ isotope values with the range wider than and not overlapping with the range for fertilizer used in West Texas. The range of $\delta^{15}N$ for cultivated land does overlap with the range of values for animal waste of West Texas.
5. The range of $\delta^{15}N$ for the subdivisions in Wisconsin overlaps with the range of values for cultivated and unfertilized soil in Texas, unfertilized soil in Nebraska, septic tank waste, and, in part, with animal waste.

Denitrification and volatilization are possible fractionation processes that increase $\delta^{15}N$. The denitrification of nitrate is subject to a large kinetic isotope effect, which results in an increase in $\delta^{15}N$ in the remaining nitrate. The extent of denitrification in the vadose zone beneath the subdivisions is unknown. However, the sandy well drained soils which underlie the subdivisions are more likely to promote nitrification and less likely to promote denitrification than more clay rich poorly drained soils. Volatile loss of gaseous ammonia is another possible cause of isotopic fractionation of fertilizer nitrogen applied in reduced forms (NH_4 and organic N). This process was found to be responsible for most of the ^{15}N isotope enrichment in nitrate produced from the nitrification of animal waste, and to be active when ammonium-based fertilizers were applied to basic soils. The extent of volatilization in the soil beneath or upgradient of the subdivisions is unknown.

The following are possible interpretations of the $\delta^{15}N$ data.
1. The $\delta^{15}N$ for the subdivisions indicate a source from fertilizers with isotope fractionation processes within the soil raising the $\delta^{15}N$ from less than 2 up to within the range of 3.6 to 10.5.
2. The $\delta^{15}N$ for the subdivisions indicate a septic tank waste source especially for the higher values (9.8, 10.1, and 10.5) in Sandy Knolls subdivision.
3. The $\delta^{15}N$ for the subdivisions indicate neither a fertilizer or septic-tank waste source but an unfertilized soil source.
4. The $\delta^{15}N$ for the subdivisions indicate some combination of a fertilizer source, septic tank waste source, or unfertilized soil source.

Conclusion: The $\delta^{15}N$ data for the water-supply well samples within the six subdivisions is inconclusive as to the source of nitrate in the wells.

Key Words: nitrogen isotope, subdivision, nitrate, septic systems, animal waste, fertilizer

Funding: DNR

Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.