

Sedimentation and Occurrence and Trends of Selected Chemical Constituents in Bottom Sediment, Empire Lake, Cherokee County, Kansas, 1905–2005

By Kyle E. Juracek

Prepared in cooperation with the
U.S. Fish and Wildlife Service and the
Kansas Department of Health and Environment

Scientific Investigations Report 2006–5307

**U.S. Department of the Interior
U.S. Geological Survey**

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2006

For sale by U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225

For more information about the USGS and its products:
Telephone: 1-888-ASK-USGS
World Wide Web: <http://www.usgs.gov/>

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted materials contained within this report.

Suggested citation:

Juracek, K.E., 2006, Sedimentation and occurrence and trends of selected chemical constituents in bottom sediment, Empire Lake, Cherokee County, Kansas, 1905–2005: U.S. Geological Survey Scientific Investigations Report 2006–5307, 79 p.

Back cover: Photographs showing sediment-thickness measurement and sediment coring operations on Empire Lake, Cherokee County, Kansas, summer 2005.

Contents

Abstract	1
Introduction	2
Previous Investigations	4
Current Study	5
Description of Spring River Basin	6
Acknowledgments	6
Methods	6
Measurement of Bottom-Sediment Thickness	6
Estimation of Bottom-Sediment Volume, Mass, and Constituent Mass	9
Sediment-Core Collection, Handling, and Processing	10
Physical Analyses	12
Chemical Analyses, Quality Control, and Age Dating	12
Trend Analysis	13
Sediment-Quality Guidelines and Background Information for Chemical Constituents Selected for Study ...	13
Nutrients and Total Organic Carbon	15
Trace Elements	15
Bottom-Sediment Volume and Mass	16
Age-Dating Results and Implications for Sediment Transport and Deposition	20
Occurrence of, and Trends in, Selected Chemical Constituents	22
Nutrients and Total Organic Carbon	22
Cadmium	22
Lead	23
Zinc	29
Other Trace Elements	29
Variability of Trace Element Concentrations in Relation to Mining Activity and Other Factors	33
Summary and Conclusions	35
References Cited	36
Supplemental Information	39

Figures

- 1–4. Maps showing:
1. Location of Empire Lake, Blackberry Hay Farm Lake, the Spring River system, the Cherokee County superfund site, and lead and zinc mined areas in the Tri-State Mining District, Kansas, Missouri, and Oklahoma..... 3
 2. Location of transect lines, reservoir segments, bottom-sediment coring sites, and flood-plain soil sampling sites..... 7
 3. Mean bottom-sediment thickness along transects, and within two areas, of Empire Lake, July and August 2005..... 17
 4. Estimated mean bulk density of bottom sediment at coring sites in Empire Lake, 2005 19

5.	Graphs showing variation in cesium-137 activity with depth of bottom-sediment samples collected from coring sites E-27 and E-36 in Empire Lake, southeast Kansas, and coring site BHF-1 in Blackberry Hay Farm Lake, southwest Missouri, September 2005.	21
6.	Map showing cadmium concentrations for the composite cores and mean cadmium concentrations for the trend cores collected from Empire Lake, 2005.	24
7.	Graphs showing variation in cadmium concentrations with depth of bottom-sediment samples collected from coring sites E-6, E-27, and E-36 in Empire Lake, August and September 2005.	25
8.	Graphs showing cadmium, lead, and zinc concentrations with depth of bottom-sediment samples collected from coring site BHF-1 in Blackberry Hay Farm Lake, southwest Missouri, September 2005.	27
9.	Map showing lead concentrations for the composite cores and mean lead concentrations for the trend cores collected from Empire Lake, 2005.	28
10.	Graphs showing variation in lead concentrations with depth of bottom-sediment samples collected from coring sites E-6, E-27, and E-36 in Empire Lake, August and September 2005.	30
11.	Map showing zinc concentrations for the composite cores and mean zinc concentrations for the trend cores collected from Empire Lake, 2005.	31
12.	Graphs showing variation in zinc concentrations with depth of bottom-sediment samples collected from coring sites E-6, E-27, and E-36 in Empire Lake, August and September 2005.	32

Tables

1.	Description of geographic extent of reservoir segments used for the estimation of total bottom-sediment volume in Empire Lake, southeast Kansas.	10
2.	Use of bottom-sediment cores collected from Empire Lake, southeast Kansas, 2005.	11
3.	Chemical analyses performed on bottom-sediment samples from Empire Lake, southeast Kansas, Blackberry Hay Farm Lake, southwest Missouri, and soil samples from the Spring River and Shoal Creek flood plains, southeast Kansas, 2005.	12
4.	Relative percentage differences for constituent concentrations in split-replicate samples from bottom-sediment cores from Empire Lake, southeast Kansas, 2005.	14
5.	Sediment-quality guidelines for selected trace elements and associated bioaccumulation index.	15
6.	Estimated surface area, mean bottom-sediment thickness, and computed bottom-sediment volume in segments of Empire Lake, southeast Kansas, July and August 2005.	16
7.	Computed bottom-sediment volume, representative bulk density, and computed bottom-sediment mass in segments of Empire Lake, southeast Kansas, July and August 2005.	20
8.	Summary of cadmium, lead, and zinc concentrations in bottom-sediment samples collected from Empire Lake composite and trend cores, southeast Kansas, and Blackberry Hay Farm Lake trend core BHF-1, southwest Missouri, 2005.	23
9.	Results of trend tests on concentrations of selected trace elements in bottom-sediment samples collected from Empire Lake cores E-6, E-27, and E-36, southeast Kansas, and Blackberry Hay Farm Lake core BHF-1, southwest Missouri, August and September 2005.	26
A1.	Latitude, longitude, depth to lakebed, depth to refusal, and estimated sediment thickness at sediment-thickness measurement sites in Empire Lake, southeast Kansas, July and August 2005.	40
A2.	Latitude and longitude coordinates, water depth, estimated penetration depth, length of recovered core, and estimated recovery percentage for bottom-sediment coring sites at Empire Lake, southeast Kansas, and Blackberry Hay Farm Lake, southwest Missouri, 2005.	52
A3.	Results of chemical analyses of reference samples and comparison to most probable values.	53
A4.	Cesium-137 and lead-210 activities for bottom-sediment samples collected from coring sites E-27 and E-36 in Empire Lake, southeast Kansas, and coring site BHF-1 in Blackberry Hay Farm Lake, southwest Missouri, September 2005.	60

A5.	Estimated bulk density of bottom sediment at coring sites in Empire Lake, southeast Kansas, 2005.....	61
A6.	Constituent concentrations for bottom-sediment samples collected from coring site E-1 in Empire Lake, southeast Kansas, April 2005.....	63
A7.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring sites E-2, E-4, E-8, E-10, and E-11 in Empire Lake, southeast Kansas, April and August 2005.....	64
A8.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring site E-6 in Empire Lake, southeast Kansas, August 2005.....	65
A9.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring sites E-14, E-17, E-19, and E-22 in Empire Lake, southeast Kansas, August 2005.....	66
A10.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring sites E-23, E-24, E-25, and E-26 in Empire Lake, southeast Kansas, August and September 2005.....	67
A11.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring sites E-29, E-31, E-32, and E-33 in Empire Lake, southeast Kansas, September 2005..	68
A12.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring site E-27 in Empire Lake, southeast Kansas, September 2005.....	69
A13.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring site E-36 in Empire Lake, southeast Kansas, September 2005.....	72
A14.	Percentage of silt and clay and constituent concentrations for bottom-sediment samples collected from coring site BHF-1 in Blackberry Hay Farm Lake, southwest Missouri, September 2005.....	76
A15.	Percentage of silt and clay and constituent concentrations for flood-plain soil samples collected from sites SCF-1 and SRF-1 near Empire Lake, southeast Kansas, August 2005.....	79

Conversion Factors, Abbreviations, and Datum

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
foot (ft)	0.3048	meter (m)
inch (in.)	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
millimeter (mm)	0.03937	inch (in.)
Area		
acre	4,047	square meter (m ²)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km ²)
square foot (ft ²)	0.09290	square meter (m ²)
square mile (mi ²)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
Mass		
gram (g)	0.03527	ounce (oz)
gram per cubic centimeter (g/cm ³)	62.43	pound per cubic foot (lb/ft ³)
microgram per gram (µg/g)	1.0	part per million (ppm)
microgram per liter (µg/L)	1.0	part per billion (ppb)
milligram per kilogram (mg/kg)	1.0	part per million (ppm)
percent concentration	10,000	milligram per kilogram (mg/kg)
pound (lb)	0.4536	kilogram (kg)
pound per cubic foot (lb/ft ³)	16.02	kilogram per cubic meter (kg/m ³)
Volume		
acre-foot (acre-ft)	1,233	cubic meter (m ³)
cubic centimeter (cm ³)	0.06102	cubic inch (in ³)
cubic foot (ft ³)	0.02832	cubic meter (m ³)
cubic foot (ft ³)	2.296 x 10 ⁻⁵	acre-foot (acre-ft)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).