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R. Stephen Fisher  
*University of Kentucky*

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# Groundwater Quality in Kentucky: Arsenic

R. Stephen Fisher  
Kentucky Geological Survey

## Introduction

Arsenic is a naturally occurring element found in low concentrations in rocks, soils, water, plants, and animals (Nriagu, 1994a, b). In Kentucky, arsenic is commonly found in iron sulfide minerals associated with coal deposits and black shales. Arsenic is released when iron sulfides oxidize during weathering. Once released, it is readily sorbed onto iron oxides and iron oxyhydroxides, which limits arsenic concentrations in the near-surface environment.

Arsenic is used as a wood preservative and in paints, dyes, metals, drugs, soaps, semiconductors, animal feed additives, and herbicides. From 1860 through 1910 arsenic was heavily used in embalming fluids. It was banned in 1910 because it interfered with investigations into suspected poisoning deaths; old graveyards may still be a source of arsenic in groundwater (Fetter, 1992). Waste-disposal sites and landfills may be sources of arsenic contamination because of the materials disposed of there, and coal combustion can release arsenic to the atmosphere. Hydrocarbons from leaking underground storage tanks can dissolve iron oxide minerals in soils, thus releasing naturally occurring arsenic to the environment (Welch and others, 2000).

Long-term exposure to arsenic in drinking water has been linked to health problems such as cancer of the skin, bladder, lungs, kidneys, nasal passages, liver, and prostate. Arsenic has also been linked to damage of the cardiovascular, pulmonary, immunological, neurological, and endocrine systems (U.S. Environmental Protection Agency, 1998). Because of these health effects, the U.S. Environmental Protection Agency (EPA) set the maximum contaminant level (MCL) for arsenic in drinking water at 50 parts per billion (ppb, or 0.050 mg/L) in 1974. In 2001 the EPA announced that this MCL will be lowered to 10 ppb (0.010 mg/L). Water-supply systems must meet the new MCL by January 2006.

## Concentrations in Groundwater

### Data Sources

Data for this report were extracted from the Kentucky Groundwater Data Repository, which is housed at and maintained by the Kentucky Geological Survey. The repository was established in 1990 to archive and distribute groundwater data collected throughout Kentucky. Sources of data for the repository include the Kentucky Division of Water, Kentucky Geological Survey, U.S. Geological Survey, National Uranium Resource Evaluation Program, U.S. Environmental Protection Agency, and other research programs.

The initial database query produced 7,081 analyses of arsenic from wells and springs throughout the Commonwealth. Data from RCRA (Resource Conservation and Recovery Act), Solid Waste, and Underground Storage Tank regulatory programs

were removed from the data set in order to exclude results from sites known or suspected to be contaminated. Many of the remaining results were censored data; that is, data reported only as being below a detection limit. Detection limits ranged from 0.052 to 0.0002 mg/L. Some of these censored values were useless because the detection limit exceeded the MCL. Because the new MCL is 0.010 mg/L, analytical results reported as less than a detection limit of 0.010 mg/L or greater were removed from the data set. Finally, some groundwater samples were collected from Kentucky Division of Water monitoring wells, but the monitoring program was not identified. These wells were probably installed to check for leaking underground storage tanks. Because hydrocarbons can dissolve iron oxides and thus release arsenic from soils, arsenic results greater than 0.010 mg/L from such monitoring wells were excluded. The final data set contained 4,402 measurements of arsenic from 930 sites, including 2,391 analyses of total arsenic (unfiltered groundwater) and 2,011 analyses of dissolved arsenic (filtered groundwater). Of the 4,402 measurements, 73 percent of the values were reported as less than 0.002 mg/L.

For this report, no distinction was made between total and dissolved arsenic in groundwater. MCL values are based on total concentrations; however, these measurements can also include arsenic associated with suspended particulate material, which would not necessarily be ingested. Dissolved arsenic concentrations give a better indication of the arsenic content of the terrain through which groundwater flows and would better reveal natural controls on arsenic in groundwater. In cases where both total and dissolved arsenic were measured at the same site, the differences between the two values were usually negligible. Therefore, both dissolved and total values were included in the data set to improve statewide coverage. In addition, the following discussions assign the analytical detection limit to censored data. That is, an analytical result reported as less than 0.005 mg/L is treated as a measured value of 0.005 mg/L. The effect of these data-treatment procedures is to slightly overrepresent actual concentrations and provide a conservative assessment of health risks posed by arsenic in groundwater.

### Regional Variations in Arsenic Concentrations

The map shows sites where arsenic has been measured; different symbols show concentration ranges. Repeatedly sampled sites may have more than one concentration-range symbol, and symbols overlap if sites are close to each other.

Approximately 95 percent of all arsenic measurements are equal to or less than 0.010 mg/L, the new MCL, and approximately 98 percent of all measurements are equal to or less than 0.050 mg/L, the previous MCL.

Many of these measurements represent repeated sampling at the same site. Only 2.4 percent (22 of 930) of the sites yielded arsenic concentrations greater than 0.050 mg/L, and only 6.8

percent (63 of 930) of the sites yielded concentrations greater than 0.010 mg/L (Table 1).

The median value for arsenic in each of Kentucky's physiographic regions is 0.002 mg/L, well below the revised MCL (map). The distribution of values greater than 0.010 mg/L reflects the bedrock lithology throughout Kentucky. In the Eastern Kentucky Coal Field, underlain by sandstone, shale, and coal beds, arsenic exceeded 0.050 mg/L at 11 sites and exceeded 0.010 mg/L at 14 sites (Table 1); in addition, the site with the highest arsenic concentration in the state (0.500 mg/L) was in this region. Similarly, the Knobs (underlain by siltstones and

Table 1. Number of sites having arsenic concentrations (mg/L) in various ranges.

Physiographic Region	> 0.050	0.011 - 0.050	Total > 0.010
Eastern Kentucky Coal Field	11	3	14
Eastern Pennyroyal	0	0	0
Knobs	1	9	10
Outer Bluegrass	1	4	5
Inner Bluegrass	0	0	0
Western Pennyroyal	1	2	3
Western Kentucky Coal Field	2	9	11
Jackson Purchase	6	14	20

shales), Jackson Purchase (underlain by poorly consolidated sands and mudstones), and Western Kentucky Coal Field (underlain by sandstone, shale, and coal beds) each had 10 or more sites where groundwater arsenic concentrations exceeded 0.010 mg/L (Table 1), and maximum concentrations were greater than 0.100 mg/L. Groundwater in the Inner and Outer Bluegrass and the Eastern Pennyroyal Regions generally had low arsenic concentrations and the smallest range of values (Fig. 1).

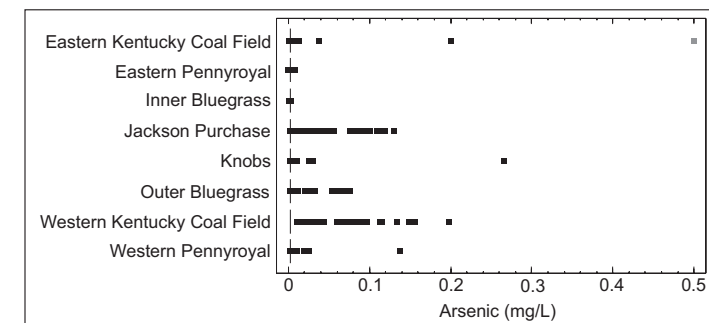


Figure 1. Arsenic concentrations by physiographic region. Vertical lines mark median value for each region.

## Water-Quality Concerns

Arsenic in Kentucky groundwater generally does not exceed the MCL, and there are no widespread occurrences of high arsenic concentrations. Some regions of the Commonwealth are more likely to have high arsenic concentrations in groundwater than others, however. These findings should be viewed as general patterns. Individual wells or springs should be tested for the occurrence of arsenic and other potential contaminants before being used for drinking-water supplies. 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, a division of the Kentucky Natural Resources and Environmental Protection Cabinet. The Groundwater Branch can provide literature on maintenance of private wells and information on sampling for water analysis.

## The Kentucky Interagency Groundwater Monitoring Network

This publication is a product of the Kentucky Interagency Groundwater Monitoring Network, which was established in 1998 by legislation (KRS 151.625) to collect groundwater

quality data, characterize groundwater resources, and distribute the resulting information. The network is assisted by an Interagency Technical Advisory Committee on Groundwater (ITAC), which was also created by statute (KRS 151.629). The following agencies are represented on ITAC:

- 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 Pesticide Regulation
- 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

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Kentucky Geological Survey, University of Kentucky  
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

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Physiographic Region	Number	Minimum	Median	Maximum
Eastern Kentucky Coal Field	897	0.0002	0.0020	0.5000
Eastern Pennyroyal	162	0.0006	0.0020	0.0080
Knobs	198	0.0010	0.0020	0.2650
Outer Bluegrass	482	0.0010	0.0020	0.0760
Inner Bluegrass	356	0.0010	0.0020	0.0040
Western Pennyroyal	1,070	0.0010	0.0020	0.1380
Western Kentucky Coal Field	482	0.0010	0.0020	0.1980
Jackson Purchase	771	0.0010	0.0020	0.1300

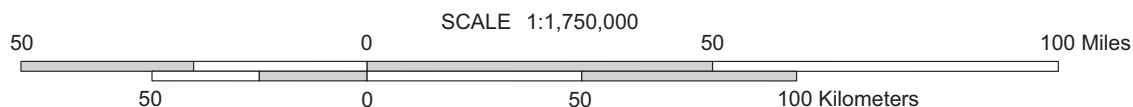
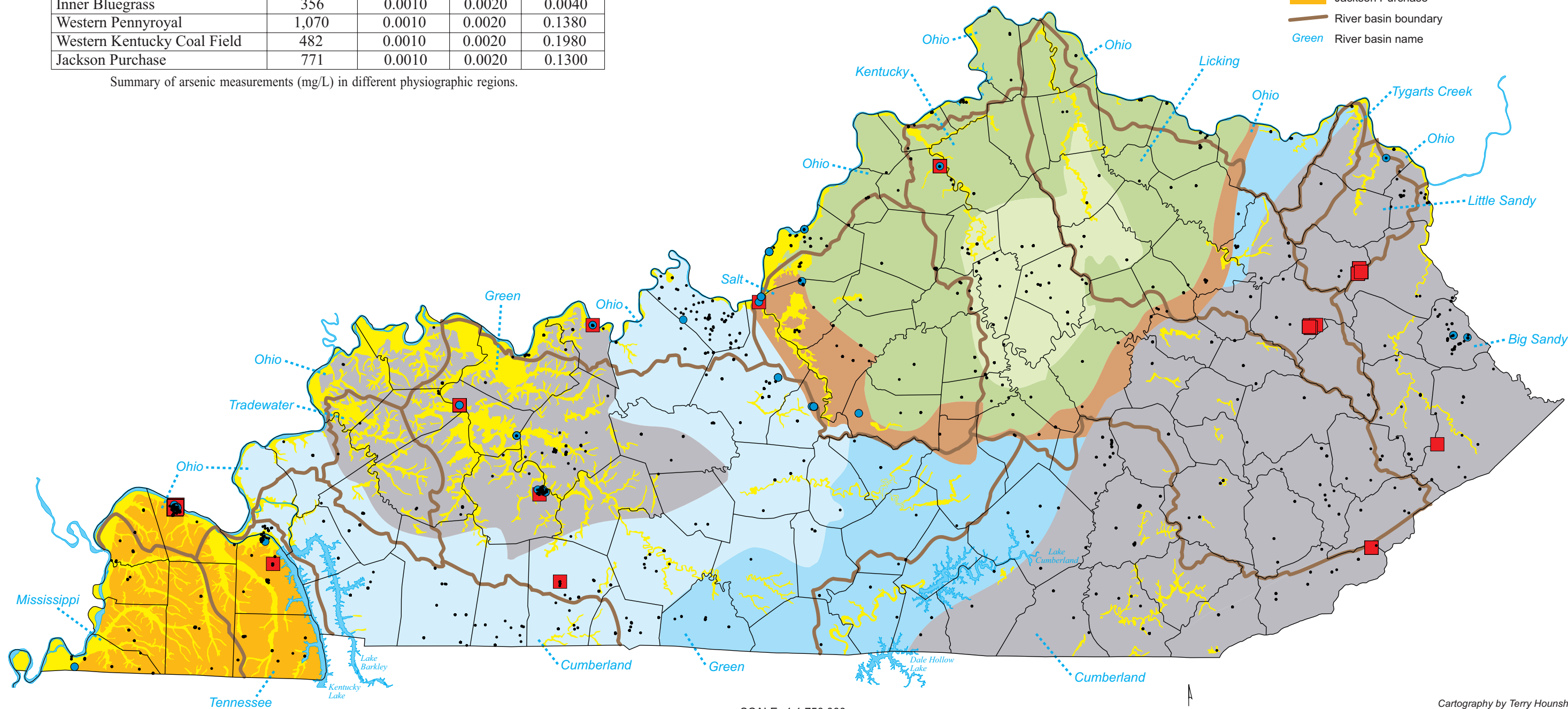
Summary of arsenic measurements (mg/L) in different physiographic regions.

Data from Kentucky Groundwater Data Repository, July 2001

**EXPLANATION**

- Arsenic concentrations**
- Greater than 0.05 mg/L
  - 0.011 to 0.050 mg/L
  - Less than or equal to 0.01 mg/L

- Physiographic areas**
- Eastern and Western Kentucky Coal Fields
  - Inner Bluegrass
  - Outer Bluegrass
  - The Knobs
  - Eastern Pennyroyal
  - Western Pennyroyal
  - Alluvium or glacial deposits
  - Jackson Purchase
  - River basin boundary
  - Green River basin name



Cartography by Terry Hounshell