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Ground-Water Quality in Kentucky: Fluoride

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What Is Fluoride and Why Is It Important?

Fluoride (F^-) is an ion of the element fluorine, and is a natural component in most water resources. According to Hem (1989), fluoride concentrations in fresh water are generally less than 1 mg/L (milligrams per liter), and the concentration of fluoride in the world's oceans is about 1.3 mg/L. The source of most fluoride in natural fresh-water resources is various rocks and minerals in bedrock and sediments.

Because of fluoride's proven value in maintaining healthy teeth and bones (Richmond, 1985), it is added to public water systems in Kentucky. The concentration in public water supplies is approximately 1 mg/L.

Although fluoride has a beneficial effect within a range of low concentrations, at higher concentrations it may cause fluorosis, which is indicated in more severe cases by brown staining or mottling of teeth (Jackson and others, 1995). The U.S. Environmental Protection Agency has established a maximum contaminant level (MCL) for fluoride in public drinking water of 4 mg/L and a secondary, or aesthetic, standard of 2 mg/L (U.S. Environmental Protection Agency, 1996). Some laboratories use a measurement unit of parts per million (ppm), which is essentially equivalent to mg/L in fresh water.

Utility companies that provide public water supplies test the water for concentrations of fluoride. 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 private wells or springs.

Water-Quality Variations

The map shows the concentration of fluoride in 4,306 private wells, public wells, monitoring 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 4 mg/L (exceeding the MCL), blue dots indicate concentrations above 2 mg/L (half of the MCL) to 4 mg/L, green triangles indicate concentrations greater than 0.5 to 2.0 mg/L, and black dots indicate concentrations up to 0.5 mg/L.

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

The distribution of samples analyzed for fluoride 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 100. 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.

The map shows the physiographic regions of Kentucky. The physical environment of a region affects the occurrence and movement of fluoride in ground water. The topography, geology, dominant soil types, and ground-water flow systems vary significantly from region to region. This helps explain some of the variation in fluoride concentrations among the sampled sites.

Fluoride 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 only if the well's total depth was on record. Some wells shown on the map did not have depth information recorded, and therefore are not represented in the table. Only two of the wells with a fluoride analysis were known to be hand dug, so there were too few data points to separately show descriptive statistics for hand-dug wells. Data for these two wells were grouped with other wells that were less than 50 ft deep.

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 681 sites and 1,008 analyses; some of those 681 sites had been sampled more than once. The average values were also used to determine the percentiles shown in the table.

Percentiles in the table show the portion of sites that are equivalent to or below a given concentration. For example, for wells from 51 to 100 ft deep, 50 percent of the wells had a

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fluoride concentration of 0.2 mg/L or less, and 90 percent of the wells had a concentration of 0.8 mg/L or less. The maximum value recorded for wells in this depth range was 78 mg/L.

Data in the table show that the MCL was exceeded in no wells from 0 to 50 ft deep (0 out of 639), less than 1 percent of wells from 51 to 100 ft deep (6 out of 708), less than 1 percent of wells from 101 to 150 ft deep (3 out of 397), and 1.3 percent of wells from 151 to 500 ft deep (7 out of 519). For all wells (0–500 ft category), less than 1 percent exceeded the MCL (16 out of 2,363). The MCL was exceeded in no spring samples (0 out of 367).

The summary table indicates fluoride concentration is related to well depth. Deep wells are likely to have a greater concentration of fluoride than shallow wells or springs. This trend indicates that most fluoride in wells is not from contamination of shallow ground water by human activities at the land surface. Rather, the sources of most fluoride are the minerals in bedrock and sediments that contain the element fluorine (Hem, 1989). In the Eastern Kentucky Coal Field, high fluoride concentration is strongly associated with ground water containing relatively high concentrations of sodium and bicarbonate with a pH greater than 8.0 (Wunsch, 1992). This type of ground water is usually found in wells that penetrate deep into the interior of a hill or ridge.

Deep ground water originates as rainfall that has infiltrated into the ground and moved downward into the rocks. Therefore, deeper water has generally spent a longer time in the subsurface than more shallow ground water. This greater time allows more minerals in the rock, such as fluorite, to dissolve into the 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 Groundwater 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. Some adjustment of sampling sites and additional monitoring will be required for a more representative view of Kentucky ground water. Data collected by GNet are available to the public through the Kentucky Ground-Water Data Repository at the Kentucky Geological Survey. The program 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.

References Cited

Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water [3d ed.]: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Jackson, R.D., Kelly, S.A., Katz, B.P., Hull, J.R., and Stookey, G.K., 1995, Dental fluorosis and caries prevalence in children residing in communities with different levels of fluoride in the water: Journal of Public Health Dentistry, v. 55, no. 2, p. 79–84.

Richmond, V.L., 1985, Thirty years of fluoridation: A review: American Journal of Clinical Nutrition, v. 41, no. 1, p. 129–138.

U.S. Environmental Protection Agency, 1996, Drinking water regulations and health advisories: U.S. Environmental Protection Agency, EPA 822-B-96-002, 11 p.

Wunsch, D.H., 1992, Ground-water geochemistry and its relationship to the flow system at an unmined site in the Eastern Kentucky Coal Field: Kentucky Geological Survey, ser. 11, Thesis Series 5, 128 p.

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228 Mining and Mineral Resources Building
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Lexington, KY 40506-0107

Fluoride (mg/L)

Fluoride concentrations 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)	*0–50*	*51–100*	*101–150*	*151–500*	*0–500*	*Springs*
Maximum	2.6	78	6.4	15	78	2.4
90th percentile	0.50	0.80	1.20	2.00	1.00	0.30
75th percentile	0.20	0.30	0.40	0.66	0.31	0.20
50th percentile (median)	0.10	0.20	0.20	0.20	0.15	0.10
25th percentile	0.10	0.10	0.10	0.10	0.10	0.08
10th percentile	nd	nd	nd	nd	nd	nd
Minimum	nd	nd	nd	nd	nd	nd
Average	0.22	0.48	0.43	0.63	0.42	0.17
Standard deviation	0.32	3.04	0.73	1.14	1.78	0.28

Sites with fluoride data	639	708	397	519	2,263	367
Sites above MCL (4 mg/L)	0	6	3	7	16	0
Sites above ½ MCL	6	18	15	49	88	2
Sites from above 0.5 to 2 mg/L	44	91	63	103	301	12
Sites at 0.5 mg/L or less	589	599	319	367	1,874	353
Number of analyses for sites	931	911	701	739	3,282	1,566
Number of analyses above MCL	1	8	3	8	20	4
Number of analyses above ½ MCL	9	27	18	60	114	9

nd=not detected

Data from Kentucky Ground-Water Data Repository, July 1999

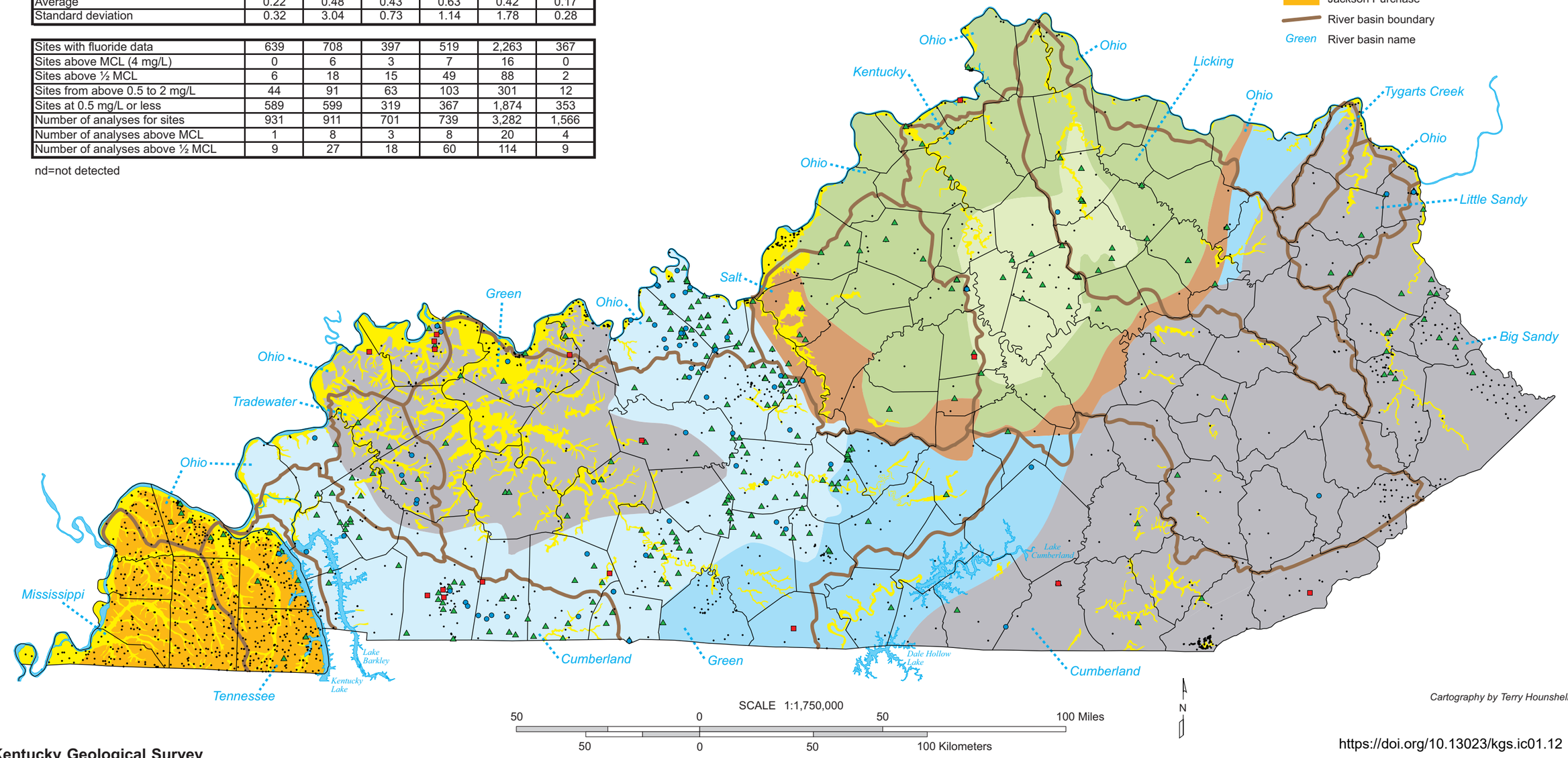
EXPLANATION

Fluoride concentrations

- Greater than 4.0 mg/L
- Greater than 2.0 and less than or equal to 4.0 mg/L
- Greater than 0.5 and less than or equal to 2.0 mg/l
- Less than or equal to 0.5 mg/L

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

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Cartography by Terry Hounshell

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FLUORIDE CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY

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