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What Is Nitrate and Why Is It Important?

Nitrate (NO_3^-) is composed of the elements oxygen and nitrogen, and is an important source of nitrogen for plant and animal life; but too much nitrate in drinking water can be harmful to human health. Common sources of nitrate in water include plant and animal matter, human and animal waste, household septic systems, and fertilizers. Because it dissolves readily in water, nitrate from these sources is usually present at least in low concentrations in drinking-water supplies, regardless of the water source.

Utility companies that provide public water supplies test the water for concentrations of nitrate. This testing is much less common for private water supplies, however. More than 900,000 people in Kentucky use ground-water supplies, including approximately 500,000 supplied through public utilities and at least 400,000 using private wells or springs.

Excess nitrate in drinking water has been found to cause methemoglobinemia, or Blue Baby Syndrome, in infants less than 6 months old (Kross and others, 1992; Bruning-Fann and Kaneene, 1993). The U.S. Environmental Protection Agency has established maximum contaminant levels (MCL's) for nitrate in public drinking water because of health concerns. The MCL for nitrogen can be expressed as units of nitrate (NO_3^-) or as units of nitrogen (N), referred to as nitrate-nitrogen (nitrate-N or NO_3^--N). The MCL expressed as units of nitrate is 45 milligrams per liter (mg/L). The MCL expressed as units of nitrate-nitrogen is 10 mg/L (U.S. Environmental Protection Agency, 1994). Some laboratories use the term "parts per million" (ppm), which is essentially equivalent to mg/L in fresh water. Because most laboratories report nitrate as units of nitrate-nitrogen, that form of measurement is used in this report.

Water-Quality Variations

The map shows the concentration of nitrate-nitrogen in private wells, public wells, and springs across Kentucky. Samples were collected from the 1940's to the mid-1990's. Less than 1 percent of the wells are industrial monitoring wells. Red squares indicate concentrations greater than 10 mg/L (exceeding the MCL), green dots indicate concentrations above 5 and up to 10 mg/L, and black dots indicate concentrations less than or equal to 5 mg/L.

The map and table show some of the broad patterns of high, moderate, and low concentrations of nitrate in Kentucky ground water. The concentration measured at individual monitoring points may not represent present-day conditions, however. Caution should be used in interpreting the significance of individual monitoring points shown on the map.

The distribution of samples analyzed for nitrate is not uniform. For example, several counties in the Blue Grass Region and the Eastern Kentucky Coal Field have analyses for fewer than 15 wells or springs, whereas a few counties in other parts of the State have more than 60. Sampling information from the Kentucky Ground-Water Data Repository used in this report does not have a uniform distribution because it was compiled from several different sampling programs. Some of these sampling programs targeted specific areas in Kentucky. Most sampled springs are in karst areas, where natural conduits in rock are large and sinkholes are present in nearby terrain. Most of the karst of Kentucky is in the Blue Grass and Pennyroyal Regions.

Data used in this report are from sites that were sampled at various times of the year. The time of year that samples are collected can affect the nitrate concentration detected. Some wells and springs have a greater concentration of nitrate from mid-December to mid-February. Some sites may also have a higher concentration within days or weeks of nearby use of fertilizers or application of manure.

The map shows the physiographic regions of Kentucky. The topography, geology, dominant soil types, and ground-water flow systems are quite different in the different regions. The physical and biological environment of a region affects the occurrence and movement of nitrate in ground water, and how quickly nitrate is reduced in the subsurface.

Other factors can also have a local influence on contamination of ground water. If a well is located near an inefficient septic system, nitrate may enter shallow ground water at high concentrations. Frequent use of nitrate fertilizers or concentrated application of manure may also locally contaminate the ground water. Ineffective seals around well casings may allow unrestricted downward movement of contaminated shallow ground water.

Nitrate-nitrogen concentrations are grouped by well depth in the table. Concentrations from sampled springs are also listed. Data for a well were included in the table

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only if the well's total depth was on record, or if the well was hand-dug. Some sites were sampled more than once; when more than one analysis was available, the analyses were averaged to produce one average value for the site. For example, for wells from 0 to 50 ft deep, there were 842 sites and 1,051 analyses; some of those 842 sites had been sampled more than once.

Percentiles in the table show the portion of wells that are equivalent to or below a given concentration. For example, for wells from 0 to 50 ft deep, 50 percent of the wells had a nitrate-nitrogen concentration of 1.2 mg/L or less, and 90 percent of the wells had a concentration of 8.3 mg/L or less.

Hand-dug wells are grouped in the second column of the table, but some of the wells in the 0–50 ft category are also hand-dug. Hand-dug wells are generally less than 50 ft deep and therefore are represented in both the hand-dug category and the 0–50 ft category.

Data in the table show that the MCL was exceeded in approximately 10 percent of hand-dug wells (38 out of 391), 7 percent of wells from 0 to 50 ft deep (59 out of 842), 5 percent of wells from 51 to 100 ft deep (77 out of 1,506), 3 percent of wells from 101 to 150 ft deep (25 out of 737), and 1 percent of wells from 151 to 500 ft deep (7 out of 660). For all wells (0–500 ft category), approximately 4.5 percent exceeded the MCL. Approximately 3 percent of sampled springs (31 out of 1,018) exceeded the MCL.

These data show that the likelihood of well contamination is highly dependent on well depth. Concentrations over the MCL are most common in hand-dug wells, and least common in wells more than 150 ft deep. Hand-dug wells are especially prone to contamination because they are recharged by very shallow ground water, and shallow ground water generally has higher concentrations of nitrate than deep ground water.

Water-Quality Concerns

Citizens with concerns about the quality of water in private wells or springs should contact their local health department or the Groundwater Branch of the Kentucky Division of Water, which is a division of the Kentucky Natural Resources and Environmental Protection Cabinet (Frankfort). The Groundwater Branch can provide literature on maintenance of private wells and information on sampling for water analysis.

How Did This Publication Come About?

This publication is a product of the Kentucky Interagency Ground-Water Monitoring Network (GNet) program. The Kentucky Geological Survey was mandated by the Kentucky legislature in 1998 to implement the long-term monitoring network in coordination with other agencies (KRS 151.625) and to report on the characteristics of ground-water resources. A portion of the sampling required for long-term ground-water characterization has been implemented, and various agencies are taking an active role. The first reports by the GNet program use both new and old data in order to view broad trends in ground-water quality.

GNet program activities offer increased consistency in data collection methods, both geographically and over time. Data collected by GNet are available to the public through the Kentucky Ground-Water Data Repository at the Kentucky Geological Survey. The program also uses these data in reports that characterize the quality, quantity, and availability of Kentucky's ground-water resources.

The Interagency Technical Advisory Committee on Groundwater (ITAC) was also created by statute (KRS 151.629). ITAC provides advice and assistance to GNet. ITAC is chaired by the director of the Kentucky Water Resources Research Institute and has representatives from 14 agencies:

- Kentucky Department for Environmental Protection
- Kentucky Department for Natural Resources
- Kentucky Department for Surface Mining Reclamation and Enforcement
- Kentucky Department of Mines and Minerals
- Kentucky Division of Conservation
- Kentucky Division of Environmental Health and Community Safety
- Kentucky Division of Forestry
- Kentucky Division of Pesticides
- Kentucky Division of Waste Management
- Kentucky Division of Water
- Kentucky Geological Survey
- Kentucky Water Resources Research Institute
- U.S. Geological Survey
- University of Kentucky College of Agriculture

The Kentucky Ground-Water Data Repository

The Kentucky Ground-Water Data Repository was established to archive and distribute ground-water data and was an important source of data for this report. Sources of data for the repository include the Kentucky Division of Water, Kentucky Geological Survey, U.S. Geological Survey, National Uranium Resource Evaluation Program, and the U.S. Environmental Protection Agency. Types of computerized data in the repository include general water-well information, water-quality data, trace-organic analysis, spring data, discharge measurements, and ground-water dye-trace data. Because the various sampling organizations have different sampling methods, the accuracy of these data cannot be guaranteed. The repository is located at the Kentucky Geological Survey in the Mining and Mineral Resources Building on the University of Kentucky campus in Lexington.

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For further information contact:
Manager, Office of Communications and Technology Transfer
Kentucky Geological Survey
228 Mining and Mineral Resources Building
University of Kentucky
Lexington, KY 40506-0107

Nitrate-Nitrogen (mg/L)

Dissolved and total nitrate-nitrogen in sampled wells and springs of Kentucky.
Data used are a composite of sampling from the 1940's to the present.

Depth of wells (ft)	*Dug wells*	*0–50*	*51–100*	*101–150*	*151–500*	*0–500*	*Springs*
Maximum	150	150	67	97	76	150	34
90th percentile	9.6	8.3	7.2	6.1	2.7	6.7	4.0
75th percentile	4.9	3.7	3.3	2.6	1.1	2.8	2.2
50th percentile (median)	1.9	1.2	0.7	0.6	0.2	0.6	1.0
25th percentile	0.6	0.2	0.1	0.1	0.1	0.1	0.5
10th percentile	0.2	0.1	nd	nd	nd	nd	0.1
Minimum	nd	nd	nd	nd	nd	nd	nd
Average	4.3	3.1	2.5	2.3	1.3	2.4	1.7
Standard deviation	10.0	6.7	4.6	5.7	4.6	5.4	2.3

Sites with nitrate-nitrogen data	391	842	1,506	737	660	3,745	1,018
Sites averaging above MCL (10 mg/L)	38	59	77	25	7	168	31
Percent above MCL	9.7%	7.0%	5.1%	3.4%	1.1%	4.5%	3.0%
Sites averaging above ½ MCL	95	157	247	99	29	532	136
Percent above ½ MCL	24.3%	18.6%	16.4%	13.4%	4.4%	14.2%	13.4%
Number of analyses for sites	391	1,051	1,668	931	839	4,489	2,604
Number of analyses above MCL	38	59	89	26	9	183	36
Number of analyses above ½ MCL	95	180	259	108	30	577	172
Total sites known in Kentucky						> 200,000	unknown

nd=not detected

EXPLANATION

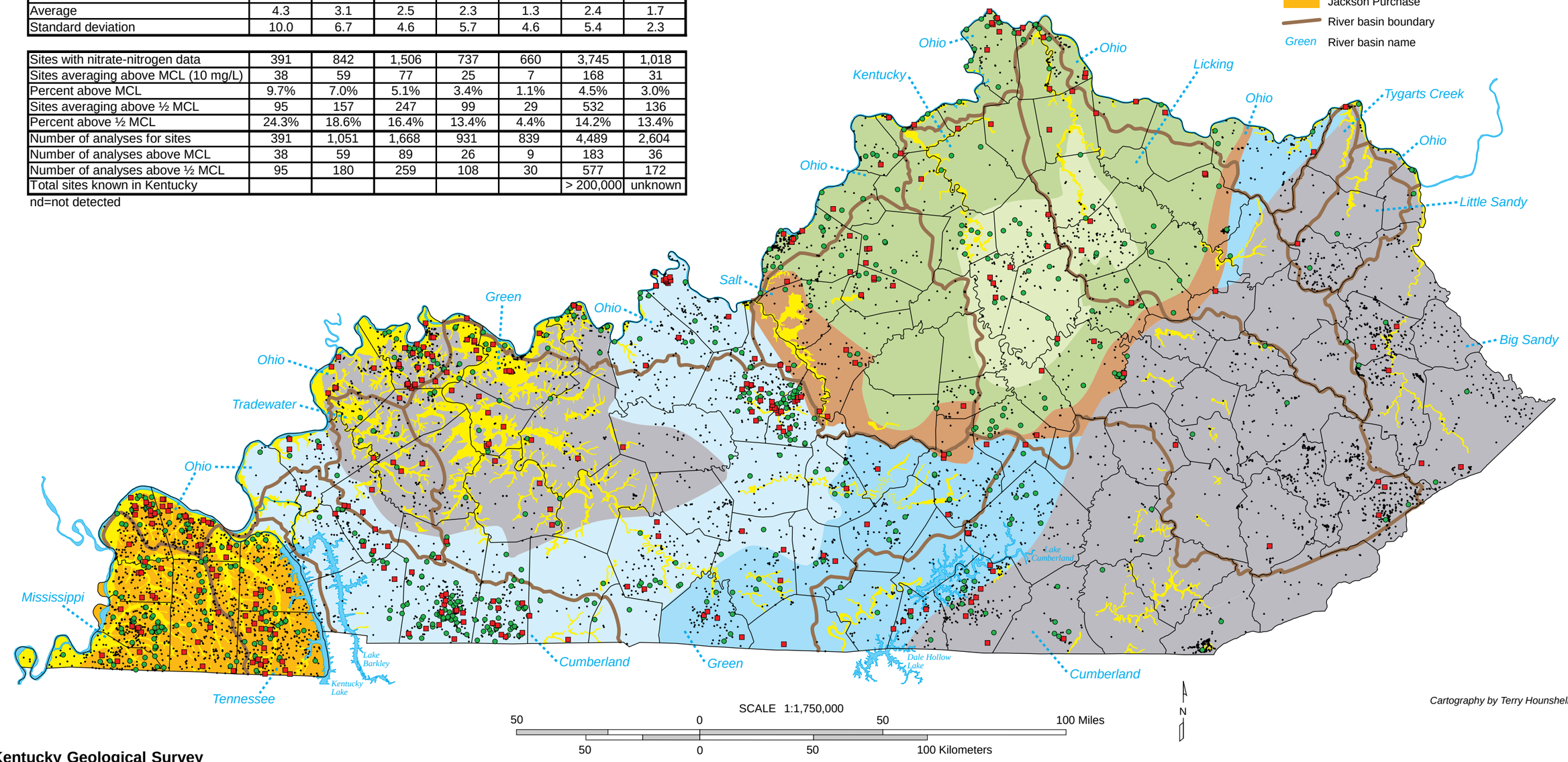
Nitrate-nitrogen concentrations

- Greater than 10 mg/L
- 5.1 to 10 mg/L
- less than or equal to 5 mg/L

Data from Kentucky Ground-Water Data Repository, July 1998

Physiographic areas

- Eastern and Western Kentucky Coal Fields
- Inner Blue Grass
- Outer Blue Grass
- The Knobs
- Eastern Pennyroyal
- Western Pennyroyal
- Alluvium or glacial deposits
- Jackson Purchase
- River basin boundary
- Green — River basin name



SCALE 1:1,750,000

50 0 50 100 Miles

50 0 50 100 Kilometers

N

Cartography by Terry Hounshell

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NITRATE-NITRATE-NITROGEN CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY

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