Prepared in cooperation with the
CITY OF WICHITA, KANSAS

Occurrence of Pesticides in Streams of the Cheney Reservoir Watershed, South-Central Kansas, 1997–99

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The quality of water in the Cheney Reservoir watershed in south-central Kansas is important to about 300,000 people in the Wichita area that rely on the reservoir as a source of drinking water. About 52 percent of the watershed is used for the production of grain crops, which generally rely on the use of pesticides for efficient production. Some pesticides subsequently may be transported in runoff water to Cheney Reservoir. The potential exposure to pesticides is of concern. The purpose of this fact sheet is to describe the occurrence of pesticides in streams within the Cheney Reservoir watershed. Pesticide concentrations are compared with Federal water-quality criteria for pesticides such that public and private organizations can evaluate the potential risks from pesticide exposure.

Background

The use of pesticides in agriculture has existed for much of the 20th century. In particular, the past 50 years has been a period of ever-increasing reliance on pesticides in an integrated system of pest management, nutrient supplementation, and irrigation in agricultural production.

Pesticide application (mainly herbicides and insecticides) creates the potential for chemical transport into environmental settings for which pesticides were not originally intended. Runoff from agricultural fields can move pesticides into surface-water systems where they may have adverse effects on aquatic life or contaminate drinking-water supplies. The movement of pesticides into and through shallow ground-water systems may contaminate those systems and affect their use as a drinking-water supply or ultimately may be discharged into surface-water systems.

In 1996, the U.S. Geological Survey (USGS) entered into a cooperative study with the city of Wichita, Kansas, with technical assistance from the Bureau of Reclamation, U.S. Department of the Interior, to define surface-water-quality characteristics of the Cheney Reservoir watershed. The purposes of the study are to:

- Describe spatial variations in concentration and load characteristics for selected water-quality constituents;
- Evaluate annual loading of selected constituents into and out of Cheney Reservoir;
- Determine the occurrence of pesticides in surface water within the Cheney Reservoir watershed.

This information will be used by the city of Wichita, which obtains 40 to 60 percent of its daily water supply from Cheney Reservoir (Jerry Blain, city of Wichita Water and Sewer Department, oral commun., 1997), to evaluate the water-quality characteristics of this valuable resource for current (2000) and future suitability as a water supply. The information also will be used by the Citizen's Management Committee, a committee of landowners within the Cheney Reservoir watershed, to evaluate the effectiveness of implemented watershed-management practices in mitigating surface-water contamination by agricultural chemicals. This fact sheet relates to the third study purpose listed; it describes the occurrence of pesticides in streams within the Cheney Reservoir watershed during 1997–99 in relation to Federal water-quality criteria.

Methods of Study

A network of six streamflow-gaging/water-quality sampling sites was

Red Rock Creek near Pretty Prairie, Kansas, 1998. Photograph by Chad Milligan.

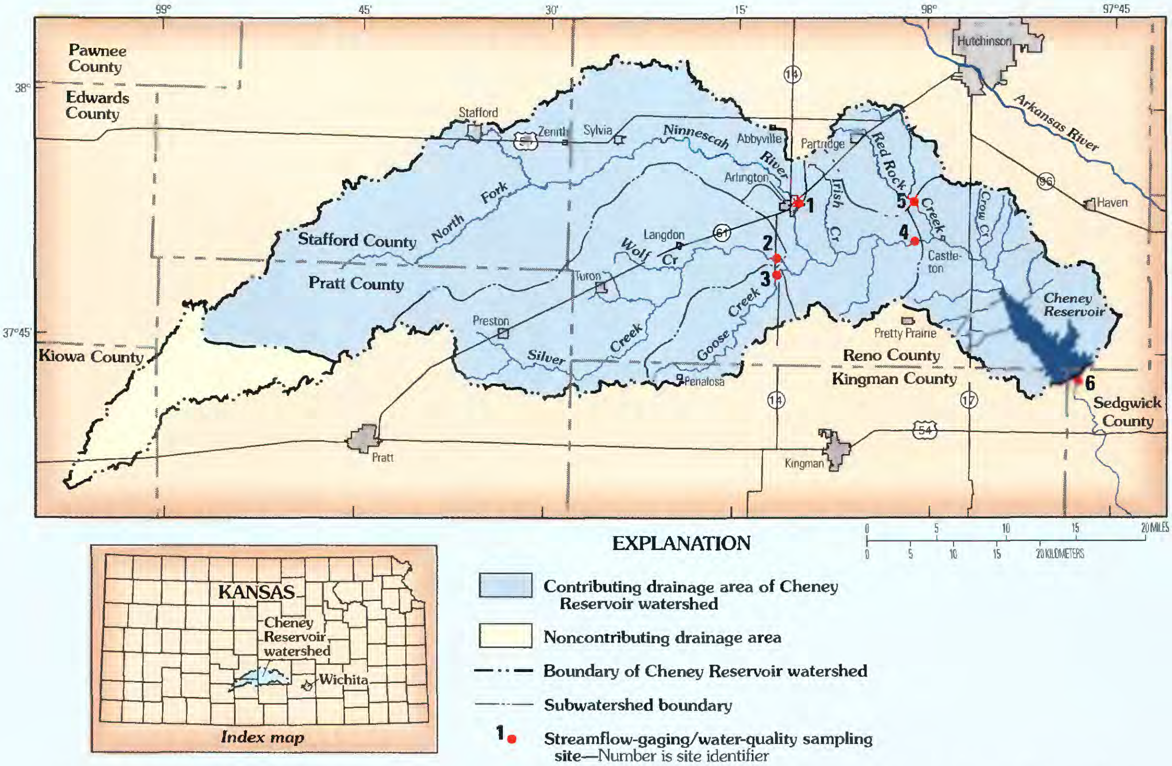

Figure 1. Location of Cheney Reservoir watershed and streamflow-gaging/water-quality sampling sites, south-central Kansas.

established in the Cheney Reservoir watershed in the fall of 1996 (fig. 1). Three of the sites were located on the North Fork Ninnescah River (two upstream from Cheney Reservoir and one at the reservoir outflow) and three on associated tributary streams. These sites were used to define the water-quality characteristics of the North Fork Ninnescah River and selected tributary streams.

Streamflow samples were collected manually at the sites according to methods presented in Horowitz and others (1994) during both low-flow (base-flow) and high-flow (storm-runoff) conditions. Water-quality samples were collected to represent the variability in seasonal and hydrologic conditions recorded at each sampling site. Samples for determination of pesticide concentrations were analyzed at the USGS National Water-Quality Laboratory in Denver, Colorado, using gas chromatography/mass spectrometry according to methods presented in Zaugg and others (1995).

Stream-water elevations (stage) were recorded continuously at the six sampling sites using pressure transducers and data-collection platforms. Daily mean streamflow (cubic feet per second) was calculated using stage-to-stage/streamflow relations according to methods presented in Kennedy (1983). Streamflow data for 1997–99 are presented in annual data reports such as Putnam and others (1999) or are on file at the USGS office in Lawrence, Kansas.

Streamflow

Annual mean streamflow in the Cheney Reservoir watershed varied substantially among 1997, 1998, and 1999, and also in comparison to long-term mean annual streamflow (fig. 2). The annual mean streamflow for sampling site 4 (fig. 1) was larger during 1998 (162 ft^3/s, cubic feet per second) than either 1997 or 1999 and was 9 percent larger than the long-term mean annual (1966–99) streamflow. Because sampling site 4 was relocated in 1996 to its current location (fig. 1) from a site about 4 miles downstream, annual mean streamflows for 1997–99 were adjusted to approximate annual mean streamflows at that previous location. This adjustment was necessary to make comparison to long-term (1966–99) annual mean streamflow.

Annual mean discharge from Cheney Reservoir (sampling site 6, fig. 1) was largest in 1999 (180 ft^3/s) and was 31 percent larger than the long-term mean annual (1965–99) streamflow. Much of the relatively large 1999 annual mean discharge from Cheney Reservoir was the result of lowering the reservoir level for dam maintenance. No long-term streamflow data exist for sampling sites 1, 2, 3, and 5 (fig. 1) because these sites were established during this study.

Occurrence of Pesticides

For the purposes of this study, 26 herbicides, 1 herbicide metabolite (degradation product), and 19 insecticides were analyzed to determine the occurrence of pesticides in the Cheney Reservoir watershed in streamflow samples collected from 1997–99. Of the 26 herbicides and 1 metabolite analyzed, 16 were detected in water from sampling sites in the watershed (table 1). The

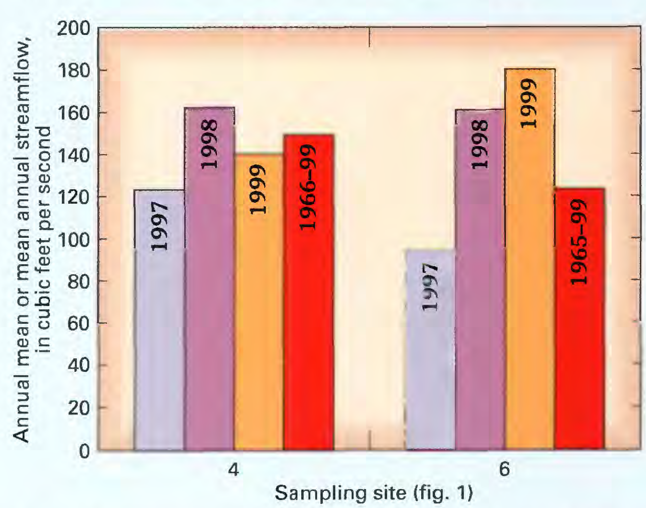

Figure 2. Comparison of annual mean streamflow for 1997–99 with long-term (1966–99 and 1965–99) mean annual streamflows at two sampling sites on the North Fork Ninnescah River.

Table 1. Statistical summary and comparison to water-quality criteria for selected herbicides and insecticides in water from six streamflow-gaging/water-quality sampling sites in the Cheney Reservoir watershed, 1997–99

[MCL, Maximum Contaminant Level; HAL, Health Advisory Level; μg/L, micrograms per liter; <, less than; --, not established]

	Constituents	Number of analyses	Number of detections	Analytical method reporting limit (μg/L)	Concentration (μg/L)			MCL[1] (μg/L)	HAL[1] (μg/L)
					Minimum	Median	Maximum		
Herbicides	Acetochlor	163	10	0.002	<0.002	<0.002	0.364	--	--
	Alachlor	163	100	.002	<.002	.007	28.6	2.0	--
	Atrazine	163	162	.001	<.001	.119	135	3.0	3.0
	Benfluralin	154	3	.002	<.002	<.002	.004	--	--
	Cyanazine	163	13	.004	<.004	<.004	.043	--	1.0
	Deethylatrazine	163	157	.002	<.002	.020	1.2	--	--
	EPTC	154	1	.002	<.002	<.002	.005	--	--
	Linuron	154	2	.002	<.002	<.002	.018	--	--
	Metolachlor	163	156	.002	<.002	.052	20.4	70	70
	Metribuzin	163	3	.004	<.004	<.004	.032	--	100
	Prometon	163	8	.018	<.018	<.018	.173	--	100
	Propachlor	163	5	.007	<.007	<.007	1.32	--	90
	Simazine	163	35	.005	<.005	<.005	.473	4.0	4.0
	Tebuthiuron	154	43	.010	<.010	<.010	.238	--	500
	Terbacil	154	6	.007	<.007	<.007	.010	--	90
	Trifluralin	154	9	.002	<.002	<.002	.034	--	5.0
Insecticides	Azinphos, methyl-	153	1	.001	<.001	<.001	.008	--	--
	Carbaryl	154	6	.003	<.003	<.003	.682	--	700
	Carbofluran	154	15	.003	<.003	<.003	1.16	40	40
	Chloropyrifos	154	1	.004	<.004	<.004	.009	--	20
	Diazinon	154	5	.002	<.002	<.002	.010	--	400
	Malathion	154	5	.005	<.005	<.005	.050	--	200

[1]U.S. Environmental Protection Agency (1995).

average number of pesticides detected per water sample did not vary substantially among the six sampling sites (four at sampling site 3 to five at sampling site 5, fig. 1). Two of the herbicides, atrazine and metolachlor, were detected in nearly every sample analyzed. Atrazine was detected in 162 of 163 samples (99 percent), and metolachlor was detected in 156 of 163 samples (96 percent). The metabolite of atrazine, deethylatrazine, was detected in 157 of 163 samples (96 percent). Three other herbicides with a large number of detections were alachlor, detected in 100 of 163 samples (61 percent); tebuthiuron, detected in 43 of 154 samples (28 percent); and simazine, detected in 35 of 163 samples (21 percent). Eleven herbicides that were not detected in streamflow samples from the Cheney Reservoir watershed are listed in table 2. Analytical method reporting limits (MRL's) ranged from 0.001 to 0.004 μg/L (micrograms per liter) for those herbicides.

Of the herbicides detected in streamflow samples during this study, only alachlor and atrazine had concentrations greater than the U.S. Environmental Protection Agency (1995) established Maximum Contaminant Level (MCL) or Health Advisory Level (HAL). An MCL is the maximum permissible level (on an annual basis) of a contaminant in water that is delivered to any user of a public water system. An HAL is defined as the maximum concentration of a chemical in drinking water that is not expected to cause adverse noncarcinogenic (noncancer-causing) effects over a lifetime of exposure, with a built-in margin of safety (U.S. Environmental Protection Agency, 1995).

Alachlor was detected in 11 streamflow samples at concentrations greater

Table 2. Pesticides not detected in water-quality samples collected from Cheney Reservoir watershed

Herbicides	Butylate	Napropamide	Propyzamide
	Dacthal	Pebulate	Thiobencarb
	Ethalfluralin	Pendimethalin	Triallate
	Molinate	Propanil	
Insecticides	p,p'-DDE	Fonofos	Parathion-methyl
	Dieldrin	Alpha-BHC	cis-Permethrin
	Disulfoton	Lindane	Phorate
	Ethoprophos	Parathion	Propargite
			Terbufos

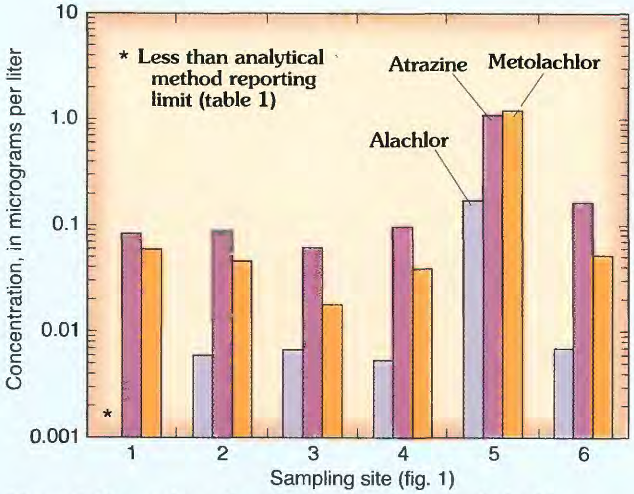

Figure 3. Comparison of median concentrations of alachlor, atrazine, and metolachlor in water from sampling sites in Cheney Reservoir watershed, 1997–99.

than the 2.0-μg/L MCL, with a maximum concentration of 28.6-μg/L. Atrazine was detected in 15 streamflow samples at concentrations greater than the 3.0-μg/L MCL, with a maximum concentration of 135 μg/L. Although deethylatrazine was detected in almost every streamflow sample, no designated MCL for this metabolite has been established. The largest concentrations of alachlor and atrazine occurred in samples of runoff during the late spring and summer and probably are related to the application of these herbicides followed by runoff-producing rainfall.

Median concentrations for all but three herbicides (alachlor, atrazine, and metolachlor) and the metabolite deethylatrazine detected in streamflow samples from the Cheney Reservoir watershed were less than analytical method reporting limits (MRL's) (table 1). The three herbicides with median concentrations larger than their respective MRL's, however, were substantially less than their MCL's.

Median concentrations for alachlor, atrazine, and metolachlor varied substantially among the six sampling sites in the Cheney Reservoir watershed (fig. 3). The largest median concentrations for these three herbicides were from the Red Rock Creek subwatershed (sampling site 5, fig. 1) and were at least 24, 6.6, and 20 times larger (respectively) than median concentrations in water samples from any other sampling site.

Nineteen insecticides were analyzed for this study. Of those, six were detected in streamflow samples (table 1). The most frequently detected insecticide, carbofuran, was detected in 15 of 154 samples (10 percent). The other five insecticides were detected at frequencies ranging from 0.6 to 3.9 percent. Maximum concentrations ranged from 0.008 μg/L for azinphos (methyl-) to 1.16 μg/L for carbofuran. These maximum concentrations are substantially less than established MCL or HAL values. Insecticides that were not detected in streamflow samples are listed in table 2. MRL's ranged from 0.001 to 0.017 μg/L for these insecticides.

Conclusions and Implications

Fifteen herbicides and one herbicide metabolite were detected in streamflow samples from the Cheney watershed during 1997–99. Two of the herbicides, alachlor and atrazine, had several concentrations greater than the established MCL and HAL for these herbicides, but long-term median concentrations were substantially less than these criteria. Of the 19 insecticides analyzed, 6 were detected in the streamflow samples from the Cheney Reservoir watershed. Maximum concentrations for all detected insecticides were substantially less than the established MCL or HAL.

Even though the extensive use of herbicides such as atrazine and metolachlor is very evident in the Cheney Reservoir watershed and their presence was detected in at least 96 percent of the samples collected during this study, median concentrations were small. Potential adverse health risks of long-term exposure for the population that relies on Cheney Reservoir as a drinking-water source appear small for the pesticides examined during this study considering current (2000) water-quality criteria. However, the long-term effects of small concentrations of the pesticides documented in this study on aquatic life are not well known and may be an issue for the watershed.

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For more information on the Cheney Reservoir Watershed Project, visit the USGS Web site at:
http://ks.water.usgs.gov/Kansas/qw/cheney/
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