Groundwater Quality in Kentucky: Selenium

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Introduction

Selenium is a naturally occurring element found in most rocks and soils (Agency for Toxic Substances and Disease Registry, 2003). In its solid form, selenium is black, gray, or red and is odorless (New Jersey Department of Health and Senior Services, 2002). Most selenium is obtained from byproducts of the copper refining industry. Selenium compounds are often used in electronic components, photocopiers, metal alloys, rubber, paint pigments, glass-making (ruby red glass), and photographic emulsions (U.S. Environmental Protection Agency, 2003). Selenium exhibits both photovoltaic and photoconductive properties. As more light shines on selenium, its electrical conductivity increases, making it extremely useful for electric eyes, photo cells, and light meters for photographic components (Thomas Jefferson National Accelerator Facility–Office of Science Education, 2004). Selenium is also used in the production of vitamins, dandruff shampoo, and as a dietary supplement for livestock (Prince Agri Products, 2004).

Selenium can be both beneficial and harmful to humans and animals. It is an essential nutrient for the human body at low levels, and serves as an antioxidant by reducing free radicals that damage cell membranes. The human body can be exposed to selenium though the air, food, or water (Agency for Toxic Substances and Disease Registry, 2003). Selenium has not been found to be a carcinogen in either humans or animals. The EPA has set the maximum contaminant level (MCL) for selenium in drinking water at 0.05 mg/L. Short-term exposure to selenium at levels above the MCL may cause changes in hair and fingernails, damage to the peripheral nervous system, and fatigue and irritability. Long-term exposure to selenium above the MCL can result in hair and fingernail loss, damage to kidney and liver tissue, and damage to the nervous and circulatory systems (U.S. Environmental Protection Agency, 2002).

Studies in animals have shown that elevated amounts of selenium can affect reproductive processes, but whether these effects occur in humans is not known. Fish and birds are highly susceptible to selenium contamination; therefore, the aquatic wildlife standard for selenium in water is 0.005 mg/L.

Concentrations in Groundwater

Data Sources

Data from 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. Major data sources for the repository include 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 5,220 analyses of selenium from 785 wells and springs throughout Kentucky as of November 2004. Data were removed from the data set if they were from known or suspected contaminated sites, identified by regulatory programs such as the Resource Conservation and Recovery Act, and the Solid Waste and Underground Storage Tank. Six hundred five analyses indicated selenium was present, but had a detection limit greater than the MCL. These data were excluded from the final data set. Data that were less than detection, and less than the MCL, are shown on the map as being less than detection, indicating that selenium was tested for, but not found.

The final data set contained 4,615 analyses, including 3,028 of total selenium (unfiltered groundwater) and 1,587 of dissolved selenium (filtered groundwater). No distinction was made in this report between total and dissolved selenium in groundwater. The EPA bases MCL values on total concentrations. In cases where both total and dissolved values 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.

Regional Variations in Selenium Concentrations

This map shows sites where selenium has been measured; different symbols show concentration ranges. Sites that have been sampled on multiple occasions may have more than one symbol, and symbols may overlap if the sites are close to each other.

Approximately 99 percent of all selenium measurements were equal to or less than the MCL of 0.05 mg/L (Figure 1). Only 20 sites yielded selenium concentrations greater than the MCL (Table 1). The median value for selenium in each of Kentucky's physiographic regions is 0.002 mg/L, well below the MCL.

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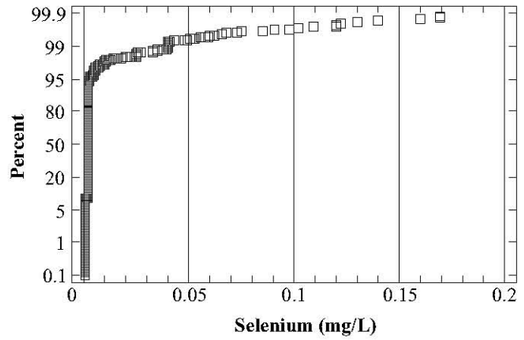

Figure 1. Cumulative percentage plot of selenium values (MCL = 0.05 mg/L).

Physiographic Region	No. of Values	Maximum Value (mg/L)	No. of Sites	No. of Sites Above MCL
Inner Bluegrass	375	0.006	14	0
Outer Bluegrass	511	0.025	90	0
Knobs	201	0.052	49	1
Eastern Ky. Coal Field	876	0.392	181	10
Western Ky. Coal Field	466	0.014	109	0
Jackson Purchase	759	0.16	176	1
Eastern Pennyroyal	232	5.37	30	5
Western Pennyroyal	1195	0.102	116	3

Table 1. Summary of selenium concentrations.

Figure 2 summarizes the selenium measurements for each physiographic region. 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 selenium range represented by the central box. Values beyond this range are shown as individual squares. The physiographic regions with the lowest range of values were the Inner Bluegrass and Western Kentucky Coal Field Regions.

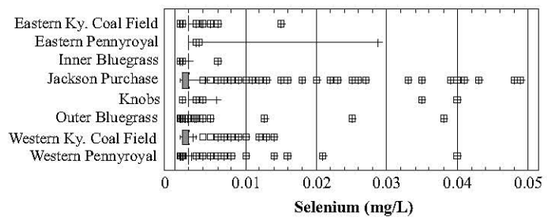

Figure 2. Box plots of selenium values for each of the major physiographic regions (MCL = 0.05 mg/L).

Water-Quality Concerns

Selenium in Kentucky groundwater only rarely exceeds the MCL. Selenium is most often associated with organic-rich sedimentary marine deposits, such as black shales, which are more abundant in the coal fields. Sites where selenium exceeds the MCL are spread across the state, and do not appear to be directly related to bedrock lithology however. More study is needed to determine selenium content in specific geologic strata.

These findings should be viewed as general patterns. Individual wells or springs should be tested for the occurrence of selenium 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 Groundwater Branch can provide literature on maintaining private wells and springs and information on sampling for water quality 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, 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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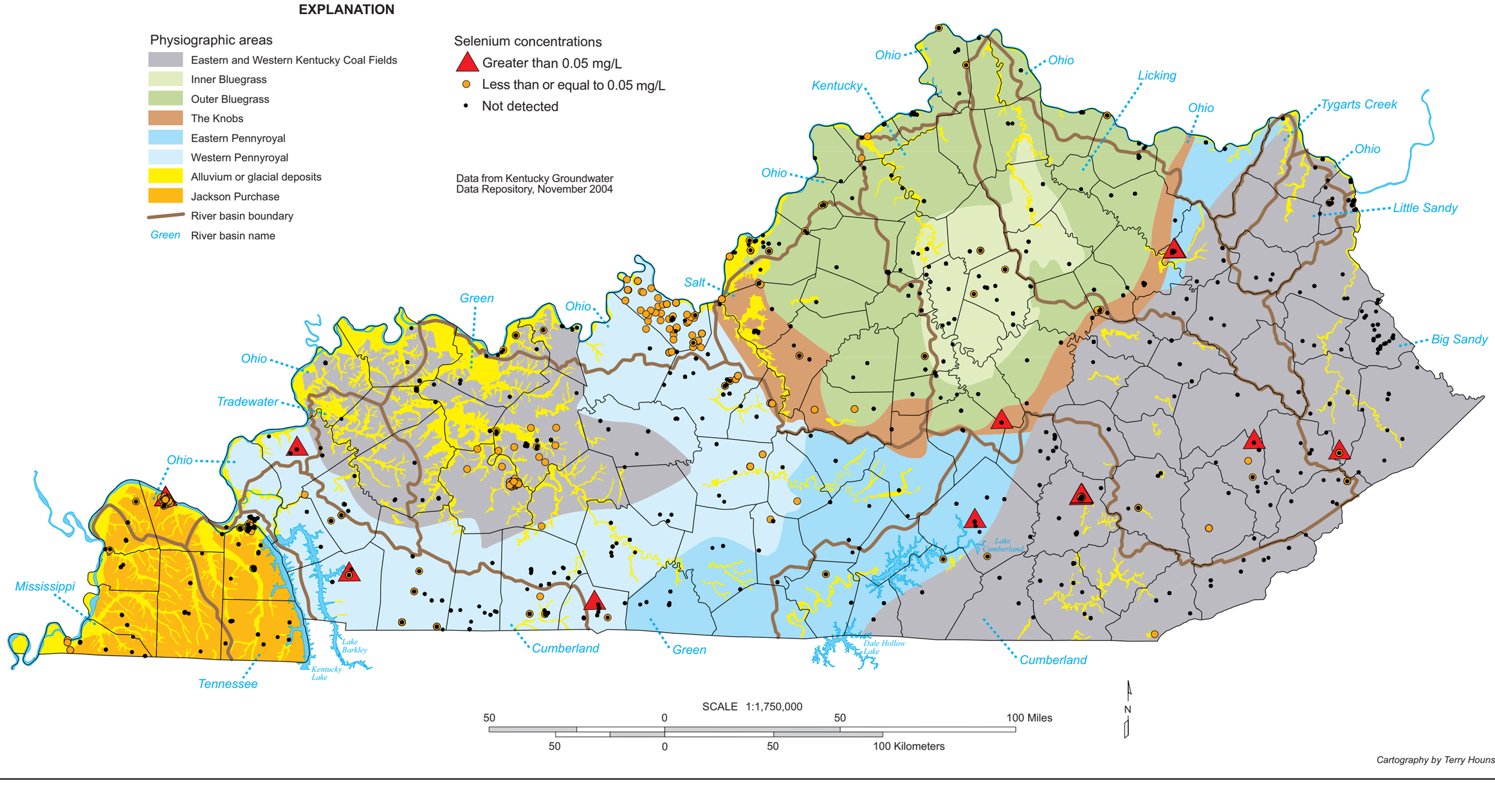
SELENIUM CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY



Cartography by Terry Hounshell