ELEMENTAL CONCENTRATIONS IN BENTHIC INVERTEBRATES COLLECTED FROM THE NEOSHO, COTTONWOOD, AND SPRING RIVERS

Final report to the U.S. Fish and Wildlife, Region 6, Manhattan, Kansas

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June 2, 1997

Introduction

In 1994, researchers at the Midwest Science Center (MSC) were funded by Region VII of the U.S. Environmental Protection Agency (USEPA) to investigate the potential effects of lead-zinc mining on Neosho madtom (*Noturus placidus*), a Federally-listed threatened fish species, populations (Schmitt et al. 1997, Wildhaber et al. 1996). Region 6 of the U.S. Fish and Wildlife Service (USFWS) funded metals analyses of benthic invertebrate tissue collected at the USEPA sites; this report presents the results of the benthic invertebrate tissue analyses.

Methods

Study Area

The study area includes the mainstems of the Neosho, Cottonwood, and Spring Rivers and the lower reaches of several Spring River tributaries in Kansas, Missouri, and Oklahoma; all three rivers are a part of the Arkansas River system (Figure 1, Table 1). The Cottonwood River feeds into the Neosho River just south of Emporia, Kansas. The Neosho river is separated from the Spring River by the Grand Lake of the Cherokees into which both rivers flow.

Sample collection

Collection sites for invertebrates were determined based on the current best information as to the probability that Neosho madtoms would be present. For the Neosho and Cottonwood River from Emporia Kansas to Grand Lake of the Cherokees, 12 gravel bars with know populations of

Neosho madtoms were selected for study (USFWS 1991). For the Spring River from the North Fork of the Spring River to Grand Lake of the Cherokees, 20 gravel bars (the great majority of gravel bars present in the river) were selected for study based on habitat characteristics known to increase the probability for the presence of Neosho madtoms in the Neosho and Cottonwood Rivers (Moss 1983, USFWS 1991, Wenke et al. 1992, Fuselier and Edds 1994). At each site, benthic invertebrates were opportunistically collected from kick seines used for fish collection and dip nets using acid washed forceps and placed in a plastic bag for later metals analyses using ICAP.

Results and Conclusions

For the three primary metals of concern (i.e., Cd, Pb, and Zn) some important patterns were observed (Tables 2 and 3). All three metals were generally found to be higher in all invertebrate classes in the Spring River and its tributaries than in the Neosho/Cottonwood River system. For Cd, the two main invertebrate categories of decapoda (i.e., crayfish) and megaloptera (i.e., dobsonflies) were generally similar in concentration. For Pb and Zn, megaloptera generally had higher concentration than did the decapoda. Within the Spring River drainage: 1) the highest concentrations of Cd were found at sites 17 (i.e., mouth of Center Creek) and 20 (i.e., Shoal Creek); 2) the highest concentrations of Pb were found at sites 17, 20, and 28 (i.e., mouth of Turkey Creek); 3) the highest concentrations of Zn were found at sites 17, 20, 26 (i.e., between Center Creek and Turkey Creek) and 28; and 4) the lowest concentrations of all three metals were found at sites above Center Creek

The results of the metals analyses of the benthic invertebrate tissues collected in the Neosho, Cottonwood, and Spring Rivers indicate one potential explanation for the previously documented limited distribution of Neosho madtoms in the Spring River (Wilkinsin et al. 1996). The lower concentrations of Cd, Pb, and Zn in benthic invertebrate tissues in the Neosho/Cottonwood River system than in the Spring River parallel the higher density of Neosho madtoms in the Neosho/Cottonwood River system than in the Spring River (Schmitt et al. 1997). Furthermore, lower concentrations of Cd, Pb, and Zn found at sites in the Spring River above Center Creek parallel the fact that, except for site 29 near Baxter Springs, Kansas, Neosho madtoms are generally not collected in the Spring River below Center Creek (Wilkinsin et al. 1996).

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Table 1. Collection sites in the Neosho, Cottonwood, and Spring Rivers, 1994. At sites with letter designations, latitude and longitude were estimated from U.S. Geological Survey 1:100,000 maps.

Date sampled	Site number	River (county and state)	Legal description (latitude, longitude)
8/29/94	0A	Neosho River just east of Oswego, Kansas (Cherokee County, Kansas)	SW 1/4, Sec 13, T33S, R21E (37° 09' 56.3" N, 95° 03' 45.8" W)
8/29/94	0B	Neosho River just north of Oswego, Kansas (Labette County, Kansas)	NW 1/4, Sec 15, T33S, R21E (37° 10' 34.1" N, 95° 06' 15.3" W)
8/30/94	1	Neosho River at Neosho Wildlife Area (Neosho County, Kansas)	NW 1/4, Sec 32, T29S, R21E (37° 28' 33.1" N, 95° 08' 21.1" W)
8/30/94	2	Neosho River at Neosho Wildlife Area (Neosho County, Kansas)	NE 1/4, Sec 31, T29S, R21E (37° 28' 50.6" N, 95° 08' 35.4" W)
8/31/94	3	Neosho River just northeast of Burlington, Kansas (Coffey County, Kansas)	SW 1/4, Sec 23, T21S, R15E (38° 12' 18.1" N, 95° 43' 47.2" W)
9/1/94	4	Cottonwood River just west of Emporia, Kansas (Chase County, Kansas)	NW 1/4, Sec 26, T19S, R8E (38° 22' 27.3" N, 96° 29' 36.0" W)
9/1/94	5	Cottonwood River just west of Emporia, Kansas (Chase County, Kansas)	SW 1/4, Sec 25, T19S, R8E (38° 21' 50.6" N, 96° 28' 41.2" W)
9/7/94	6	Neosho River just south of Humbolt, Kansas (Allen County, Kansas)	SW 1/4, Sec 4, T26S, R18E (37° 48' 36.4" N, 95° 26' 50.1" W)
9/7/94	6A	Neosho River just south of Humbolt, Kansas (Allen County, Kansas)	NW 1/4, Sec 9, T26S, R18E (37° 47' 57.1" N, 95° 26' 48.5" W)
9/8/94	7A	Neosho River just east of Emporia, Kansas (Lyon County, Kansas)	NW 1/4, Sec 23, T19S, R12E (38° 23' 27.1" N, 96° 03' 26.0" W)

Date sampled	Site number	River (county and state)	Legal description (latitude, longitude)
9/8/94	7B	Neosho River just east of Emporia, Kansas (Lyon County, Kansas)	NE 1/4, Sec 23, T19S, R12E (38° 23' 12.1" N, 96° 02' 57.6" W)
9/13/94	8	Spring River just downstream of I-44 bridge (Ottawa County, Oklahoma)	NE 1/4, Sec 8, T28N, R24E (36° 55' 27.5" N, 94° 44' 26.0" W)
9/14/94	9	Spring River just northeast of Quapaw, Oklahoma (Ottawa County, Oklahoma)	SW 1/4, Sec 28, T29N, R24E (36° 57' 40.3" N, 94° 43' 21.1" W)
9/15/94	10	Spring River just upstream of Oklahoma-Kansas border (Cherokee County, Kansas)	NE 1/4, Sec 18, T35S, R25E (37° 00' 07.4" N, 94° 42' 52.0" W)
9/20/94	11	Spring River just south of Riverton, Kansas (Cherokee County, Kansas)	SE 1/4, Sec 19, T34S, R25E (37° 03' 54.2" N, 94° 42' 21.7" W)
9/21/94	12	Spring River just upstream State Highway 96 (Cherokee County, Kansas)	SW 1/4, Sec 11, T33S, R25E (37° 10' 52.2" N, 94° 38' 36.0" W)
9/21/94	13	Spring River just upstream State Highway 96 (Cherokee County, Kansas)	SW 1/4, Sec 11, T33S, R25E (37° 10' 56.7" N, 94° 38' 40.7" W)
9/22/94	14	Spring River just upstream State Highway 96 (Cherokee County, Kansas)	SW 1/4, Sec 11, T33S, R25E (37° 10' 46.1" N, 94° 38' 32.4" W)
9/23/94	15	Shoal Creek just upstream State Highway 26 (Cherokee County, Kansas)	NW 1/4, Sec 35, T34S, R25E (37° 02' 30.0" N, 94° 38' 22.0" W)
9/24/94	16	Spring River just upstream of Oklahoma-Kansas border (Cherokee County, Kansas)	NE 1/4, Sec 18, T35S, R25E (36° 59' 57.3" N, 94° 42' 47.2" W)
9/26/94	17	Center Creek just upstream of mouth (Jasper County, Missouri)	SW 1/4, Sec 14, T28N, R34W (37° 09' 05.1" N, 94° 36' 59.6" W)

Date sampled	Site number	River (county and state)	Legal description (latitude, longitude)
9/27/94	18	Spring River just downstream of State Highway 96 (Cherokee County, Kansas)	NW 1/4, Sec 24, T33S, R25E (37° 09' 34.0" N, 94° 37' 47.3" W)
9/28/94	19	Spring River western channel just downstream of State Highway 96 (Cherokee County, Kansas)	NE 1/4, Sec 14, T33S, R25E (37° 10' 23.7" N, 94° 38' 23.0" W)
9/29/94	20	Shoal Creek just southwest of Galena, Kansas (Cherokee County, Kansas)	NW 1/4, Sec 34, T34S, R25E (37° 02' 36.8" N, 94° 39' 26.1" W)
10/1/94	21	Spring River just east of Waco, Missouri (Jasper County, Missouri)	NE 1/4, Sec 18, T29N, R33W (37° 14' 35.4" N, 94° 34' 00.9" W)
10/2/94	22	Spring River just south of Waco, Missouri (Jasper County, Missouri)	NE 1/4, Sec 35, T29N, R34W (37° 12' 03.8" N, 94° 36' 25.7" W)
10/3/94	23	Spring River just south of Waco Missouri (Jasper County, Missouri)	SE 1/4, Sec 23, T29N, R34W (37° 13' 19.9" N, 94° 36' 03.1" W)
10/4/94	24	Spring River just south of Waco, Missouri (Jasper County, Missouri)	NW 1/4, Sec 26, T29N, R34W (37° 12' 55.2" N, 94° 36' 28.6" W)
10/4/94	25	Spring River just southeast of Lawton, Kansas (Cherokee County, Kansas)	NE 1/4, Sec 1, T33S, R25E (37° 11' 58.2" N, 94° 37' 32.7" W)
10/5/94	26	Spring River just southeast of Lawton, Kansas (Cherokee County, Kansas)	SE 1/4, Sec 25, T33S, R25E (37° 08' 17.6" N, 94° 37' 13.2" W)
10/5/94	27	Spring River just north west of Belleville, Missouri (Cherokee County, Kansas)	NW 1/4, Sec 36, T33S, R25E 37°07'58.8"N 94°37'40.1"W

Date sampled	Site number	River (county and state)	Legal description (latitude, longitude)
10/6/94	28	Turkey Creek just upstream of mouth (Cherokee County, Kansas)	NW 1/4, Sec 36, T33S, R25E 37°07'44.9"N 94°37'32.5"W
10/6/94	29	Spring River just north of Baxter, Kansas in western channel (Cherokee County, Kansas)	NE 1/4, Sec 36, T34S, R24E (37° 02' 42.6" N, 94° 43' 35.7" W)

Table 2 First 7 elements determined in the laboratory for benthic invertebrate tissue samples. Samples were collected opportunistically from a site using dip nets and kick seines. For sample composition, 'decapoda' represents crayfish, 'megaloptera' represent dobsonflies, 'other' generally represents molluscs, and 'all' represents samples that were too small to be separated in the previous three categories. All elemental measurements are in ug/g wet weight.

Site	Sample composition	Wet weight (g)	Percent moisture	Al	B	Ba	Be	Cd	Cr	Cu
1	all	2.34	73.87	177.9	<1.07	9.5	<0.053	0.24	24.02	18.63
2	Decapoda	3.98	76.13	83.2	0.99	85.6	<0.049	0.12	9.33	56.26
3	Decapoda	17.00	68.82	86.3	<1.01	35.3	<0.051	0.12	1.75	45.86
3	Megaloptera	17.92	72.32	102.1	<1.06	4.2	<0.053	0.08	22.03	18.03
4	Decapoda	23.25	73.89	103	<1.07	61	<0.107	<0.11	2.49	82.92
4	Megaloptera	5.99	77.80	127	<0.9	3.9	<0.045	0.05	17.75	21.69
5	Decapoda	30.40	73.09	193.6	<1.06	50.6	<0.053	0.1	7.56	97.78
5	Megaloptera	4.84	75.20	100.6	<1.04	4	<0.052	0.07	15.7	19.51
6	Decapoda	38.12	68.05	127	<1.16	73	<0.058	0.08	2.79	84.11
6	Megaloptera	9.00	77.56	124.7	<0.89	4.5	<0.045	0.08	10.59	20.69
8	all	3.43	77.25	136.9	<0.86	10.8	<0.043	0.46	7.94	30.8
9	Decapoda	3.10	76.13	110.7	<0.96	32.8	<0.048	0.19	3.2	73.51
9	Megaloptera	13.29	79.01	96.6	<0.81	3.8	<0.041	0.14	25.18	21.81
10	Megaloptera	4.69	77.83	134.1	<0.76	5.1	<0.038	0.2	4.04	20.31

Site	Sample composition	Wet weight (g)	Percent moisture	Al	B	Ba	Be	Cd	Cr	Cu
11	Decapoda	32.04	70.59	90.6	<1.04	41.7	<0.052	0.18	1.29	97.43
11	Megaloptera	21.96	74.00	135.7	<0.94	6.1	<0.047	0.37	15.07	27.3
12	Decapoda	35.99	71.95	144.5	<1.09	49.8	<0.109	<0.11	4.88	72.45
13	Decapoda	20.85	71.18	94.7	<1.18	49.3	<0.118	<0.12	<2.04	73.63
14	Decapoda	52.53	71.92	89	<1.07	34.5	<0.107	0.25	<1.9	58.77
15	Decapoda	90.01	72.35	144.6	<1	47.7	<0.1	<0.1	<1.81	69.43
15	Megaloptera	12.64	81.03	119.3	<0.74	2.2	<0.074	0.35	21.36	33.22
15	other	4.69	59.62	122.9	<1.62	15.5	<0.162	0.39	4.5	13.37
16	Decapoda	8.01	65.99	151.1	<1.43	85.3	<0.143	0.39	9.8	127.2
16	Megaloptera	18.19	76.56	187.8	<0.94	9.7	<0.094	0.41	140	21.75
17	Decapoda	84.64	71.66	91.8	<1.15	34.6	<0.057	1.09	2.19	73.25
17	Megaloptera	7.69	79.63	137	<0.81	4.9	<0.081	1.62	15.09	25.75
17	other	4.56	84.89	116.2	<0.61	3.2	<0.061	1.61	7.24	30.5
18	Decapoda	34.07	74.28	97.9	<1.05	37.1	<0.052	0.06	2.32	65.89
18	Megaloptera	31.95	73.56	278.1	<1.08	24.6	<0.108	0.15	8.16	30.26
18	other	3.09	26.01	142.9	<2.6	41.2	<0.26	<0.26	3.45	6.81
19	Decapoda	32.00	72.09	150	<1.14	67	<0.114	0.12	3.64	90.7

Site	Sample composition	Wet weight (g)	Percent moisture	Al	B	Ba	Be	Cd	Cr	Cu
19	Megaloptera	2.76	80.36	129.8	<0.77	7.3	<0.077	0.09	20.16	23.15
19	other	26.51	35.44	86	<2.42	17.1	<0.242	<0.24	3.8	3.75
20	Decapoda	24.15	72.29	75.1	<1.05	14.8	<0.105	1.64	5.49	82.12
20	Megaloptera	36.78	79.28	150.1	<0.81	3.5	<0.081	1.32	32.67	26.93
21	Decapoda	80.02	69.49	109	<1.13	58.4	<0.113	<0.11	5.15	72.24
21	Megaloptera	8.47	80.71	148.4	<0.76	7.7	<0.076	0.12	10.17	24.7
21	other	6.19	40.03	88	<2.03	15.4	<0.203	<0.2	2.12	5.57
22	Decapoda	63.94	71.65	139.2	<1.12	73.8	<0.112	<0.11	2.47	78.03
22	Megaloptera	12.49	76.21	166.6	<0.91	11	<0.091	<0.09	46.22	25.53
22	other	4.07	48.62	120.1	<1.77	15.9	<0.177	<0.18	4.94	7.62
23	Decapoda	55.59	71.47	122.9	<1.14	39.1	<0.057	0.07	5.69	67.65
23	Megaloptera	5.53	79.26	112.1	<0.86	5.9	<0.086	0.09	13.15	22.59
23	other	83.90	35.12	79.6	<2.49	44.8	<0.124	<0.12	3.01	5.45
24	Decapoda	79.56	72.24	121.5	<1.07	54.7	<0.107	<0.11	2.42	73.82
24	Megaloptera	16.18	81.03	146.4	<0.77	8.4	<0.077	<0.08	13.36	24.44
24	other	11.86	35.71	166.7	<2.67	22.8	<0.267	<0.27	6.78	6.14
25	Decapoda	114.54	72.09	103.7	<1.06	51	<0.106	<0.11	8.85	64.33

Site	Sample composition	Wet weight (g)	Percent moisture	Al	B	Ba	Be	Cd	Cr	Cu
25	Megaloptera	11.52	79.83	170.4	<0.8	12.3	<0.08	0.11	11.75	31.25
25	other	24.54	28.93	99	<2.7	29.7	<0.27	<0.27	4.22	4.26
26	Decapoda	70.35	73.49	81.8	<1	35.1	<0.1	0.35	<1.88	46.52
26	Megaloptera	19.54	82.95	173.2	<0.69	15.6	<0.069	0.41	20.81	26.81
27	Decapoda	97.49	75.94	78.8	<0.95	31.6	<0.095	0.28	<1.97	72.58
27	Megaloptera	3.34	80.84	79.7	<0.75	6.4	<0.075	0.15	10.86	23.24
28	Decapoda	54.50	76.17	55	<0.92	14.8	<0.092	0.7	2.55	92.86
28	Megaloptera	3.46	81.42	76.9	<0.79	4.2	<0.079	0.97	7.75	35.16
29	Decapoda	29.53	74.97	139.1	<0.93	28.4	<0.093	0.21	8.86	98.67
29	other	4.95	72.19	148.5	<1	5.2	<0.1	0.4	14.25	31.37

Table 3. Last 9 elements determined in the laboratory for benthic invertebrate tissue samples. Samples were collected opportunistically from the site using dip nets and kick seines. For sample composition, 'decapoda' represents crayfish, 'megaloptera' represent dobsonflies, 'other' generally represents molluscs, and 'all' represents samples that were too small to be separated in the previous three categories. All elemental measurements are in ug/g wet weight.

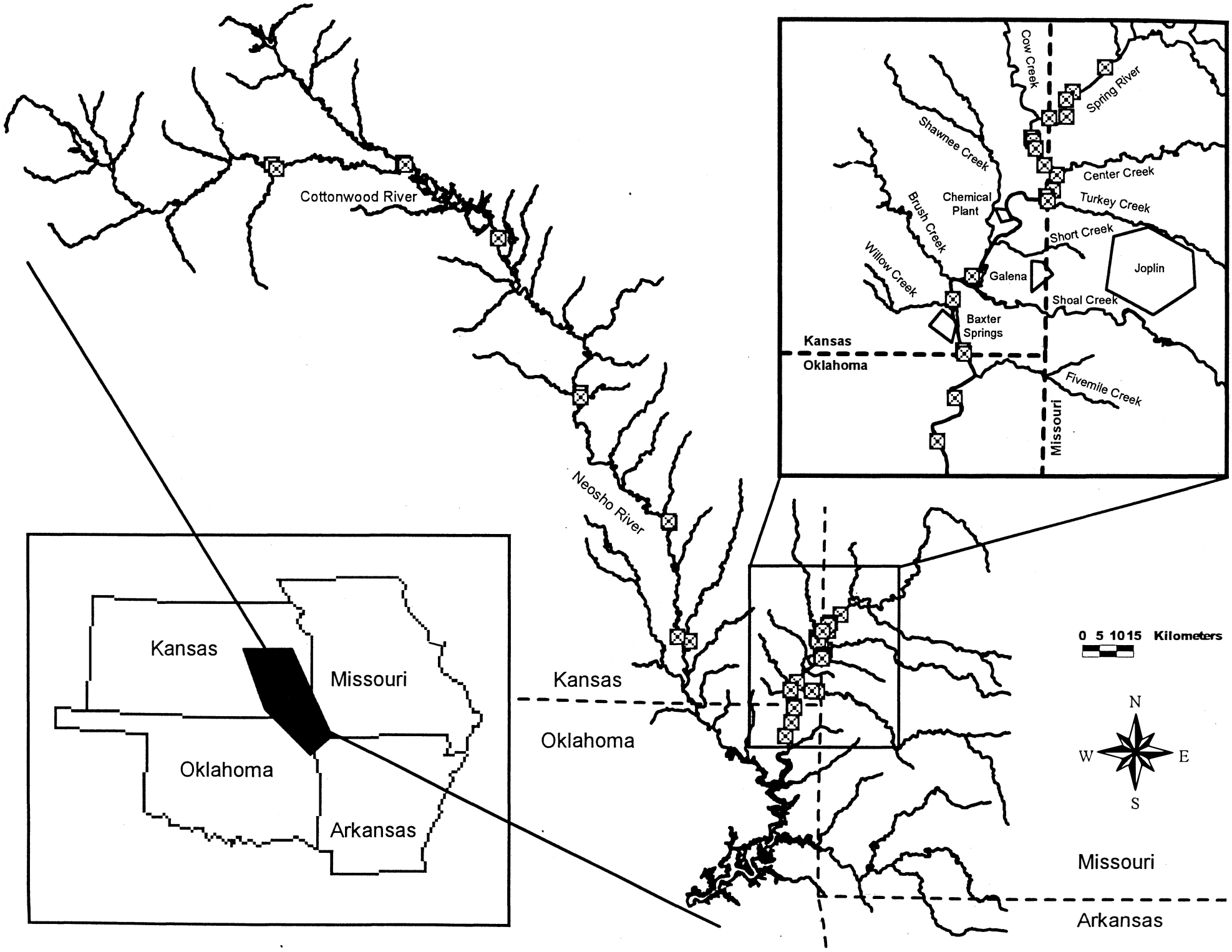
Site	Sample compostion	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
1	all	514.8	237.4	97.6	<0.267	1.48	0.78	3.02	1.17	30.8
2	Decapoda	86.3	478.4	32.3	<0.245	0.33	<0.49	210.84	<0.245	44.9
3	Decapoda	99.2	473.9	52.9	<0.253	0.48	<0.51	158.77	0.309	32.7
3	Megaloptera	224.1	250.9	67	<0.266	0.91	<0.53	5.15	0.54	26.9
4	Decapoda	83.7	541.5	49.6	<0.533	<0.69	<1.07	329.25	<0.533	21.5
4	Megaloptera	173	237.8	51.9	<0.225	0.67	<0.45	6.36	0.398	20.6
5	Decapoda	155.5	525.6	32.7	<0.266	0.67	<0.53	302.47	0.4	19
5	Megaloptera	186.9	285.2	50.5	0.348	0.74	<0.52	5.46	0.589	25.8
6	Decapoda	87.9	732.3	37.8	<0.29	0.39	0.68	296.08	<0.29	26
6	Megaloptera	216.3	253.1	50.3	<0.224	0.76	<0.45	4.54	0.525	24.1
8	all	248.4	228.6	105.6	<0.215	0.94	2.33	7.26	0.318	79.3
9	Decapoda	107	283.1	36.8	<0.241	0.39	1.33	27.74	<0.241	35.8
9	Megaloptera	188.7	180.3	101.9	<0.203	1.16	1.72	0.74	0.268	52.2
10	Megaloptera	237.7	202.8	115.2	<0.19	0.9	2.29	0.52	0.325	55.1

Site	Sample compostion	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
11	Decapoda	74.5	357.3	69.9	<0.26	0.41	1.06	34.67	<0.26	36.9
11	Megaloptera	331.2	217.9	171	<0.235	1.28	3.09	0.83	0.391	66.1
12	Decapoda	106.3	422.7	140.8	<0.544	<0.71	<1.09	33.52	<0.544	21.5
13	Decapoda	90.1	382.2	140.1	<0.588	<0.76	<1.18	38.01	<0.588	23.6
14	Decapoda	63	360.3	39.8	<0.534	<0.69	1.73	20.12	<0.534	40.9
15	Decapoda	94	369.7	144.3	<0.501	<0.65	<1	37.11	<0.501	20.3
15	Megaloptera	179.5	216.8	36.6	<0.368	0.87	2.25	0.44	<0.368	76.2
15	other	112.5	190.3	48.8	<0.808	<1.05	2.02	24.35	<0.808	77.9
16	Decapoda	133.2	492.1	267.8	<0.714	1.17	2.8	38.87	<0.714	67.4
16	Megaloptera	836.3	211.5	209.5	0.473	3.68	4.13	1.58	0.808	95.2
17	Decapoda	106.5	315.4	80.5	<0.287	0.53	5.21	19.01	<0.287	119.4
17	Megaloptera	266.2	238.1	124.5	<0.407	1.14	12.59	1.14	<0.407	208.4
17	other	223.5	125.7	53.6	<0.306	0.74	10.66	0.67	<0.306	127.7
18	Decapoda	99.2	298.4	120.4	<0.261	0.48	<0.52	28.29	<0.261	18.9
18	Megaloptera	480.7	334.7	926.7	<0.542	2.65	1.14	1.6	0.927	45.6
18	other	329.9	51.7	275.3	<1.298	<1.69	<2.6	111.8	<1.298	12.1
19	Decapoda	169.4	427.9	374.6	<0.57	0.81	<1.14	40.78	<0.57	25.3
19	Megaloptera	263.2	220.8	221.1	<0.384	0.91	<0.77	1.21	0.429	25.2

Site	Sample compostion	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
19	other	93.2	31.6	45.2	<1.209	<1.57	<2.42	81.09	<1.209	9.4
20	Decapoda	74.1	334.5	26.8	<0.523	0.72	3.43	9.74	<0.523	74
20	Megaloptera	256.1	224.4	116.5	<0.405	1.4	14.43	0.57	<0.405	128.5
21	Decapoda	115.4	390.8	102.9	<0.565	<0.73	<1.13	28.94	<0.565	22.5
21	Megaloptera	282.8	198.1	138.3	<0.38	0.84	<0.76	1.63	0.427	27.1
21	other	56.1	43	28.6	<1.016	<1.32	3.27	41.91	<1.016	10.9
22	Decapoda	108.9	401.2	142.5	<0.56	<0.73	<1.12	29.26	<0.56	31
22	Megaloptera	350.9	213.7	257.9	<0.454	1.34	<0.91	1.4	0.506	32.7
22	other	118.9	68.4	42	<0.886	<1.15	1.93	36.8	<0.886	15.3
23	Decapoda	117.1	322.4	86.6	<0.285	0.64	<0.57	20.99	<0.285	21.5
23	Megaloptera	238.9	224.6	116.8	<0.429	0.77	0.89	1.32	<0.429	40
23	other	134.8	40.5	121.7	<0.621	<0.81	<1.24	63.52	<0.621	6.8
24	Decapoda	93.6	379.8	100.9	<0.534	<0.69	<1.07	25.08	<0.534	22.9
24	Megaloptera	228.8	203	232.6	<0.386	1.03	<0.77	1	<0.386	29.7
24	other	467.3	71.7	39.4	<1.334	<1.73	<2.67	52.65	<1.334	20.5
25	Decapoda	91.9	394.4	121.4	<0.529	<0.69	<1.06	25.28	<0.529	21.1
25	Megaloptera	223.5	221.5	248.9	<0.4	1.01	<0.8	2.06	<0.4	30.4
25	other	74.8	55.9	39.3	<1.351	<1.76	<2.7	65.39	<1.351	11.6

Site	Sample compostion	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
26	Decapoda	76.2	335.9	75.6	<0.498	0.68	1.07	24.67	<0.498	48
26	Megaloptera	237	191.8	472.5	<0.345	2.19	1.99	2.06	0.425	121.2
27	Decapoda	63.6	347.2	56.9	<0.474	<0.62	<0.95	20.74	<0.474	47
27	Megaloptera	163.5	199.8	222.1	<0.376	0.87	1.15	0.73	<0.376	60.4
28	Decapoda	70.5	296.4	32.5	<0.46	<0.6	3.54	18.16	<0.46	102.2
28	Megaloptera	170.7	220.9	202.5	<0.394	1.04	14.84	1.32	<0.394	137.5
29	Decapoda	325.6	291.8	78.4	<0.467	1.05	1.24	22.55	<0.467	59.2
29	other	259.9	197.8	150.8	<0.498	1.19	2.37	0.67	<0.498	76.8

Figure 1. Map of the Neosho, Cottonwood, and Spring River drainage. Crossed squares indicate location of sites where samples were collected.


Cottonwood River
Neosho River
Kansas
Oklahoma
Missouri
Arkansas
Cow Creek
Spring River
Shawnee Creek
Center Creek
Chemical Plant
Turkey Creek
Brush Creek
Short Creek
Willow Creek
Galena
Joplin
Shoal Creek
Baxter Springs
Fivemile Creek
0 5 10 15 Kilometers
N
W
E
S