



NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

NITRATE AND PESTICIDES IN GROUND WATER OF THE OZARK PLATEAUS REGION IN ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA



INTRODUCTION

In 1991, the U.S. Geological Survey began a water-quality study of the Ozark Plateaus region as part of the National Water-Quality Assessment (NAWQA) Program. The Ozark Plateaus study unit, one of 60 study units in the NAWQA Program, is approximately 48,000 square miles in area and includes parts of Arkansas, Kansas, Missouri, and Oklahoma (Freiwald, 1991). The study unit includes most of the Ozark Plateaus Province and parts of the Osage Plains section of the Central Lowland Province and the Mississippi Alluvial Plain section of the Coastal Plains Province. The Ozark Plateaus Province is divided into three sections—the Salem Plateau which includes the St. Francois Mountains, the Springfield Plateau, and the Boston Mountains (Adamski and others, 1995; fig. 1). Second-growth forests cover most (about 71 percent) of the land in the Salem Plateau, whereas agriculture, primarily the raising of poultry and cattle, composes most (about 58 percent) of the land use in the Springfield Plateau (fig. 1). About 358,300 tons of nitrogen are generated as animal wastes each year in the study unit (Davis and others, 1995). Animal wastes commonly are applied to pastures as fertilizer, a process that could adversely affect ground-water quality of the region. The use of pesticides in the region also could adversely affect ground-water quality. The six most commonly applied pesticides in the region are 2,4-D, alachlor, atrazine, propanil, trifluralin, and metolachlor. Pesticide use ranges from less than 0.01 to 1 pound per acre per year (Bell and others, 1996).

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Two major aquifers in the study unit—the Springfield Plateau and Ozark aquifers—were investigated as part of this study (Adamski and others, 1995). The unconfined parts of the Springfield Plateau and Ozark aquifers coincide with the Springfield Plateau and Salem Plateau, respectively (fig. 2). Both of these aquifers consist primarily of limestone and dolomite rocks which have been dissolved by ground water in places to form caves, sinkholes, and springs. These dissolution features allow rapid recharge which makes the aquifers susceptible to surface contamination.

A total of 225 ground-water samples were collected from 211 springs and wells from 1993 through 1995 (fig. 2). Samples were analyzed for nitrite plus nitrate, and 88 pesticides and pesticide metabolites. The samples were collected during four studies that differed in spatial scales and objectives. The first study, the study-unit survey, was largest in area and was based on samples from 50 springs and 49 wells to determine the general water quality of the Springfield Plateau and Ozark aquifers. The two land-use studies were based on samples from 22 springs and 20 wells in a poultry-dominated agricultural area (poultry land-use study) and 20 springs and 20 wells in a cattle-dominated agricultural area (cattle land-use study), both overlying the Springfield Plateau aquifer. The small-watershed study was smallest in area and was based on samples collected once from 4 springs and 18



Typical spring in Ozark Plateaus region.



Typical domestic well in Ozark Plateaus region.

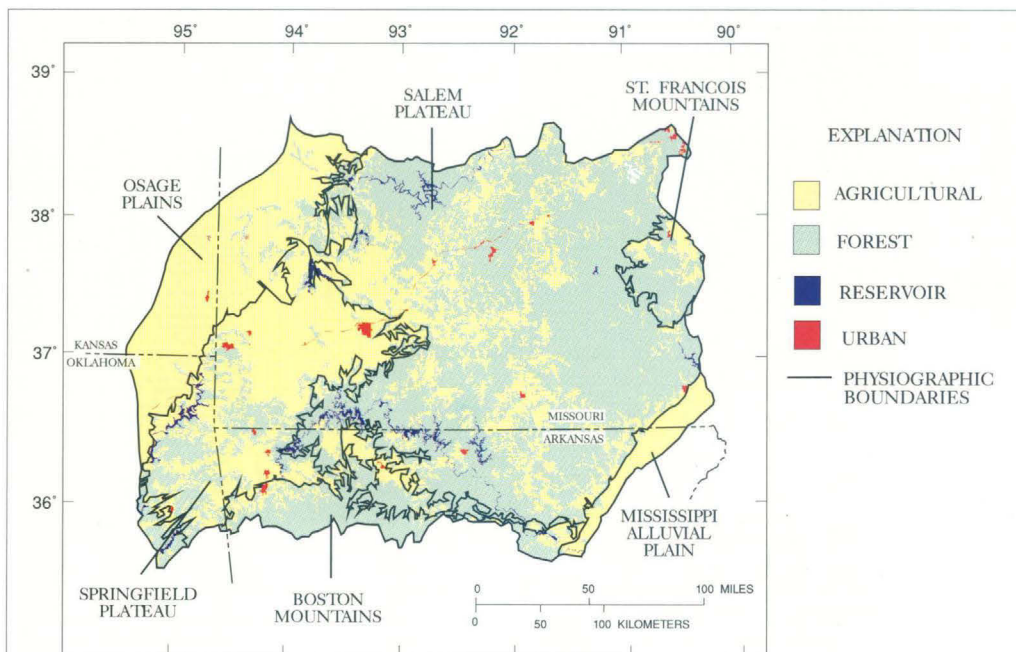
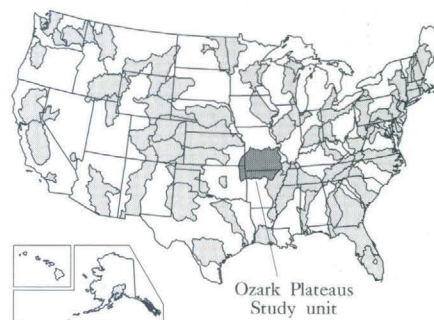


Figure 1. Generalized land use in the Ozark Plateaus study unit.



Agricultural land use in Ozark Plateaus region.



Map of NAWQA study units

domestic wells, and samples collected twice from 11 monitoring wells in the Flint Creek Basin of northwestern Arkansas. The objective of the small-watershed study was to determine local-scale spatial variation of water quality in the Springfield Plateau aquifer.

SIGNIFICANT NITRATE RESULTS

- Nitrite was not detected in 82 percent of the samples (hence, nitrite plus nitrate will be referred to as nitrate throughout the rest of this report).
- Nitrate concentrations ranged from less than 0.05 to 25 (mg/L) milligrams per liter as nitrogen. Background nitrate concentrations in ground water from forested areas are low, generally less than 1 mg/L.
- Nitrate concentrations in ground water exceeded background concentrations in 46 percent of the samples collected during the study-unit survey; in 74 percent of the samples collected during the poultry land-use study; in 68 percent of the samples collected during the cattle land-use study; and in 73 percent of the samples collected during the small-watershed study (fig. 2).
- Nitrate concentrations in samples from two domestic wells and two monitoring wells exceeded 10 mg/L as nitrogen, the U.S. Environmental Protection Agency's (1986) maximum contaminant level (MCL) for nitrate in drinking water.
- Median nitrate concentration in samples collected from the Springfield Plateau aquifer (1.7 mg/L) was greater than in samples collected from the Ozark aquifer (0.44 mg/L; fig. 3).
- Median nitrate concentration in samples collected from springs (2.5 mg/L) was greater than in samples collected from wells (1.6 mg/L; fig. 3).
- Nitrate concentrations generally were related to the percent of agricultural land use within each spring basin or within 1-mile radius of each well site (fig. 4).

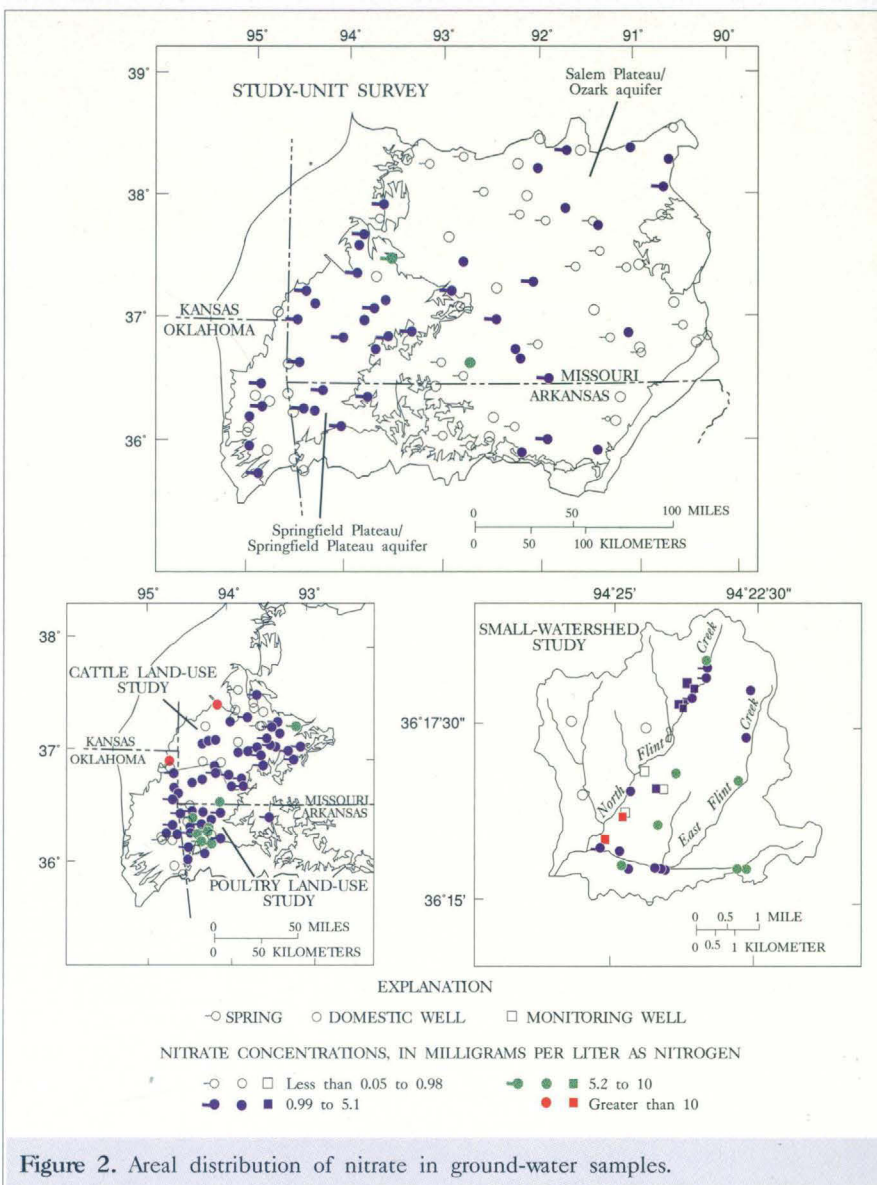


Figure 2. Areal distribution of nitrate in ground-water samples.

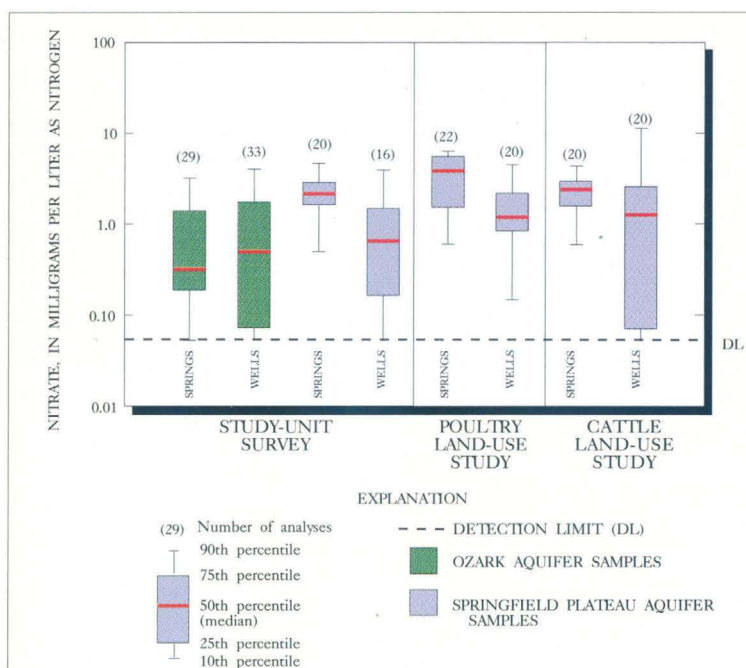


Figure 3. Distribution of nitrate concentrations in ground-water samples collected during the study-unit survey, and the poultry and cattle land-use studies.

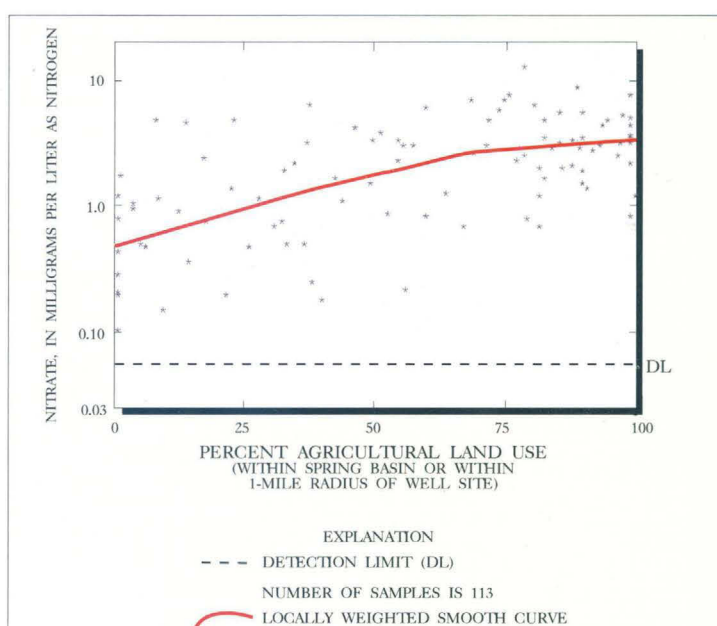


Figure 4. Relation of nitrate concentrations in samples from springs and domestic wells to agricultural land use.

SIGNIFICANT PESTICIDE RESULTS

- Pesticides were detected in ground-water samples from 21 springs and 11 wells during the study-unit survey; 8 springs and 2 wells during the poultry land-use study; 10 springs and 7 wells during the cattle land-use study; and 4 springs, 3 domestic wells, and 7 monitoring wells during the small-watershed study (fig. 5).
- Twenty pesticides were detected, with a maximum of five pesticides detected in any one sample. The most commonly detected pesticides and metabolites were tebuthiuron, atrazine, prometon, desethylatrazine, and simazine (table 1).
- Pesticide concentrations were low (table 1). Maximum concentrations ranged from 0.003 (benfluralin, metolachlor, *p,p'*-DDE, and trifluralin) to 1.0 (atrazine) microgram per liter. Concentrations did not exceed any of the U.S. Environmental Protection Agency's MCLs for pesticides in drinking water (Nowell and Resek, 1994).
- Pesticides were detected more frequently in samples from the Springfield Plateau aquifer (50 percent) than in samples from the Ozark aquifer (22 percent) (fig. 5).
- Pesticides were detected more frequently in samples from springs (47 percent) than in samples from wells (22 percent) (fig. 5).
- As with nitrate, pesticides in ground water were related to the percent of agricultural land use associated with each spring or well site (fig. 6).
- Pesticide detections were inversely related to the percent of forest land associated with each spring and well site (fig. 6).

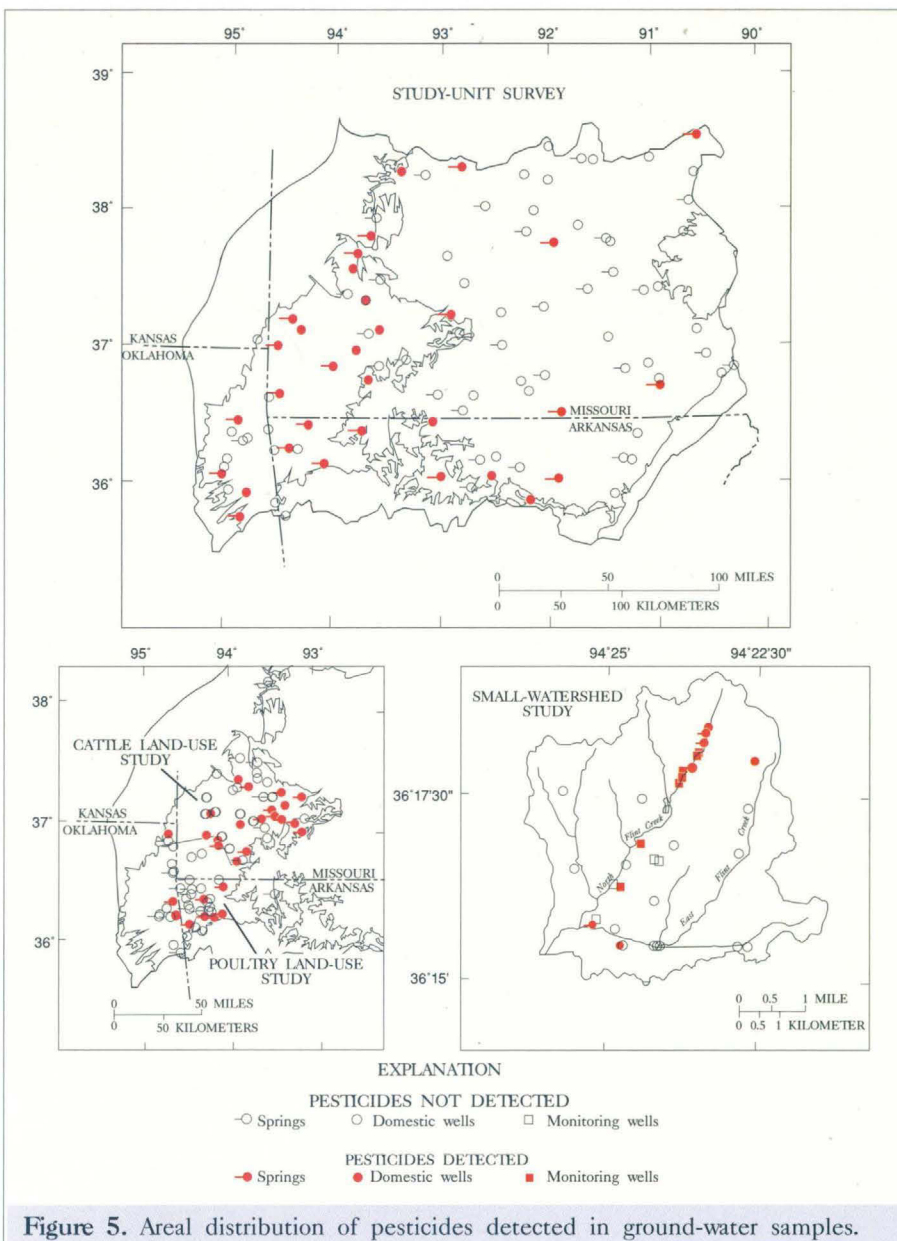


Figure 5. Areal distribution of pesticides detected in ground-water samples.

Table 1. Number of pesticide detections in each network component and range of concentrations [number in parentheses, total number of samples; $\mu\text{g/L}$, microgram per liter]

Pesticide	Study-unit survey detections (99)	Poultry land-use study detections (42)	Cattle land-use study detections (40)	Small-watershed study detections (44)	Total number of detections (225)	Range of concentrations ($\mu\text{g/L}$)	Use
Atrazine	14	7	6	3	30	0.001 - 1.0	Herbicide
Benfluralin	1	0	0	0	1	.003	Herbicide
Carbaryl	2	2	0	0	4	.012 - .03	Insecticide
Carbofuran	0	2	0	0	2	.007 - .016	Insecticide
Chlorpyrifos	2	0	0	0	2	.003 - .013	Insecticide
DCPA	1	2	0	0	3	.002 - .014	Herbicide
Desethylatrazine	8	7	3	1	19	.002 - .35	None
Dieldrin	1	0	1	0	2	.025 - .057	Insecticide
Diuron	0	0	1	1	2	.01 - .18	Herbicide
Lindane	2	0	0	0	2	.028 - .032	Insecticide
Linuron	0	1	0	0	1	.016	Herbicide
Metolachlor	3	0	1	1	5	.002 - .003	Herbicide
Metribuzin	0	0	0	3	3	.004 - .14	Herbicide
<i>p,p'</i> -DDE	7	2	1	0	10	.001 - .003	None
Prometon	11	2	12	0	25	.002 - .88	Herbicide
Propanil	2	0	0	0	2	.007 - .012	Herbicide
Propargite	1	0	0	0	1	.008	Acaricide
Simazine	7	7	4	0	18	.003 - .026	Herbicide
Tebuthiuron	7	1	9	14	31	.005 - .24	Herbicide
Trifluralin	1	0	0	0	1	.003	Herbicide

CONCLUSIONS

The ground-water quality of the Springfield Plateau and Ozark aquifers is susceptible to surface contamination and has been affected by elevated concentrations of nitrate and the occurrence of pesticides. Nitrate concentrations exceeded background concentrations in 60 percent of the samples. Concentrations in four samples exceeded the maximum contaminant level of 10 mg/L for nitrate in drinking water. Pesticides were detected in 80 of 225 (36 percent) samples. Pesticide concentrations in samples did not exceed any maximum contaminant levels. Elevated nitrate concentrations and pesticides occur more frequently in samples from springs than in samples from wells indicating that water from springs generally is more susceptible to surface contamination than water from wells. Elevated nitrate concentrations and pesticides occur more frequently in samples from the Springfield Plateau aquifer than in samples from the Ozark aquifer which is probably related to the greater agricultural land use in the Springfield Plateau compared to the Salem Plateau. The occurrence of elevated nitrate concentrations and pesticides in ground water of both aquifers is related to the percent of agricultural land use associated with each spring or well site.

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- Adamski, J.C., Petersen, J.C., Freiwald, D.A., and Davis, J.V., 1995, Environmental and hydrologic setting of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 94-4022, 69 p.
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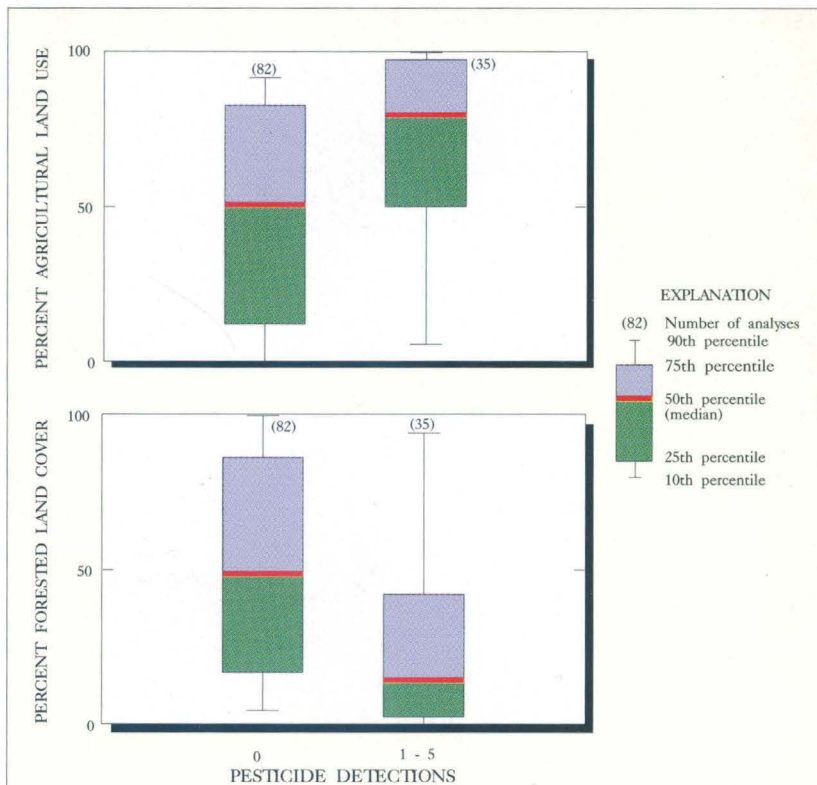


Figure 6. Relation of agricultural land use and forested land cover to pesticide detections in ground-water samples.



Cattle operation in Ozark Plateaus region.

U.S. Department of the Interior
U.S. Geological Survey
Fact Sheet FS-182-96

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