2005

Groundwater Quality in Kentucky: Cadmium

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Introduction

Cadmium is a metallic element that occurs naturally in the earth's crust, especially in zinc-, lead-, and copper-bearing ores (Forstner and Whittmann, 1981). Pure cadmium is a soft silver-white metal, but is rarely found naturally in its pure form. It is commonly combined with other elements, such as oxygen (cadmium oxide) and sulfur (cadmium sulfate).

Cadmium is released to the environment when coal and other fossil fuels are burned, and may be found in municipal wastes and cigarettes. Cadmium is a byproduct of the metal industry, especially in zinc, lead, and copper refining. Industrial uses of cadmium include metal plating and coating processes, nickel-cadmium and solar batteries, paint pigments for machinery and baking enamels, and stabilizers in plastics. Cadmium salts are occasionally used as fungicides for golf courses and lawns (U.S. Environmental Protection Agency, 2002).

People can ingest cadmium by eating plants grown in soil containing cadmium or by consuming fish or seafood caught in water contaminated by cadmium (Fetter, 1999). Such contamination usually results from improper disposal of industrial waste and chemicals.

Cadmium is a probable carcinogen, and smokers generally have higher cadmium levels in their bodies than nonsmokers (New Jersey State Department of Health and Senior Services, 1999). Cadmium has been found to cause a variety of ill effects from acute exposure, including nausea, vomiting, diarrhea, muscle cramps, liver injury, convulsions, and kidney failure. Long-term exposure to cadmium in drinking water has been linked to health problems such as liver, bone, and blood damage (U.S. Environmental Protection Agency, 2003).

Because of these adverse health effects, the U.S. Environmental Protection Agency (EPA) set the maximum contaminant level (MCL) for cadmium in drinking water at 0.005 mg/L (parts per million, or 5 parts per billion). The EPA health advisory level (HAL) for children is 0.04 mg/L in a 1- to 10-day exposure rate.

Concentrations in Groundwater

Data Sources

Data for this report were compiled from the Kentucky Groundwater Data Repository, maintained by the Kentucky Geological Survey. The repository was established in 1990 to archive and disseminate groundwater data collected by various agencies in Kentucky. The primary data sources for the repository are the Kentucky Division of Water, the Kentucky Geological Survey, the U.S. Geological Survey, the National Uranium Resource Evaluation Program, and the U.S. Environmental Protection Agency.

The database contained 5,523 cadmium measurements from 1,186 sites throughout Kentucky as of July 2004. Many sites were sampled more than once. Data from regulatory programs concerned with known or suspected contamination sites, including the Resource Conservation and Recovery Act and the Solid Waste and Underground Storage Tank programs, were excluded. No distinction was made in this report between total (unfiltered sample) and dissolved (filtered sample) cadmium in groundwater. In cases where both total and dissolved values were measured at the same site, the differences between the two values were negligible. Therefore, both dissolved and total values were included in the data set to improve statewide coverage. MCL values are based on total concentrations.

Regional Variations in Cadmium Concentrations

The map shows sites where cadmium has been measured, using symbols to represent different concentration ranges. Sites that were sampled on multiple occasions may have more than one symbol, and symbols may overlap if the sites are close to each other. Sampled sites are not uniformly distributed throughout Kentucky, but are concentrated in the areas where groundwater use is common. Approximately 80 percent of the statewide results were reported as being below analytical detection limits, which ranged from 0.0001 to 0.006 mg/L. These results indicate that the groundwater was analyzed for cadmium but none was detected. Sites where cadmium concentrations exceed either the MCL or the HAL are not restricted to any particular region or watershed.

Only 3.5 percent of the sites produced groundwater that had cadmium concentrations greater than the MCL, and only 1 percent of the sites produced groundwater that had cadmium concentrations greater than the HAL (Table 1). The median cadmium concentration in each of Kentucky's physiographic regions is less than a detection limit of 0.001 mg/L.

Physiographic Region	No. of Values	No. of Sites	No. of Sites Above MCL	No. of Sites Above HAL
Inner Bluegrass	434	51	2	1
Outer Bluegrass	628	136	7	1
Knobs	223	61	2	1
Eastern Ky. Coal Field	1,169	300	7	2
Western Ky. Coal Field	547	124	3	3
Jackson Purchase	833	188	10	2
Eastern Pennyroyal	245	54	7	1
Western Pennyroyal	1,444	272	4	1

Table 1. Summary of cadmium concentrations

ISSN 0075-5583

KENTUCKY GEOLOGICAL SURVEY
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INFORMATION CIRCULAR 9
SERIES XII, 2005

https://doi.org/10.13023/kgs.ic09.12

More than 80 percent of all measurements were less than the MCL of 0.005 mg/L, and more than 99 percent of all measurements were less than the HAL of 0.04 mg/L (Figure 1).

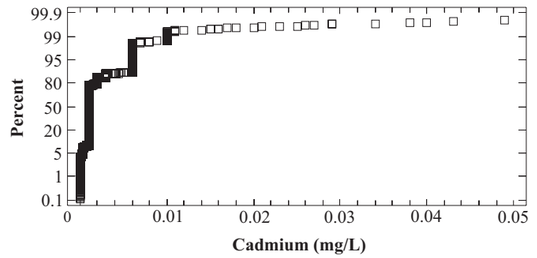

Figure 1. Cumulative percentage plot of cadmium values. Higher values were excluded to better show concentrations near the MCL (0.005 mg/L) and the HAL (0.04 mg/L).

The range of cadmium concentrations was greater in water from wells than springs (Figure 2). In this plot, boxes enclose the central 50 percent of the values. The median value is shown by vertical line through the box, and lines extend from each edge of the box for a distance of 1.5 times the cadmium range represented by the central box. Values beyond this range are shown as individual squares. Shallow wells account for the highest concentrations (Figure 3).

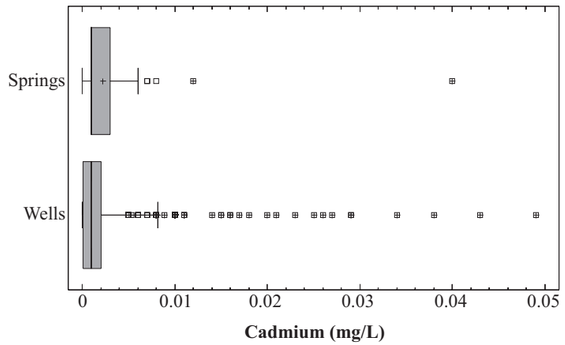

Figure 2. Comparison of cadmium values from wells and springs.

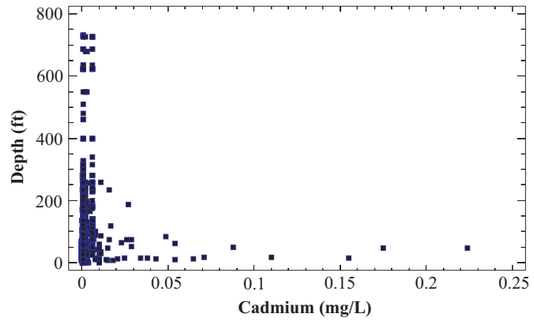

Figure 3. Plot of cadmium concentrations versus well depth. (MCL = 0.005 mg/L)

Water-Quality Concerns

Cadmium in Kentucky groundwater rarely exceeds the MCL. Concentrations that do exceed the MCL are spread across the state, and do not appear to be strongly controlled by bedrock lithology. Cadmium concentrations might be expected to be higher in western Kentucky (specifically Caldwell, Crittenden, and Livingston Counties), where fluorspar was mined in the 1940's, because of the association of barium and galena (lead ore) with fluorite. The Eastern Kentucky Coal Field also contains high amounts of sphalerite (zinc ore) associated with coal seams, which could cause higher cadmium levels. However, the available data for cadmium concentrations do not show systematically high values in these areas.

These findings should be viewed as general trends. Individual wells or springs should be tested for the occurrence of cadmium and other potential contaminants before being used as 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 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 161.625) 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, which was also created by statute (KRS 151.629). Additional information and member agencies can be found at http://www.uky.edu/KGS/water/gnet/gnet.htm.

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Information Circular 9
Series XII, 2005
https://doi.org/10.13023/kgs.ic09.12

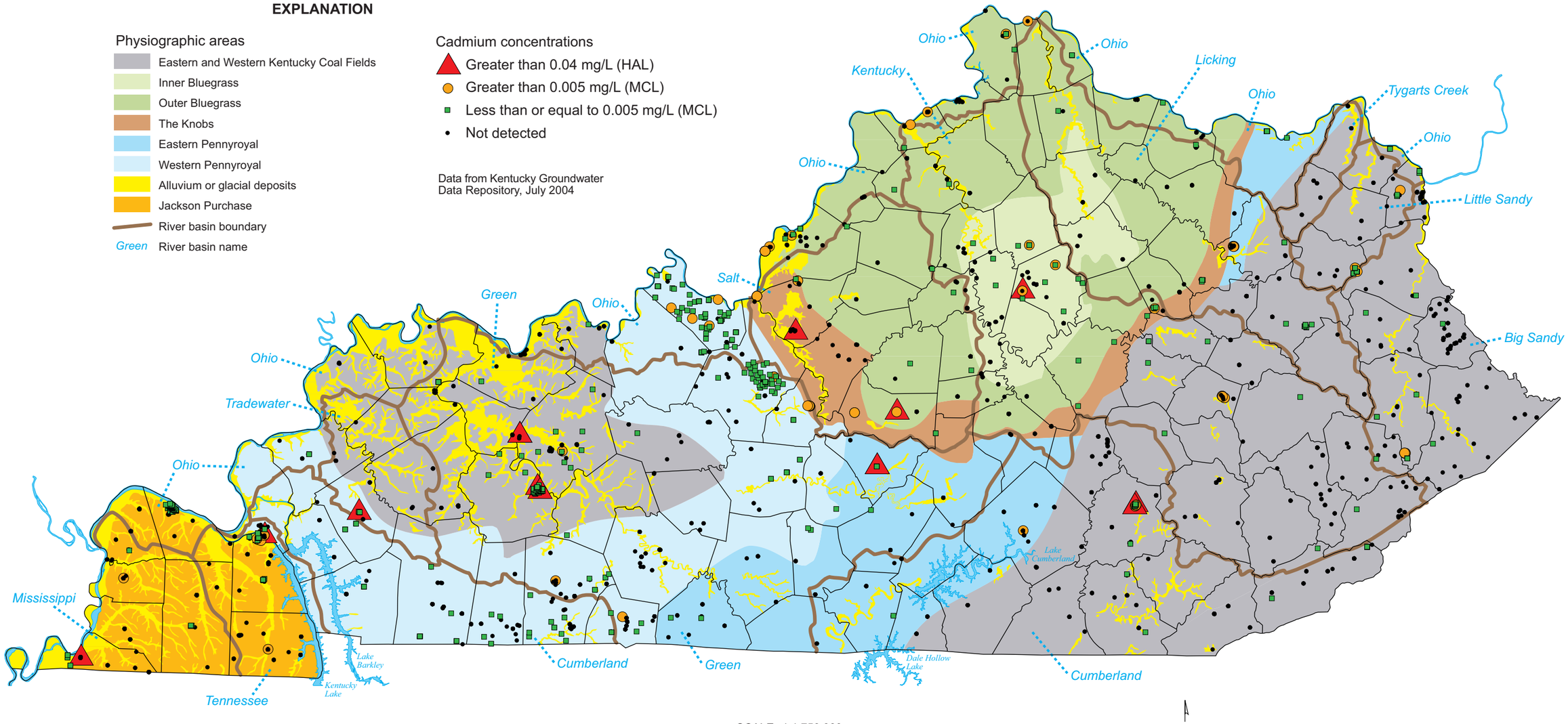
CADMIUM CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY

EXPLANATION

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

Cadmium concentrations
- Greater than 0.04 mg/L (HAL)
- Greater than 0.005 mg/L (MCL)
- Less than or equal to 0.005 mg/L (MCL)
- Not detected

Data from Kentucky Groundwater Data Repository, July 2004



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Cartography by Terry Hounshell