U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

STATISTICAL COMPARISON OF SELECTED CHEMICAL CONSTITUENTS IN WATER FROM CHEMIGATION AND CONVENTIONAL IRRIGATION WELLS IN KANSAS, 1987

By

Charles A. Perry

U.S. Geological Survey

and

Marc R. Anderson

Kansas State Board of Agriculture

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 91-4049

Lawrence, Kansas

1991

Prepared in cooperation with the

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

CONVERSION FACTORS

Multiply	*By*	*To obtain*
foot	0.3048	meter
mile	1.609	kilometer
acre	4,047	square meter
degree Fahrenheit (°F)	(1)	degree Celsius (°C)

[1] °C = 5/9 (°F-32).
°F = 9/5 (°C)+32.

INTRODUCTION

The major source of drinking water for more than one-half the population of Kansas comes from ground water (Solley and others, 1988). In many areas, the practice of applying agricultural chemicals through irrigation systems (chemigation) has become an increasingly popular method of agriculture in the State. In most instances of chemigation, fertilizers, herbicides, and insecticides are injected into the irrigation pipeline not more than a few feet away from the irrigation well.

Because of the potential for ground-water contamination and the need for a standardized and reasonable set of guidelines for chemigation, the Kansas Legislature passed the Kansas Chemigation Safety Law in July 1985. The law requires all chemigators in the State to register annually with the Kansas State Board of Agriculture, install antipollution devices on their irrigation systems, monitor the chemigation system, and keep records pertaining to chemical applications made through their irrigation systems. Table 1 lists the Kansas Notification and Action Levels for selected agricultural-related chemicals (Kansas Department of Health and Environment, 1988; U.S. Environmental Protection Agency, 1986a,b) in addition to the soil persistence and water solubility of the most commonly used pesticides.

The purpose of this report is to present the statistical results of a study to determine if chemigation has increased the concentrations of selected chemicals in the ground water of major irrigated regions of Kansas. The study was conducted by the U.S. Geological Survey and the Kansas State Board of Agriculture, in cooperation with the Kansas Department of Health and Environment.

SELECTION OF WELLS FOR SAMPLING

As part of the regulatory practices of the Kansas State Board of Agriculture's Chemigation Program, the Division of Plant Health initiated a ground-water-monitoring program for 83 selected chemigation wells throughout the State. These 83 chemigation wells were sampled in 1987 in addition to 28 conventional irrigation wells sampled as part of a U.S. Geological Survey program to monitor agricultural-chemical leaching in fields where irrigation water was applied. The 28 conventional irrigation wells were located in south-central Kansas. The distribution of the 111 sampled wells allowed a regional grouping of chemigation and conventional irrigation wells into subsets for water-quality comparison (fig. 1). The regions are: (1) south-central Kansas, 69 wells; (2) southwest Kansas, 21 wells; (3) northwest Kansas, 19 wells; and (4) north-central Kansas, 2 wells. These regions are characterized by different soil types and varying depths to water. The south-central region was the only region where both chemigation (41) wells and conventional irrigation (28) wells were sampled.

The western part of the south-central region is a mix of sandy soil with little runoff on undulating, dune-type landscapes and silty, sandy, and loamy soil on nearly level to gently undulating landscapes to loamy and clayey soil on nearly level to steeply sloped landscapes. In the eastern part of the south-central region, soil ranges from silty, sandy, or loamy surface layers on nearly level landscapes to sloping and dune-type landscapes. In the southwest region, soil types range from very sandy soil on hilly landscapes to loamy sandy and silty soil to primarily loamy soil on nearly level to gently undulating landscapes. Soil types at sample locations in the northwest region range from deep silty soil to silty loamy soil on nearly level to gently sloping to steep landscapes. The north-central region has silty or silty clay soils on gently sloping to steep landscapes (Anderson, 1988). Well depths range from 40 to 160 feet in the south-central region, 110 to 422 feet in the southwest region, 80 to 310 feet in the northwest region, and 120 to 224 feet in the north-central region.

WELL LOCATIONS

Well locations in this report are given according to a modified version of a system of land subdivisions used by the U.S. Bureau of Land Management (fig. 2). An example of a typical well location is 24S-33W-36BAC in Finney County. The first two digits indicate the township, which in Kansas are nearly all south (S) of the 40th parallel base line. The second two digits indicate the range west (W) of the sixth principal meridian. The last two digits indicate the section in which the well is located. The first letter following the section number denotes the quarter section or 160-acre tract; the second, the quarter-quarter section or 40-acre tract; and the third, the quarter-quarter-quarter section or 10-acre tract. The quarter sections, quarter-quarter sections, and so forth, are designated A, B, C, and D in a counterclockwise direction, beginning with A in the northeast quadrant.

SAMPLE COLLECTION AND CHEMICAL ANALYSES

Well-water samples were collected, chilled to 4 °C (Cohen and others, 1986), and shipped to

Table 1. *Kansas Notification and Action Levels, soil persistence, and water solubility for selected chemicals.*

[From Kansas Department of Health and Environment, 1988. --not determined]

Chemical	Trade name[1]	Unit of measurement[2]	KAL[3]	KNL[4]	Soil persistence[5]	Water solubility[6] (milligrams per liter)
Nitrate as nitrogen (N)	--	mg/l.	10	--	--	--
Nitrogen, ammonia (NH_4)	--	mg/L	--	--	--	--
Phosphate	--	mg/l.	5	--	--	--
Sulfate	--	mg/L	250	--	--	--
Sodium	--	mg/L	100	--	--	--
Potassium	--	mg/L	--	--	--	--
Alachlor	Lasso	µg/l.	5.0	0.5	N	220
Atrazine	AAtrex	µg/l.	25	2.5	M	70
Butylate	Sutan	µg/l.	467	46.7	N	45
Chlorpyrifos	Lorsban	µg/l.	8	2.1	M	2
Metolachlor	Dual	µg/l.	17	1.75	M	530
Propachlor	Ramrod	µg/l.	105	10.5	N	700
Propazine	Milogard	µg/L	117	11 7	P	8.6
Trifluralin	Treflan	µg/l.	17	1.7	M	24

[1] The use of trade names is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

[2] mg/L (milligrams per liter) equals ppm (parts per million); µg/l. (micrograms per liter) equals ppb (parts per billion).

[3] KAL, Kansas Action Level, the level at which long-term exposure to contaminant concentrations is unacceptable. Chronic health effects may occur after long-term consumption of water containing a pesticide at 10 to 100 times the health advisory level (KAL).

[4] KNL, Kansas Notification Level, administrative level confirming that ground-water contamination does exist.

[5] N, nonpersistent (less than 30-day half-life); M, moderately persistent (30- to 100-day half-life); and P, persistent (greater than 100-day half-life).

[6] Perry and others, 1988.

either the Kansas State Board of Agriculture's laboratory in Topeka, Kans., or to the U.S. Geological Survey's laboratory in Arvada, Colo. Inorganic analyses were performed using methods described in Skougstad and others (1979). Pesticide analyses were performed using U.S. Environmental Protection Agency, Method 608 (U.S. Environmental Protection Agency, 1984). The results of all analyses are presented in table 8 at the end of this report.

STATISTICAL COMPARISONS

The chemical analyses of well samples were grouped into various sets and subsets for comparison of water quality among geographical regions and between chemigation and conventional irrigation practices in south-central Kansas (tables 2-6). Statistical parameters included the median, which is the central value of a ranked distribution (tables 2-6), and the standard deviation and the first and third quartiles (table 7), which provided a measure of the distribution of the samples within a set.

Table 2 provides information on dissolved-inorganic constituents for all 111 wells that were sampled. Table 3 provides a statistical summary of dissolved-nitrate concentrations, and figure 3 shows the location of those wells in which nitrate-as-nitrogen concentrations in water samples exceeded the Kansas Action Level (KAL) of 10 milligrams per liter (Kansas Department of Health and Environment, 1988). Table 4 provides a statistical summary of

Table 2. *Statistical summary of selected chemical-constituent concentrations in water samples from all study-area wells, 1987*

[--, not determined]

Chemical constituent (dissolved)	Unit of measurement[1]	Kansas Action Level (KAL)[2]	Number of wells sampled	Minimum concentration	Median concentration	Maximum concentration	Percentage of wells exceeding Kansas Action Level (KAL)[2]
Nitrate as nitrogen (N)	mg/L	10	111	<0.10	3.7	16	8.0
Phosphate (PO_4)	mg/L	5	110	<.03	.03	.34	0
Sulfate (SO_4)	mg/L	250	111	9.4	24	1,700	6.3
Potassium (K)	mg/L	--	111	1.1	3.3	13	0
Nitrogen, ammonia (NH_4)	mg/L	--	81	<.10	<.10	12.0	--
Pesticides[3]	µg/L	25	111	<.5	<.5	2.2	0

1 mg/L, milligrams per liter; µg/L, micrograms per liter.

2 Kansas Department of Health and Environment, 1988.

3 Only atrazine detected. Analyses of all water samples included the following pesticides with detection levels of U.S. Geological Survey laboratory (USGS) or Kansas State Board of Agricultural (KSBA) laboratory:

Pesticide	Detection level (micrograms per liter) USGS	KSBA	Pesticide	Detection level (micrograms per liter) USGS	KSBA
Atrazine	0.10	0.5	Metolachlor	0.10	0.5
Alachlor	.10	.5	Metribuzin	.10	1.0
Ametryn	.10	--	Permethrin	--	1.0
Butylate	--	.5	Propachlor	--	.5
Chlorpyrifos	--	.5	Propazine	--	.5
Cyanazine	.10	1.0	Trifluralin	--	.5
Dimethoate	--	2.0			

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdman, D.E., and Duncan, S.S., eds., 1979, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A1, 626 p.

Solley, W.B., Merk, C.F., and Pierce, R.R., 1988, Estimated use of water in the United States in 1985: U.S. Geological Survey Circular 1004, p. 13.

U.S. Environmental Protection Agency, 1984, Method 608: Code of Federal Regulations, v. 49, no. 209, p. 89-104.

___1986a, Maximum contaminant levels (subpart B of part 141, National interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 524-528.

___1986b, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 587-590.

Table 3. Statistical summary of dissolved-nitrate as nitrogen concentrations detected in water samples from four regions, 1987

[Concentrations in milligrams per liter]

Region (fig. 1)	Number of wells sampled	Minimum concentration	Median concentration	Maximum concentration	Percentage of wells exceeding Kansas Action Level (KAL)[1]
South central (Chemigation wells)	41	<0.10	3.4	15	7.3
South central (Conventional irrigation wells)	28	.10	6.8	16	17.8
Southwest	21	1.6	4.7	12	4.8
Northwest	19	.40	2.8	8.7	0
North central	2	1.9	5.4	8.9	0
Composite	111	<0.10	3.7	16	8.0

[1] KAL for dissolved nitrate as nitrogen is 10 milligrams per liter (Kansas Department of Health and Environment, 1988).

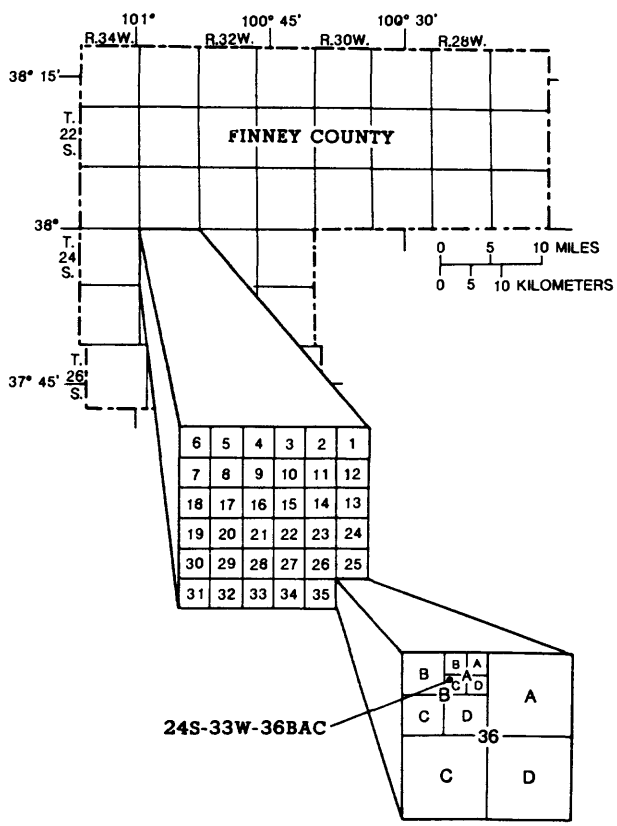

Figure 2. Well-location system.

Table 4. *Statistical summary of dissolved-phosphate concentrations detected in water samples from four regions, 1987*

[Concentrations in milligrams per liter]

Region (fig. 1)	Number of wells (sampled)	Minimum concentration	Median concentration	Maximum concentration	Percentage of wells exceeding Kansas Action Level (KAL)[1]
South central (Chemigation wells)	41	<0.03	0.05	0.22	0
South central (Conventional irrigation wells)	27	<.03	.09	.34	0
Southwest	21	<.03	<.03	.04	0
Northwest	19	<.03	<.03	.05	0
North central	2	.19	.19	.20	0
Composite	110	<.03	.03	.34	0

[1] KAL for dissolved phosphate is 5 milligrams per liter (Kansas Department of Health and Environment, 1988).

Table 5. *Statistical summary of dissolved-sulfate concentrations detected in water samples from four regions, 1987*

[Concentrations in milligrams per liter]

Region (fig. 1)	Number of wells sampled	Minimum concentration	Median concentration	Maximum concentration	Percentage of wells exceeding Kansas Action Level (KAL)[1]
South central (Chemigation wells)	41	10	24	540	2.4
South central (Conventional irrigation wells)	28	9.4	23	600	3.6
Southwest	21	10	35	1,700	23.8
Northwest	19	10	22	120	0
North central	2	11	14	17	0
Composite	111	9.4	24	1,700	6.3

[1] KAL for dissolved sulfate is 250 milligrams per liter (Kansas Department of Health and Environment, 1988).

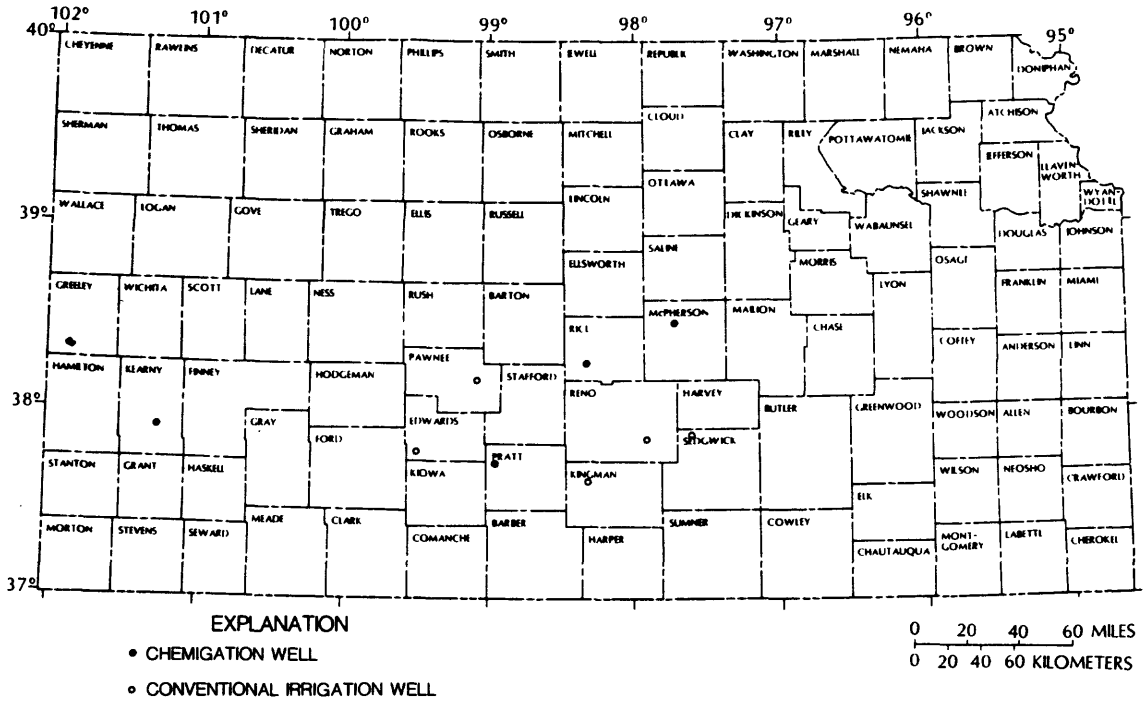

Figure 3. Location of wells in which dissolved-nitrate, as nitrogen, concentrations exceeded 10 milligrams per liter.

Table 6. *Statistical summary of pesticides detected in water samples from four regions, 1987*

[Concentrations in micrograms per liter]

Region (fig. 1)	Number of wells sampled	Minimum concentration	Median concentration	Maximum concentration	Percentage of wells exceeding Kansas Action Level (KAL)[1]
South central (Chemigation wells)	41	<0.5	<0.5	<0.5	0
South central (Conventional irrigation wells)	28	<.5	<.5	1.4	0
Southwest	21	<.5	<.5	2.2	0
Northwest	19	<.5	<.5	<.5	0
North central	2	<.5	<.5	<.5	0
Composite	111	<.5	<.5	2.2	0

[1]KAL's for pesticides are given in table 1 (Kansas Department of Health and Environment, 1988).

Table 7. *Chemical concentrations detected in water samples from chemigation and conventional irrigation wells in south-central Kansas, 1987*

Chemical	Well type	Number of wells sampled	Minimum concentration	First quartile	Median concentration	Third quartile	Maximum concentration	Standard deviation
Nitrate[1]	All	69	<0.10	1.2	5.3	8.2	16	4.1
Do.	Chemigation	41	<.10	1.0	3.0	6.6	15	3.8
Do.	Conventional	28	.10	3.6	6.8	9.3	16	4.4
Phosphate[1]	All	68	<0.03	<0.03	0.06	0.12	0.34	0.07
Do.	Chemigation	41	<.03	<.03	.05	.08	.22	.04
Do.	Conventional	27	<.03	.04	.09	.17	.34	.08
Sulfate[1]	All	69	9.4	14	24	64	600	102
Do.	Chemigation	41	10	14	24	53	540	95
Do.	Conventional	28	9.4	12	23	74	600	112
Potassium[1]	All	69	1.1	2.0	2.7	3.4	8.5	1.4
Do.	Chemigation	41	1.1	1.8	2.7	4.0	8.5	1.7
Do.	Conventional	28	1.1	2.0	2.6	3.0	5.1	.8
Pesticide[2]	All	69	<0.5	<0.5	<0.5	<0.5	1.4	0.17
Do.	Chemigation	41	<.5	<.5	<.5	<.5	<.5	0
Do.	Conventional	28	<.5	<.5	<.5	<.5	1.4	.27

[1] Concentrations given in milligrams per liter as nitrogen.
[2] Concentrations given in micrograms per liter (only atrazine detected).

Table 8. *Water-quality data collected for study-area wells, 1987*

[--, not determined. ND, not detected]

Location (fig. 1)	County	Well type[1]	pH[2]	Specific conductance[3]	Dissolved nitrate as nitrogen[4]	Dissolved phosphate[4] as PO_4	Dissolved sulfate[4] as SO_4	Dissolved potassium[4] as K	Dissolved nitrogen, ammonia[4] as NH_4	Pesticide concentration[5]	Type of pesticide
South-central region											
20S-14W-24CCA	BARTON	C	7.6	1,000	1.4	<0.03	30	4.1	<0.10	ND	
20S-11W-03ABB	BARTON	C	7.3	2,100	4.8	.05	540	8.5	<.10	ND	
20S-13W-27ABD	BARTON	NC	7.8	538	7.2	.21	14	2.7	-	ND	
26S-19W-09ACA	EDWARDS	C	8.0	520	3.7	.04	110	1.5	<.10	ND	
25S-16W-13BDB	EDWARDS	C	7.8	465	2.7	<.03	23	2.2	<.10	ND	
25S-18W-09BBD	EDWARDS	C	7.6	475	7.8	.04	25	1.4	<.10	ND	
24S-18W-17BBD	EDWARDS	NC	7.9	332	3.2	.15	16	1.3	-	ND	
24S-18W-34ABD	EDWARDS	NC	7.9	447	6.7	.15	20	2.0	-	ND	
25S-17W-30BAC	EDWARDS	NC	8.0	420	9.3	.12	27	3.3	-	ND	
25S-18W-07BAC	EDWARDS	NC	7.9	360	5.4	.12	30	1.3	-	ND	
26S-17W-32ABD	EDWARDS	C	7.9	404	.43	.06	13	2.6	-	ND	
26S-20W-01B	EDWARDS	NC	7.7	1,700	4.8	.03	600	5.1	-	ND	
26S-20W-36BCA	EDWARDS	NC	7.9	620	13	.09	130	1.9	-	1.4	ATRAZINE
22S-03W-09DBC	HARVEY	C	7.5	970	2.8	.11	100	2.9	<.10	ND	
23S-03W-16DAC	HARVEY	C	6.4	330	6.0	.13	14	1.2	<.10	ND	
23S-03W-22CBB	HARVEY	C	7.4	1,880	.90	.11	36	7.5	<.10	ND	
23S-03W-21ACC	HARVEY	C	6.7	1,100	6.3	.06	20	4.2	<.10	ND	
23S-02W-29BBD	HARVEY	C	7.4	350	.8	.22	14	1.3	<.10	ND	
23S-03W-22CAB	HARVEY	C	7.3	505	3.0	.05	16	3.0	<.10	ND	
23S-03W-36BBD	HARVEY	C	7.2	510	2.0	.19	28	2.0	<.10	ND	
23S-03W-22DAC	HARVEY	C	7.3	505	3.0	.05	16	3.0	1.6	ND	
24S-02W-11AAA	HARVEY	C	7.7	685	<.10	.15	90	1.6	.20	ND	
24S-02W-08ACC	HARVEY	NC	7.2	478	.10	.03	100	3.0	-	ND	
24S-02W-27B	HARVEY	NC	7.7	719	.10	.09	68	2.6	-	ND	
24S-03W-15C	HARVEY	NC	7.7	1,000	.15	.03	110	3.2	-	ND	
27S-08W-16BBA	KINGMAN	NC	7.6	450	12	.15	13	1.4	-	ND	
27S-19W-07CCA	KIOWA	C	8.1	260	5.7	.07	13	2.1	<.10	ND	
28S-17W-02CCA	KIOWA	C	7.6	350	6.5	.15	14	3.2	<.10	ND	
27S-16W-30BBD	KIOWA	NC	7.6	340	8.4	.21	12	3.2	-	ND	
27S-18W-05CAC	KIOWA	NC	8.0	266	5.3	.04	11	3.0	-	ND	
27S-17W-01BBD	KIOWA	NC	7.7	310	6.2	.18	11	2.7	-	ND	
27S-16W-06CCA	KIOWA	NC	7.7	289	5.0	.09	9.4	2.0	-	ND	
18S-03W-32BCC	McPHERSON	C	7.5	1,000	13	<.03	70	4.7	12	ND	
19S-04W-36DDB	McPHERSON	C	7.7	600	.80	.05	28	1.5	<.10		
20S-03W-06CCB	McPHERSON	C	7.5	585	1.0	<.03	21	1.4	<.10	ND	
20S-04W-10CDD	McPHERSON	C	7.5	780	2.5	.08	58	3.5	<.10	ND	
20S-03W-30DCD	McPHERSON	C	7.3	680	.10	.06	11	1.9	<.10	ND	
19S-03W-31C	McPHERSON	NC	7.6	582	.74	.06	22	2.2	-	ND	
20S-04W-34A	McPHERSON	NC	7.6	845	6.0	.06	56	2.2	--.10		ATRAZINE
21S-15W-17CDD	PAWNEE	C	7.6	1,100	8.7	<.03	240	4.7	<.10	ND	
21S-15W-06ACC	PAWNEE	C	7.4	900	2.0	.11	48	2.7	<.10	ND	
22S-18W-05BBD	PAWNEE	C	7.6	995	<.10	<.03	120	5.6	<.10	ND	
22S-17W-11CCA	PAWNEE	C	7.9	675	.80	<.03	180	3.9	<.10	ND	
22S-15W-36BBD	PAWNEE	C	7.6	520	5.9	.04	23	4.2	<.10	ND	
22S-16W-27CCB	PAWNEE	NC	7.9	561	.10	.06	76	3.4	-	ND	
22S-16W-31BBD	PAWNEE	NC	7.8	420	12	<.03	19	2.8	-	ND	
26S-14W-31ACA	PRATT	C	7.5	430	13	.07	10	2.2	<.10	ND	
27S-13W-06ADB	PRATT	C	7.6	465	3.4	.05	11	2.2	<.10	ND	
26S-14W-21CCA	PRATT	C	7.8	385	5.6	.04	11	3.5	<.10	ND	
29S-11W-20AAC	PRATT	C	7.5	510	9.7	<.03	10	2.2	<.10	ND	
26S-14W-18CCB	PRATT	NC	7.8	421	9.3	.25	11	2.5	-	ND	
27S-14W-06CAD	PRATT	NC	7.7	306	7.0	.21	9.4	2.9	-	ND	
28S-11W-30AAB	PRATT	C	7.8	431	2.9	.06	10	2.6	-	ND	
29S-11W-26DBC	PRATT	NC	7.7	524	10	-	9.6	1.5	-	ND	
23S-04W-28CCA	RENO	C	7.4	445	<.10	.07	41	1.6	<.10	ND	
26S-10W-32DDB	RENO	C	7.9	560	8.0	.03	12	1.1	<.10	ND	
25S-08W-08CBB	RENO	C	7.5	550	8.4	.08	16	1.6	<.10	ND	
24S-10W-19DBD	RENO	C	7.2	1,450	6.8	.06	27	4.4	.10	ND	
24S-05W-17BAA	RENO	NC	7.7	607	7.8	.18	24	2.5	-	ND	
26S-07W-12DDD	RENO	NC	7.4	315	16	.34	19	2.0	-	ND	

Table 8. *Water-quality data collected for study-area wells, 1987*--Continued

Location (fig. 1)	County	Well type[1]	pH[2]	Specific conductance[3]	Dissolved nitrate as nitrogen[4]	Dissolved phosphate[4] as PO_4	Dissolved sulfate[4] as SO_4	Dissolved potassium[4] as K	Dissolved nitrogen, ammonia[4] as NH_4	Pesticide concentration[5]	Type of pesticide
South-central region--Continued											
21S-09W-07ACA	RICE	C	7.3	1,320	15	<0.03	230	6.1	<.10	ND	
25S-02W-17AAB	SEDGWICK	NC	7.3	1,040	12	.06	100	3.6	–	0.30	ATRAZINE
25S-01W-18DAC	SEDGWICK	NC	7.5	710	.58	.03	96	2.7	–	ND	
26S-02W-04DCC	SEDGWICK	NC	7.5	916	8.6	.12	60	2.5	–	ND	
25S-14W-27CCA	STAFFORD	C	7.7	530	3.0	<.03	16	2.3	<.10	ND	
24S-13W-10CAC	STAFFORD	C	7.3	1,130	7.8	<.03	30	3.2	<.10	ND	
21S-14W-25ACA	STAFFORD	C	7.6	760	3.6	.04	30	3.6	<.10	ND	
21S-11W-07ACA	STAFFORD	C	7.7	860	1.1	.07	24	3.5	<.10	ND	
23S-13W-27AAC	STAFFORD	NC	7.5	832	8.8	.09	24	2.8	–	ND	
Southwest region											
25S-31W-09BAD	FINNEY	C	7.6	780	2.5	<.03	210	3.8	<.10	ND	
24S-32W-27BAC	FINNEY	C	7.5	740	2.8	<.03	170	4.5	<.10	ND	
24S-33W-10DBB	FINNEY	C	7.1	3,600	<	.03	1,700	8.1	<.10	ND	
24S-33W-36BAC	FINNEY	C	7.6	365	8.8	<.03	13	3.7	<.10	ND	
23S-32W-34BCD	FINNEY	C	7.4	1,340	3.1	<.03	420	9.6	<.10	ND	
24S-34W-14AAC	FINNEY	C	7.8	528	2.1	<.03	93	5.1	<.10	ND	
26S-26W-36CDA	FORD	C	6.8	480	5.0	.04	27	5.0	<.10	ND	
27S-26W-06DBB	FORD	C	7.1	425	3.4	<.03	23	3.4	<.10	ND	
27S-22W-19ACC	FORD	C	7.6	570	5.4	<.03	16	3.3	<.10	ND	
27S-25W-01DAC	FORD	C	7.5	490	6.5	<.03	26	3.8	<.10	2.2	ATRAZINE
28S-24W-31AAB	FORD	C	7.8	487	1.6	<.03	12	4.3	<.10	ND	
27S-27W-36ACD	GRAY	C	7.0	440	3.5	<.03	23	3.9	<.10	1.4	ATRAZINE
26S-28W-14ACD	GRAY	C	8.6	870	7.8	<.03	210	4.7	<.10	ND	
26S-28W-19AAC	GRAY	C	7.1	455	6.9	<.03	78	3.9	<.10	ND	
26S-30W-01CDA	GRAY	C	7.1	400	2.9	<.03	35	3.3	<.10	ND	
25S-29W-30BAC	GRAY	C	7.2	3,200	6.2	<.03	1,600	8.4	<.10	ND	
24S-36W-26CCB	KEARNY	C	7.0	3,600	12	<.03	1,700	10	6.2	ND	
26S-35W-06BCC	KEARNY	C	7.6	269	2.1	<.03	10	2.1	<.10	ND	
25S-35W-21CAC	KEARNY	C	7.1	416	6.3	<.03	34	3.3	<.10	ND	
26S-37W-22CAA	KEARNY	C	7.4	425	2.4	<.03	33	3.8	<.10	ND	
24S-36W-26CCB	KEARNY	C	7.4	3,000	4.7	<.03	1,400	7.0	<.10	ND	
Northwest region											
05S-42W-21BBD	CHEYENNE	C	6.9	327	2.2	<.03	10	5.7	<.10	ND	
04S-42W-03ACA	CHEYENNE	C	7.9	430	8.7	<.03	22	7.4	<.10	ND	
05S-30W-35BCB	DECATUR	C	6.8	450	2.5	<.03	14	7.7	<.10	ND	
05S-30W-35BCD	DECATUR	C	6.8	510	6.2	<.03	24	7.6	<.10	ND	
05S-31W-20CCA	RAWLINS	C	7.3	950	.40	.05	120	13	<.10	ND	
07S-29W-21ABB	SHERIDAN	C	7.0	390	2.3	<.03	20	4.7	<.10	ND	
09S-28W-33BCC	SHERIDAN	C	7.1	430	1.8	<.03	19	7.3	<.10	ND	
10S-28W-09BBB	SHERIDAN	C	6.8	460	2.6	<.03	18	7.0	<.10	ND	
10S-29W-11BAC	SHERIDAN	C	6.9	470	3.2	<.03	19	6.8	<.10	ND	
10S-29W-11BCD	SHERIDAN	C	6.9	535	3.3	<.03	36	7.3	<.10	ND	
08S-29W-06DAC	SHERIDAN	C	7.0	435	2.5	<.03	23	7.3	<.10	ND	
08S-41W-15DDB	SHERMAN	C	7.0	390	2.3	<.03	20	4.7	<.10	ND	
10S-41W-03DDC	SHERMAN	C	6.5	320	2.5	<.03	15	3.9	<.10	ND	
07S-37W-17BBD	SHERMAN	C	7.7	595	7.6	<.03	48	6.1	<.10	ND	
07S-32W-25ACC	THOMAS	C	7.8	440	2.8	<.03	22	6.4	<.10	ND	
08S-31W-27ACC	THOMAS	C	7.9	550	5.4	<.03	34	7.5	<.10	ND	
06S-31W-32CAB	THOMAS	C	7.8	470	4.8	<.03	22	7.5	<.10	ND	
08S-31W-01DDB	THOMAS	C	7.8	475	3.1	<.03	27	6.9	<.10	ND	
09S-33W-15ACC	THOMAS	C	7.6	470	3.2	<.03	28	6.2	<.10	ND	
North-central region											
01S-03W-08BAC	REPUBLIC	C	7.6	435	1.9	.20	11	4.0	<.10	ND	
01S-03W-15ABA	REPUBLIC	C	7.6	673	8.9	.19	17	3.2	<.10	ND	

[1] C = Chemigation, NC = Conventional irrigation.
[2] pH given in standard units.
[3] Concentrations given in microsiemens per centimeter at 25 degrees Celsius.
[4] Concentrations given in milligrams per liter.
[5] Concentrations given in micrograms per liter (Atrazine only detection levels for other pesticides listed in footnote 3 in table 2).

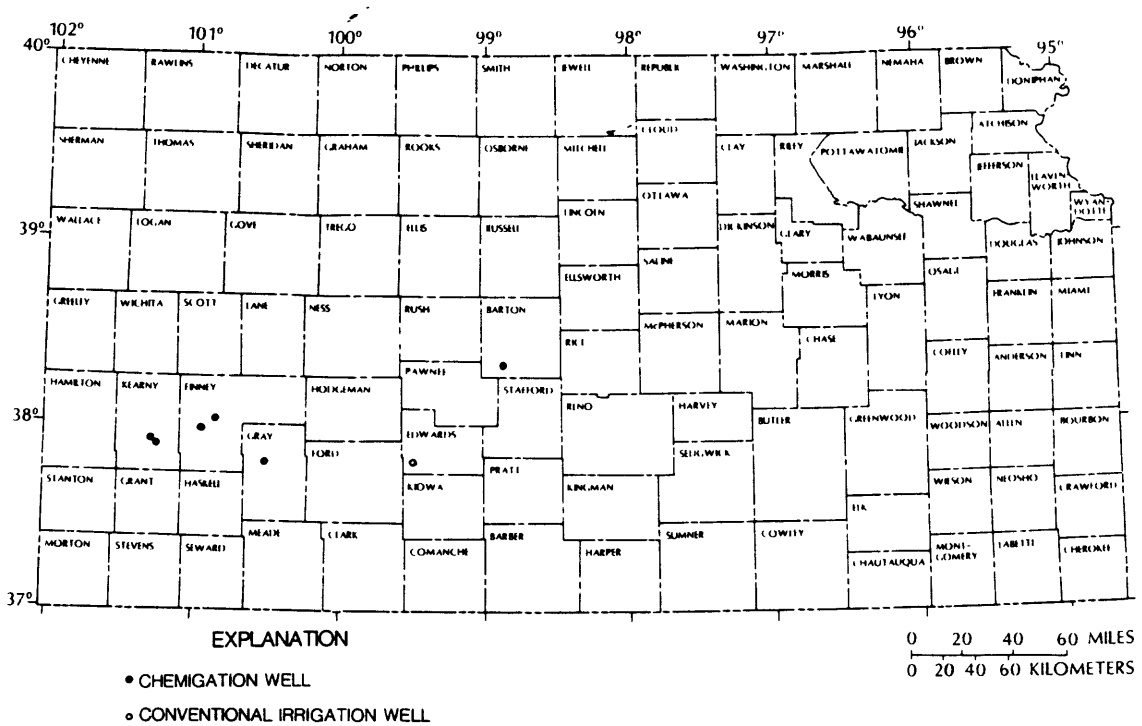

Figure 4. Location of wells in which dissolved-sulfate concentrations exceeded 250 milligrams per liter.

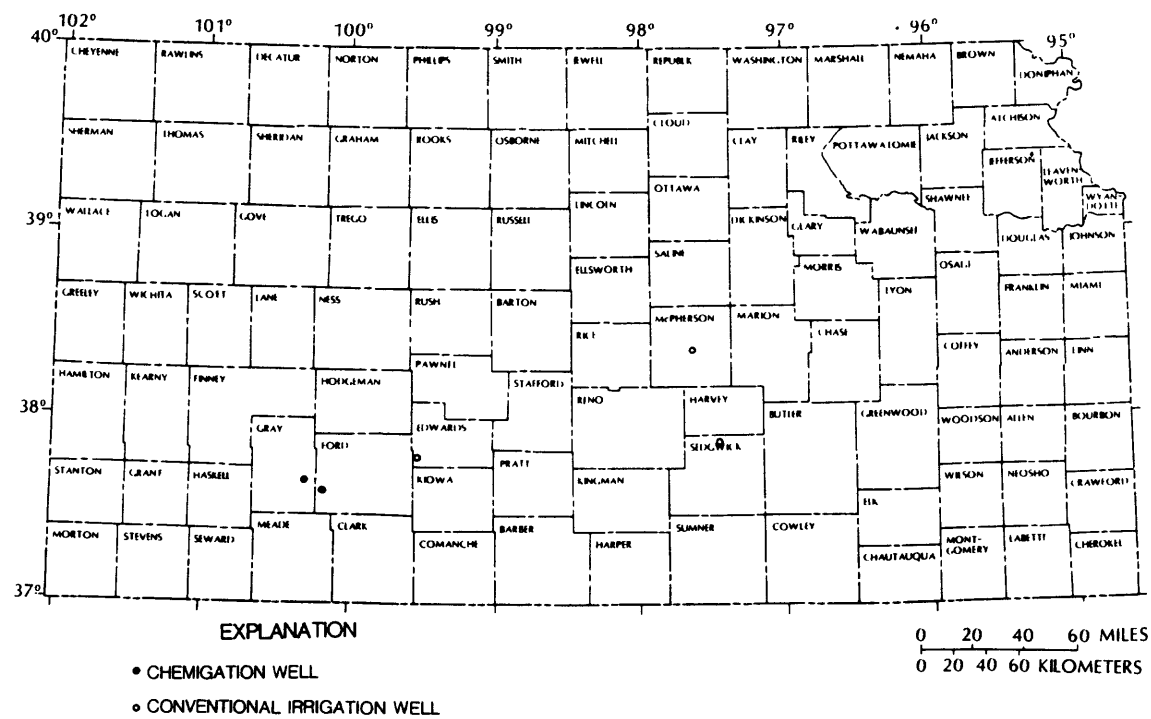

Figure 5. Location of wells in which pesticides were detected.

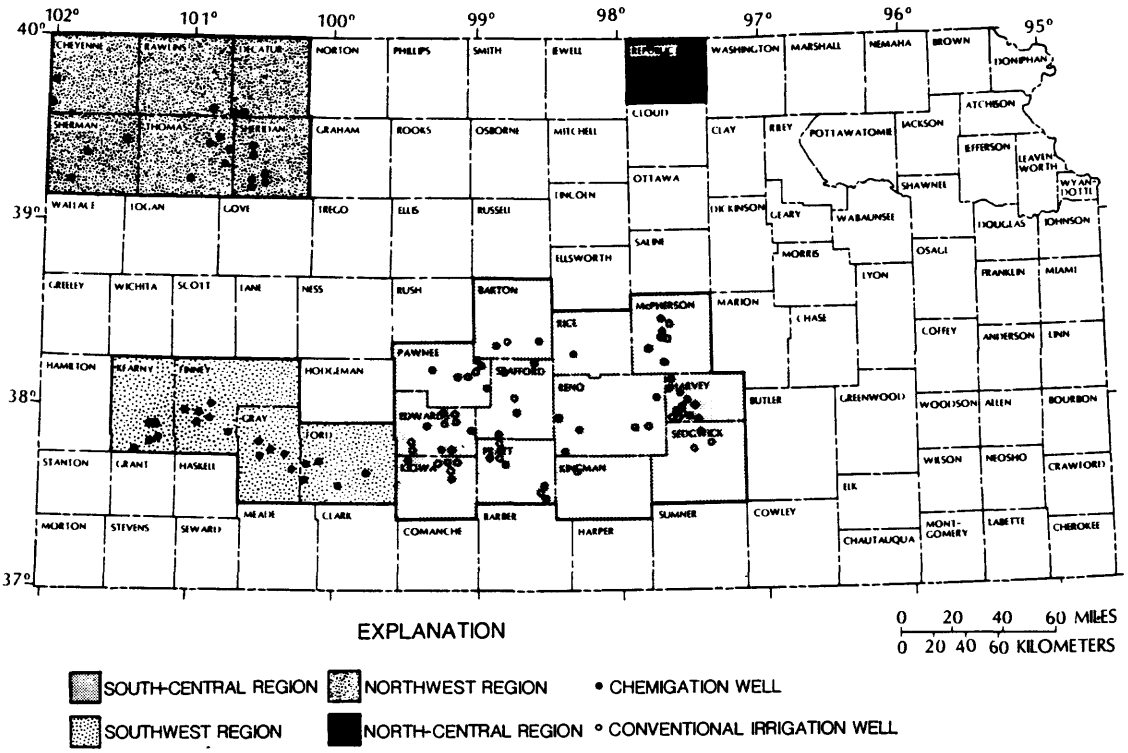

Figure 1. Location of chemigation and conventional irrigation wells, and regions used for water-quality comparison.

dissolved-phosphate concentrations. None of the well samples contained dissolved-phosphate concentrations that exceeded the KAL of 5 milligrams per liter. Table 5 provides a statistical summary of dissolved-sulfate concentrations, with figure 4 showing the location of those wells in which dissolved-sulfate concentrations in water samples exceeded the KAL of 250 milligrams per liter. Table 6 provides a statistical summary of wells in which those pesticides listed in table 1 were detected in water samples. The location of those wells with positive detections is shown in figure 5. Table 7 provides a comparison of agricultural-chemical concentrations detected in water samples from chemigation and conventional irrigation wells in the south-central region.

RESULTS OF COMPARISON

A statistical comparison of samples from chemigation and conventional irrigation wells in south-central Kansas (table 7) shows no indication of an increase in chemical concentrations as a result of chemigation. In fact, dissolved-nitrate and dissolved-phosphate concentrations were slightly larger in samples from the conventional irrigation wells. The largest difference in chemical concentrations was from one region of the State to another. The more permeable soil and shallower wells in the south-central region may have contributed to the largest concentrations of dissolved nitrate of all the regions. Dissolved-sulfate and atrazine concentrations were largest in the southwest region. Water from wells sampled in the northwest region and the two wells in the north-central region generally had smaller concentrations for the selected chemical constituents than water from wells in the other regions, probably a result of deep wells and less-permeable soil at the surface.

REFERENCES

Anderson, M.R., 1988, Chemigation well water quality study: Scott City, Kansas State Board of Agriculture, 23 p.

Cohen, S.Z., Eiden, Catherine, and Lorber, M.N., 1986, Monitoring ground water for pesticides: Washington D.C., American Chemical Society Symposium Series 315, p. 170-196.

Kansas Department of Health and Environment, 1988, Final ground water contaminant target concentrations: Topeka, Kansas Deparment of Health and Environment Memorandum, June 6, 1988, 28 p.

Perry, C.A., Robbins, F.V., and Barnes, P.L., 1988, Factors affecting leaching in agricultural areas and an assessment of agricultural chemicals in the ground water of Kansas: U.S. Geological Survey Water-Resources Investigations Report 88-4104, 55 p.