Ohio Research

Nitrate in Private Rural Water Supplies: Building Local Data Bases

By David B. Baker

Information on nitrate (NO_3) contamination in local areas can support the development of locally appropriate responses to concerns regarding agricultural contamination of groundwater. Often, local data are unavailable. Since NO_3 contamination is so variable, national, statewide and even county average data may be of little use in optimally addressing local groundwater issues. Cooperative well testing programs provide a rapid, efficient and low cost means to develop local data bases.

IS CONTAMINATION of private drinking water supplies with NO_3 a problem in your county, in your neighborhood, or your own well? Can you respond to these concerns as they relate to nitrogen (N) fertilizer rates, sources of N, and N use efficiency? Can you support your answers with relevant data? The answers may have a significant impact on the future choices you will have in N fertilizer management.

To help agricultural organizations develop local data bases on the extent of NO_3 and pesticide contamination, our laboratory, in cooperation with the American Farm Bureau Federation, has developed the Cooperative Private Well Testing Program. In this program, local organizations, such as soil and water conservation districts or Farm Bureau groups, sponsor a county-wide well testing program. Individual residents, who volunteer to participate, pay a relatively low fee to have their wells tested and receive a confidential report on their well. The sponsoring organizations receive summaries and maps of the results from all wells tested in their county.

Since 1987, 34,000 rural residents from 276 counties and 15 states have submitted water samples to our laboratory for testing as part of this program. The kinds of data generated are illustrated in this report. All NO_3 concentrations are reported as NO_3-N.

Overall Results

The distribution of NO_3-N concentrations in the entire data set is shown in **Figure 1**. Nitrate concentrations in excess of the safe drinking water standard were present in 3.8 percent of the wells tested. The standard is 10 milligrams per liter (mg/L) or 10 parts per million (ppm). In another 11.9 percent, NO_3-N concentrations fell between 3.0 and 10 ppm. Together, these two groups represent the fraction of wells in which NO_3-N concentrations are likely to be reflecting the effects of various human activities. In 21.3 percent of the wells tested, NO_3-N concentrations fell between 0.3 and 3.0 ppm, while in the remaining 63 percent, concentrations were less than 0.3 ppm. On a nationwide basis, the U.S. Environmental Protection Agency (EPA) has estimated that NO_3-N exceeds the safe drinking water standard in about 2.4 percent of the approximately 10.5 million rural domestic wells.

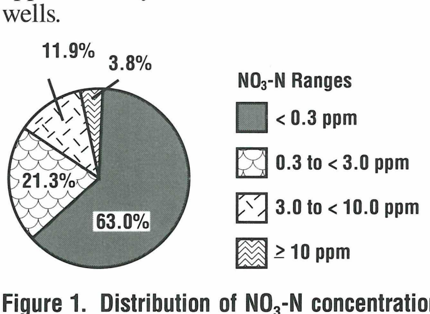

Figure 1. Distribution of NO_3-N concentrations in 33,753 private water supplies.

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State-to-State Variability

Extensive testing of private water supplies by state agencies is largely confined to those states with greater vulnerability to NO_3-N contamination, such as Iowa and Nebraska. Recent studies in Iowa suggest that NO_3-N exceeds 10 ppm in about 18 percent of that state's private wells. In Nebraska, about 20 percent of the well samples tested for NO_3-N exceed 10 ppm, although Nebraska data don't necessarily reflect statewide conditions.

As part of our program, extensive private well testing has been extended to states which are less vulnerable to NO_3-N contamination. In **Table 1**, the extent of NO_3-N contamination in the eight states with the largest participation is summarized. For most of these states, only a small proportion of the counties has been tested, and consequently, the NO_3-N concentration data are not necessarily representative of the entire state. In Ohio, Indiana and Kentucky, the three states with the largest data sets, the portion of wells exceeding 10 ppm NO_3-N was only 3.0 percent, 3.5 percent and 4.6 percent, respectively.

County-to-County Variability

One of the more striking features of the data set is the extensive variability among counties with regard to NO_3-N concentrations. **Figure 2** illustrates the variability for the 201 counties for which there were 25 or more wells tested. In 71 counties, the average concentrations were between 0 and 1.0 ppm. County average concentrations exceeded 3.0 ppm in 28 counties.

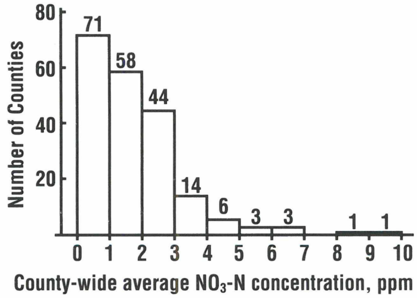

Figure 2. Distribution of county average NO_3-N concentrations.

Figure 3 illustrates the variability among these same counties in the percentage of wells exceeding the safe drinking water standard. In 88 counties, NO_3-N exceeded 10 ppm in less than 2 percent of the wells. In 23 counties, more than 8 percent of the wells tested exceeded 10 ppm. These graphs indicate that, for the large majority of counties, NO_3-N contamination is uncommon.

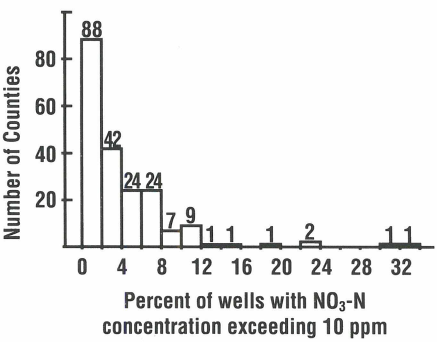

Figure 3. Distribution of the percentage of wells exceeding the drinking water standard.

Table 1. Summary of NO_3-N data for states with largest participation in the Cooperative Private Well Testing Program.

State	Counties tested	Number of samples	Average concentration NO_3-N, ppm	Percent over 10 ppm NO_3-N
Illinois	8	286	5.76	19.9%
Indiana	33	5,685	0.92	3.5%
Kentucky	90	4,559	2.50	4.6%
Louisiana	23	997	1.19	0.8%
New Jersey	5	1,108	2.60	6.8%
Ohio	80	18,202	1.32	3.0%
Virginia	24	1,054	2.92	7.1%
West Virginia	13	1,288	0.83	0.8%
Totals	276	33,179	1.54	3.5%

Many of the counties with low levels of NO_3-N contamination are counties in which row crop agriculture is the dominant land use. In Ohio, there is no correlation between county N fertilizer sales and county average NO_3-N concentrations (**Figure 4**). For these same Ohio counties, there is a correlation between vulnerability to contamination, as estimated by a groundwater vulnerability model, and NO_3-N contamination in wells (**Figure 5**).

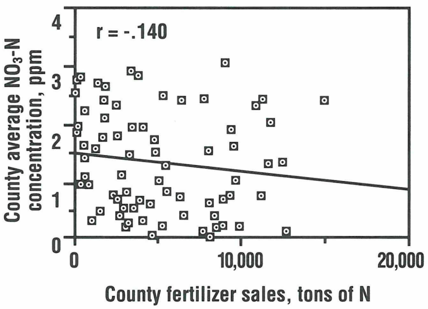

Figure 4. Relationship of county N fertilizer sales and county average NO_3-N concentrations.

Within County Variability

Often NO_3-N contamination is much more prevalent in some areas of a county than in other areas. Our testing program provides maps which illustrate the patterns of NO_3-N concentration in individual counties. Those familiar with the soils, geology and land use in a particular county can often provide logical explanations for the NO_3-N contamination patterns evident in the county maps.

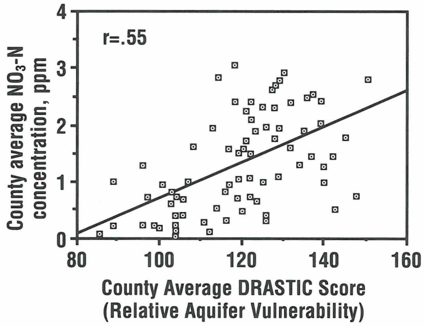

Figure 5. Relationship between county average NO_3-N concentration and county average vulnerability.

Individual Well Characteristics

Several characteristics of well construction also influence the likelihood of NO_3-N contamination in private wells. Along with the water sample, each participant in this program submits a sheet containing information about well construction. Comparisons of NO_3-N concentrations with data from the information sheets illustrate these relationships (**Table 2**). As a whole, springs, dug wells and driven wells (e.g., sand point wells) have much greater levels of contamination than drilled wells. **Shallow wells and older wells are more likely to be contaminated than deeper wells and newer wells.**

Table 2. Summary of well characteristics in relationship to NO_3-N concentration.

Well characteristic	Number of samples	Average concentration NO_3-N, ppm	Percent over 10 ppm NO_3-N
Year Drilled Summary			
1800s	244	4.01	13.1%
1900-1949	2,940	2.03	5.6%
1950-1970	7,475	1.32	2.9%
after 1970	10,377	1.12	2.3%
Well Depth Summary			
< 50 ft.	5,042	2.45	8.5%
50-100 ft.	10,167	1.42	3.5%
over 100 ft.	8,250	0.94	1.6%
Construction Type			
Drilled	12,750	1.43	3.5%
Driven	1,263	2.84	8.8%
Dug	1,080	4.75	12.5%
Springs	1,550	2.91	5.7%

Temporal Variability

Surveys of the type conducted in this program provide a "snapshot" in time of the NO_3-N concentrations in water rural residents are consuming. How constant are the concentrations in private rural wells? In Ohio, we have conducted follow-up studies in which we have monitored individual wells on a weekly or biweekly basis for a year. When we selected wells simply on the basis of existing levels of contamination (i.e., we wanted to be sure the wells initially contained NO_3-N), we found that there was a large month-to-month variability in individual wells, and that the amount of variability increased with increasing initial concentration. Nitrate concentrations in many wells were below the drinking water standard some of the time, but above the standard at other times. Seasonal effects were not evident. When we selected wells based on information regarding (1) the specific aquifer tapped by the well, (2) indications of proper well construction and (3) the occurrence of NO_3-N contamination, the choices of wells for study became quite restricted and the extent of variability observed was much less.

These results suggest that, at least for Ohio, most contaminated wells are either tapping shallow aquifers that respond rather quickly to variations in weather conditions or are improperly constructed or maintained, such that contaminated surface water periodically enters the well.

Trends in Nitrate Concentrations

While many wells in agricultural areas currently show essentially no evidence of NO_3-N contamination, it would be very useful to know whether or not a continuation of current agricultural N management practices in these same areas would eventually lead to increasing levels of NO_3-N contamination. Information regarding current and future trends in NO_3-N contamination is very difficult to obtain. This question can be approached either through research on the fate of N within the soil and unsaturated zone along groundwater recharge pathways or by the establishment of appropriate trend monitoring programs. Programs to address the issue of long-term trends in NO_3-N contamination are being initiated in several areas. It is likely that the answers to this question will also be site specific.

Conclusions

Information on NO_3-N contamination in rural private wells underscores the following:

- The extent of NO_3-N contamination in rural wells varies greatly from region to region.
- In most areas, NO_3-N contamination is uncommon.
- Minimal NO_3-N contamination is present in many areas of intensive row crop agriculture, while areas of more extensive contamination occur both in agricultural and nonagricultural regions.
- Shallower and older wells are more likely to be contaminated than deeper and newer wells; and springs, driven wells and dug wells are more likely to be contaminated than drilled wells.
- Where contamination is present, NO_3-N concentrations often exhibit considerable month to month variability, especially when the wells are tapping shallow aquifers and/or suffer from faulty construction.
- The question of appropriate N management in a given area depends not only on the current extent of NO_3-N contamination in that area, but also on local trends in contamination.

Cooperative private well testing programs offer a means to rapidly develop a local data base on the extent of NO_3-N contamination in private rural wells in a given area. The resulting information can be used to help assure that agricultural programs addressing groundwater concerns are appropriate for the local conditions. Rural well contamination is generally a local problem requiring local solutions, and local solutions often benefit from local data. ■