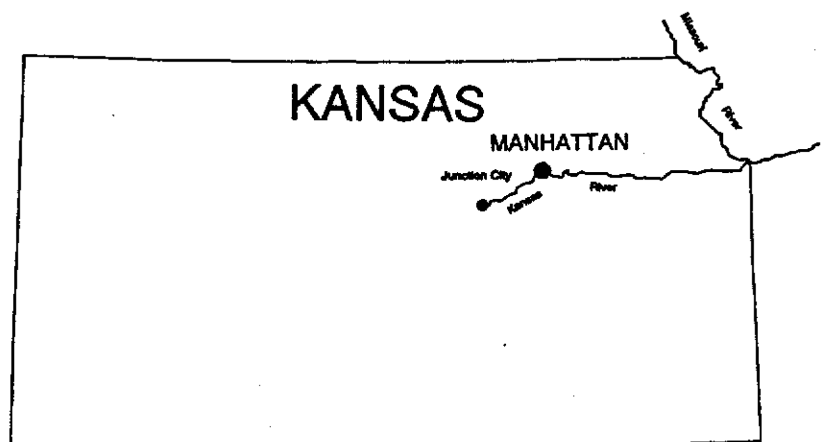
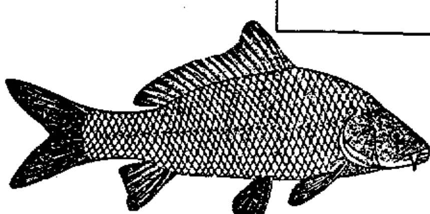
Contaminant Report Number: R6/509M/92

U.S. FISH & WILDLIFE SERVICE
REGION 6

CONTAMINANTS PROGRAM

METALS AND ORGANIC COMPOUNDS IN FISH AND SEDIMENTS FROM THE MISSOURI AND LOWER KANSAS RIVERS IN KANSAS IN 1991




Common Carp

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METALS AND ORGANIC COMPOUNDS IN FISH AND SEDIMENTS FROM THE MISSOURI AND LOWER KANSAS RIVERS IN KANSAS IN 1991

by

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March 1992

ABBREVIATIONS AND CONVERSIONS

Abbreviations

micrograms per gram	mcg/g
not detected (i.e. below analytical detection limits)	ND

Conversions

micrograms per gram	ppm

SUMMARY

► I sampled sediments and common carp (*Cyprinus carpio*) at two locations on the Kansas River and two locations on the Missouri River adjacent to Kansas in June 1991. All samples were analyzed for metals, organochlorine compounds, and aliphatic and aromatic hydrocarbons. Sediments also were analyzed for aromatic hydrocarbons.

► Concentrations of aluminum, cadmium, chromium, and lead in one or more of the sampling locations are of concern.

► In the common carp composites, chlordane compound concentrations were above the level at which detrimental effects might be found at Kansas City and at Bonner Springs. However, there is probably little that can be done to reduce chlordane pollution of the rivers.

► Aliphatic hydrocarbon concentrations in the fish composites indicate chronic exposure to petroleum compounds. However, the aromatic hydrocarbon concentrations suggest that exposure to petroleum contamination did not occur just prior to sampling.

ACKNOWLEDGMENTS

I appreciate the assistance of the following people in fish collections for this study:

Roger Wolfe and John Reinke of the Kansas Department of Wildlife and Parks,
Vernon Tabor and Ken Powell of the Manhattan, Kansas office of the Fish and Wildlife Service,
Tim Fannin and Brent Esmoil of the Grand Island, Nebraska office of the Fish and Wildlife Service, and
Linda Lyon of the Division of Environmental Contaminants of the Fish and Wildlife Service in Washington, D.C.

Tom Jackson and Gene Hansmann of the Denver office of the Fish and Wildlife Service coordinated funding for this study.

Dan Welsh, Dick Ruelle, Tim Fannin, and Brent Esmoil reviewed drafts of this report. I appreciate their work.

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INTRODUCTION

In 1991, U.S. Fish and Wildlife Service Environmental Contaminants Specialists from Region 6 conducted contaminants sampling of the Missouri River and its major tributaries in the region. Upstream sampling efforts focused on known problems, but the effort in Kansas was considered more for determination of background contaminant concerns. For the Kansas portion of the study, common carp composites and sediment composites were collected on the Missouri River and the lower Kansas River. This report presents the data from those collections.

STUDY AREA AND METHODS

I collected composites of four or five common carp and sediment samples from the Kansas River at Bonner Springs in March, and at Lawrence in June (Figure 1, Table 1). The Missouri River samples were collected at Elwood, Kansas and at Parkville, Missouri in June. The sediment composites were placed in chemically clean jars and frozen. Each fish was measured, weighed, and double wrapped in aluminum foil. All samples were kept on ice in the field. Thereafter, they were frozen until preparation for analyses. I considered aluminum contamination from wrapping samples in foil to be negligible. Samples were submitted to the analytical laboratories in July 1991. I received laboratory results in December.

Metals were analyzed by the Environmental Trace Substances Research Center in Columbia, Missouri. Total arsenic, mercury, and selenium were analyzed using atomic absorption spectroscopy. Detection limits for metals analyzed are shown in Table 2. Sediments were analyzed using induction coupled plasma emission spectroscopy (ICP) without preconcentration to test for aluminum, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, strontium, vanadium, and zinc. For better detection of boron, the samples were analyzed by ICP without preconcentration.

Organic compound concentrations were determined by the Texas A&M Research Foundation in College Station, Texas (Table 3). The sediment and fish were analyzed for chlorinated hydrocarbons and aliphatic hydrocarbons. The sediment samples also were analyzed for aromatic hydrocarbons. Concentrations of chlorinated hydrocarbon compounds were determined using electron capture gas chromatography. Wet weight concentrations were reported for organics; the detection limit was 0.01 mcg/g. Because lipid-normalization of organic compounds does not improve data reporting (Huckins *et al.* 1988, Schmitt *et al.* 1990), they will not be addressed in this report. Aliphatic and aromatic hydrocarbon concentrations were determined with capillary gas chromatography.

No anomalies were reported in the samples. Each sample collected was large enough for the laboratory to determine the concentration of each element or compound at the limit of the analytical equipment. Laboratory quality control was reviewed by the Patuxent Analytical Control Facility (PACF) of the Service. Precision and accuracy of the laboratory analyses were confirmed with procedural blanks, duplicate analyses, test recoveries of spiked materials, and reference material analyses. Round-robin tests among Service and contract analytical labs

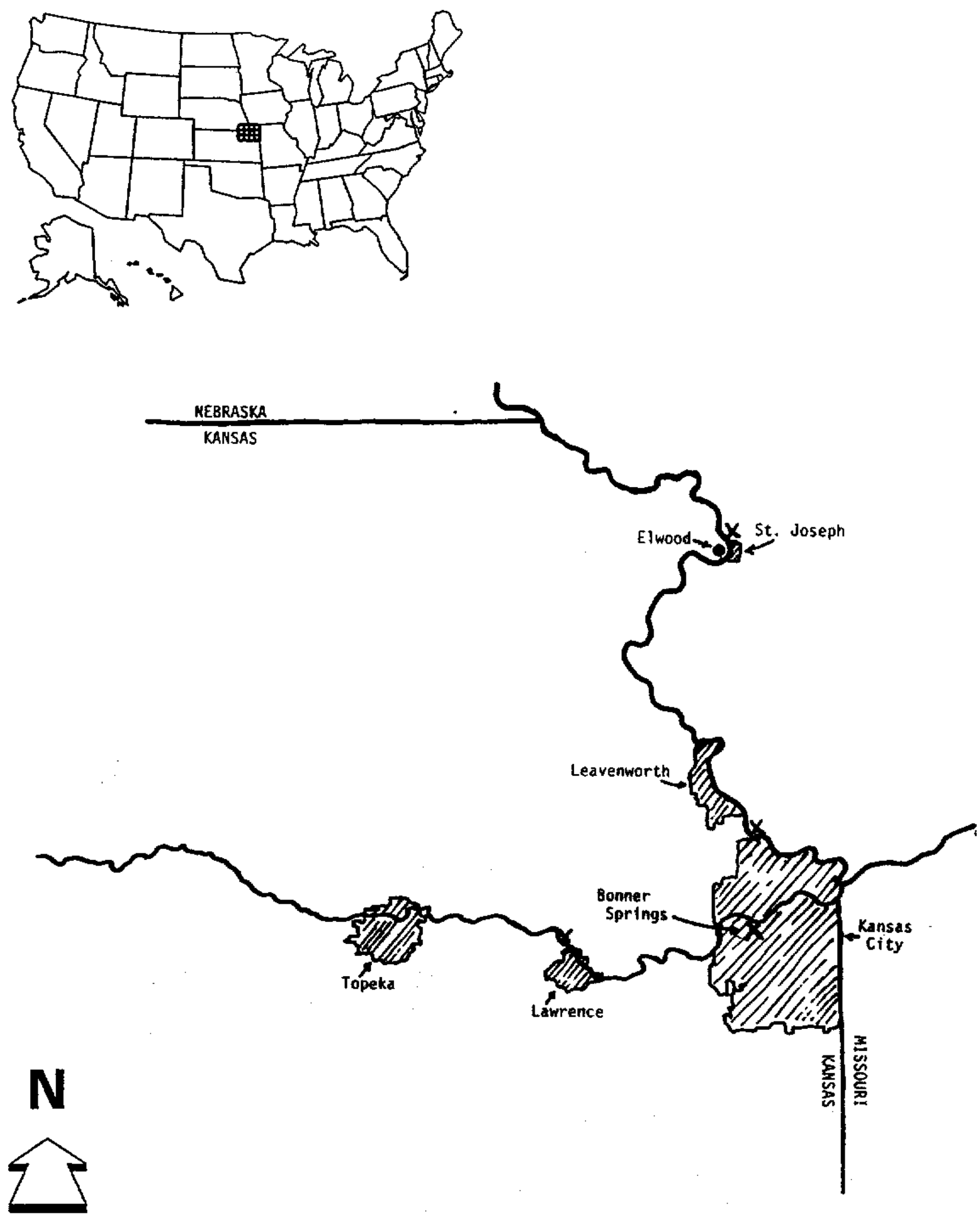

Figure 1. Sampling locations on the Missouri River in 1991.

Table 1. Weights and lengths of common carp collected from the Missouri River and the Kansas River in 1991.

	Length (cm)	Weight (g)		Length (cm)	Weight (g)
Missouri River					
Elwood			Kansas City		
Inorganic Analyses	55.0	2500	Inorganic Analyses	54.0	2650
	49.0	2050		46.5	1650
	48.0	2000		46.5	1350
	46.0	1450		45.0	1300
	25.5	250		42.0	1050
Organic Analyses	51.0	2250	Organic Analyses	49.5	2000
	53.5	2050		45.0	1350
	48.0	1650		42.5	1350
	45.5	1750		39.0	1050
	44.5	1150		39.0	900
Kansas River					
Lawrence			Bonner Springs		
Inorganic Analyses	65.5	4250	Inorganic Analyses	68.0	5100
	43.5	1250		62.5	3450
	42.0	1050		61.5	3250
	38.0	900		57.0	3150
				56.0	2450
Organic Analyses	53.5	2100	Organic Analyses	68.0	4550
	43.0	1250		63.5	3950
	40.5	1000		62.0	3600
	37.5	800		60.5	3200
				44.0	1400

also were part of the quality control.

Duplicate analyses for arsenic, mercury, and selenium had a maximum relative difference of 3.8%. Duplicate ICP analyses had a relative percent difference of 11% or less, except in the following analyses of sediments: 17.8% for aluminum, 49.6% for boron, 28.6% for cadmium, and 22.9% for vanadium.

Spike recoveries for metals ranged from 75.9% to 107.9% for arsenic, mercury and selenium, and from 57.5% to 108.0% for ICP analyses. Analyses of reference standards reported concentrations from 73.0% to 100% of the expected values, with the exceptions of low recoveries for aluminum, barium, chromium, strontium, and vanadium, and a high recovery for lead. Other reference material metals analyses were acceptable.

Duplicate organochlorine analyses differed by no more than 0.01 mcg/g. Spike recoveries ranged from 90% to 130%, with the exceptions of

Table 2. Estimated detection limits for metals in Missouri River and Kansas River samples in 1991. Concentrations are mcg/g dry weight.

Element	Sediment	Fish
aluminum	5.0	5.0
arsenic	0.1	0.2
barium	0.1	0.1
beryllium	0.1	0.01
boron	2.0	2.0
cadmium	0.2	0.02
chromium	1.0	0.1
copper	0.7	0.7
iron	1.0	1.0
lead	4.0-5.0	0.4
magnesium	10.0	10.0
manganese	0.3	0.3
mercury	0.01	0.005
molybdenum	1.0	1.0
nickel	2.0	0.1
selenium	0.2	0.09
strontium	0.1	0.1
vanadium	1.0	1.0
zinc	0.3	0.3

low recoveries for hexachlorobenzene and for benzene hexachloride (BHC).

The largest percentage difference for aliphatic hydrocarbon duplicates was 6.8% (0.143 mcg/g). Spike recoveries for aliphatics ranged from 91.3% to 105.2%.

For aromatic hydrocarbon duplicates, the largest percentage difference between duplicate analyses was 0.010 mcg/g. Spike recoveries were 73.0% to 116.5%.

Concentration data were not adjusted to reflect spike recoveries. Tests of reference standards were not done for organic compounds.

Table 3. Organic compounds analyzed in Missouri River and Kansas River sediment and common carp samples in 1991.

Chlorinated Hydrocarbons	Aliphatic Hydrocarbons	Aromatic Hydrocarbons
alpha-BHC	n-C^{12}	Napthalene
beta-BHC	n-C^{13}	1-Methyl Napthalene
delta-BHC	n-C^{14}	2-Methyl Napthalene
gamma-BHC	n-C^{15}	2,6-Dimethyl Napthalene
Hexachlorobenzene	n-C^{16}	2,3,4-Trimethyl Napthalene
Oxychlordane	n-C^{17}	Acenapthylene
alpha-Chlordane	Pristane	Acenapthene
gamma-Chlordane	n-C^{18}	Biphenyl
cis-Nonachlor	Phytane	Fluorene
trans-Nonachlor	n-C^{19}	Phenanthrene
Heptachlor	n-C^{20}	1-Methyl Phenanthrene
Heptachlor Epoxide		Anthracene
Aldrin		Benzo (a) Anthracene
Dieldrin		Dibenzo Anthracene
Endrin		Fluoranthrene
Mirex		Benzo (b) Fluoranthrene
Toxaphene		Benzo (k) Fluoranthrene
o,p'-DDT		Pyrene
p,p'-DDT		Benzo (a) Pyrene
o,p'-DDE		Benzo (e) Pyrene
p,p'-DDE		Indenopyrene
o,p'-DDD		Crysene
p,p'-DDD		Perylene
Total PCBs		Benzo (ghi) Perylene

RESULTS AND DISCUSSION

METALS

Results of the arsenic, mercury, and selenium analyses are shown in Table 4, results of ICP scans are shown in Table 5. Molybdenum was not detected in any sample. Metal concentrations in sediments collected for this study are compared to the concentrations in U.S. soils, western U.S. soils, northern Great Plains soils, north-central U.S. sediments, and sediments from western U.S. Department of the Interior drainwater studies reported by Harms *et al.* (1990), Martin and Hartman 1984, Severson and Tidball (1979), and Severson *et al.* (1987).

Table 4. Arsenic, mercury, and selenium concentrations in Missouri River and Kansas River sediment and common carp samples in 1991.

River	Location	Percent Moisture	Concentration (mcg/g) Arsenic Dry Weight	Arsenic Wet Weight	Mercury Dry Weight	Mercury Wet Weight	Selenium Dry Weight	Selenium Wet Weight
			Sediments					
Missouri	Elwood	19.9	3.1	2.5	0.02	0.02	0.2	0.2
Missouri	Kansas City	30.9	5.8	4.0	0.03	0.02	0.4	0.3
Kansas	Lawrence	39.0	4.6	2.8	0.03	0.02	0.4	0.2
Kansas	Bonner Springs	41.8	7.7	4.5	0.03	0.02	0.6	0.4
			Common Carp					
Missouri	Elwood	70.6	0.4	0.1	0.23	0.07	3.3	1.0
Missouri	Kansas City	72.6	ND	ND	0.28	0.08	2.6	0.7
Kansas	Lawrence	73.1	0.3	0.1	0.39	0.10	3.0	0.8
Kansas	Bonner Springs	71.4	0.6	0.2	0.43	0.12	3.2	0.9

Arsenic concentrations in sediments were not elevated compared to soil concentrations in the northern Great Plains or in the western United States and the conterminous United States. However, they were higher than concentrations found in riverine locations by Martin and Hartman (1984). Arsenic concentrations in common carp were comparable to the mean concentrations found in samples collected in 1984 for the National Contaminant Biomonitoring Program (NCBP) (Schmitt and Brumbaugh 1990).

Mercury concentrations in sediments were comparable to conterminous U.S. values in soils and sediments. Concentrations in common carp were, at most, only slightly above the mean value from the 1984 NCBP samples.

Table 5. Element concentrations from ICP Analyses of Missouri River and Kansas River sediment and common carp samples in 1991.

River	Location	Aluminum Dry Weight	Aluminum Wet Weight	Barium Dry Weight	Barium Wet Weight	Beryllium Dry Weight	Beryllium Wet Weight	Boron Dry Weight	Boron Wet Weight
		Element Concentration (mcg/g)							
Sediments									
Missouri	Elwood	4020	3220	316	253	0.3	0.2	3.0	2.0
Missouri	Kansas City	15400	10600	223	154	0.7	0.5	5.0	3.0
Kansas	Lawrence	22400	13700	200	122	0.9	0.5	6.8	4.1
Kansas	Bonner Springs	38000	22100	269	157	1.4	0.8	11.0	6.4
Common Carp									
Missouri	Elwood	120	35	10	3	ND	ND	ND	ND
Missouri	Kansas City	30	8	15	4	ND	ND	ND	ND
Kansas	Lawrence	130	35	11	3	ND	ND	ND	ND
Kansas	Bonner Springs	61	17	14	4	ND	ND	ND	ND

River	Location	Cadmium Dry Weight	Cadmium Wet Weight	Chromium Dry Weight	Chromium Wet Weight	Copper Dry Weight	Copper Wet Weight	Iron Dry Weight	Iron Wet Weight
		Element Concentration (mcg/g)							
Sediments									
Missouri	Elwood	ND	ND	7.7	6.2	2	2	7010	5610
Missouri	Kansas City	0.4	0.30	15.0	10.0	10	7	14300	9880
Kansas	Lawrence	0.3	0.20	19.0	12.0	11	7	16000	9760
Kansas	Bonner Springs	ND	ND	34.0	20.0	18	10	26000	15100
Common Carp									
Missouri	Elwood	0.6	0.20	1.3	0.4	3.8	1.1	161	47.3
Missouri	Kansas City	0.2	0.05	0.8	0.2	3.1	0.9	103	28.2
Kansas	Lawrence	0.1	0.03	1.3	0.4	2.9	0.8	187	50.3
Kansas	Bonner Springs	0.2	0.05	0.8	0.2	2.7	0.8	166	47.4

River	Location	Lead Dry Weight	Lead Wet Weight	Magnesium Dry Weight	Magnesium Wet Weight	Manganese Dry Weight	Manganese Wet Weight	Nickel Dry Weight	Nickel Wet Weight
		Element Concentration (mcg/g)							
Sediments									
Missouri	Elwood	5	4	1830	1470	165	132	6.8	5.4
Missouri	Kansas City	10	7	4060	2810	415	287	16.0	11.0
Kansas	Lawrence	10	6	3970	2420	473	289	15.0	9.1
Kansas	Bonner Springs	20	12	7130	4150	657	382	26.0	15.0
Common Carp									
Missouri	Elwood	0.5	0.1	1110	326	9.7	2.9	0.7	0.2
Missouri	Kansas City	0.5	0.1	1340	367	14.0	3.8	0.5	0.1
Kansas	Lawrence	0.4	0.1	1240	333	12.0	3.2	0.8	0.2
Kansas	Bonner Springs	0.8	0.2	1190	340	11.0	3.1	0.5	0.1

Table 5 (concluded). Element concentrations from ICP analyses of Missouri River and Kansas River sediment and common carp samples in 1991.

River	Location	Element Concentration (mcg/g)					
		Strontium		Vanadium		Zinc	
		Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight
		Sediments					
Missouri	Elwood	18.2	14.6	14	11	16	13
Missouri	Kansas City	39.2	27.1	31	21	44	31
Kansas	Lawrence	81.5	49.7	36	22	44	27
Kansas	Bonner Springs	111.0	64.6	56	33	74	43
		Common Carp					
Missouri	Elwood	56.8	16.7	ND	ND	274	81
Missouri	Kansas City	60.8	16.7	ND	ND	169	46
Kansas	Lawrence	100.0	26.9	ND	ND	198	53
Kansas	Bonner Springs	83.0	23.7	ND	ND	138	39

Selenium concentrations in sediment samples from the Missouri and Kansas Rivers were comparable to values from the conterminous U.S. and the western U.S. and from the north-central U.S. Selenium concentrations in the common carp samples were greater than the 85th percentile value from the 1984 NCBP (Schmitt and Brumbaugh 1990). However, the concentrations were below the 2 mcg/g wet weight (Baumann and May 1984) and 12 mcg/g dry weight (Lemly and Smith 1987) levels of concern in the literature.

Aluminum concentrations in sediment samples for this study were lower than the means for U.S., western U.S., and northern Great Plains soils. Aluminum concentrations in common carp composites from the Missouri River and the Kansas River were lower than many of the concentrations found in the Missouri River in 1988 (Allen and Wilson 1991) and in the Spring River in southeast Kansas (Allen and Wilson 1992). However, aluminum has no known metabolic value, and although aluminum concentrations in common carp often are high (personal observation) the aluminum concentrations in carp from Elwood and Lawrence are of concern.

Barium is often found in U.S. soils at much higher concentrations than those found in the Missouri and Kansas rivers in this study. There is very little information in the scientific literature about the effects of barium on aquatic biota, and I do not know if there are any detrimental effects of the the concentrations observed in the common carp collected from the Missouri and Kansas rivers.

Beryllium and beryllium compounds are extremely toxic (Jenkins

1981, Keith and Telliard 1979). Beryllium concentrations in sediments from the two rivers were comparable to concentrations reported for U.S., western U.S., and northern Great Plains soils. Beryllium was not found in any fish composite.

Boron concentrations in sediments samples from the two rivers were low compared to the means for U.S., western U.S., and northern Great Plains soils. Boron was not detected in any fish composite.

The cadmium concentrations in sediments at Kansas City and Lawrence were approximately equal to the 0.26 mcg/g mean for north-central U.S. riverine wetlands sampled by Martin and Hartman (1984). The mean and 85^{th} percentile cadmium concentrations in whole fish from the 1984 NCBP sampling were 0.03 and 0.05 mcg/g wet weight, so only the common carp composite collected at Elwood exceeded the NCBP values. However, cadmium is generally present in aquatic systems as a result of human activities (Eisler 1985, Pratrap *et al.* 1989), and is a nonessential teratogen and carcinogen. Therefore, the cadmium concentration in fish at Elwood is of concern.

Chromium is a toxic heavy metal and priority pollutant (Jenkins 1981, Keith and Telliard 1979), but freshwater fish can regulate chromium levels over a wide range of ambient conditions (Leland and Kuwabara 1985). Mean chromium concentrations in soils in the U.S. are 37 mcg/g overall, 41 mcg/g in the western U.S., and 45 mcg/g in the north-central Great Plains. In fish, Eisler (1986) considered 4.0 mcg/g dry weight or more to be life-threatening. Buhler *et al.* (1977), Giesy and Wiener (1977), and Tong *et al.* (1974) reported normal chromium concentrations in fish of less that 0.4 mcg/g dry weight. Chromium contamination can come from a number of sources, so the concentrations in all fish composites indicate that further assessment of chromium contamination in the Missouri and Kansas rivers is warranted. Allen and Wilson (1991) found that chromium concentrations in fish collected from the Missouri River in 1988 also were elevated.

The concentrations of copper in sediments were comparable to the values found in soils and sediments of the U.S. and in north-central U.S. wetlands. Copper concentrations in the common carp composites were all slightly above the mean for the 1984 NCBP samples, but were below the 85th percentile values.

Iron is normally found in high proportions in soils and sediments and in fish. The concentrations in sediment samples from the Missouri and Kansas rivers were not elevated. Iron concentrations in the fish composites were much lower than some of the concentrations found in Missouri River fish in 1988 (Allen and Wilson 1991).

Lead concentrations in the sediment samples from Kansas City, Lawrence, and Bonner Springs were above the concentrations found in north-central U.S. riverine wetlands by Martin and Hartman (1984), and were above the values for U.S. and western U.S. soils. Lead concentrations in the common carp composites were equal to the mean from the 1984 NCBP at Elwood, Kansas City, and Lawrence. The concentration at Bonner Springs was just below the 1984 NCBP 85^{th} percentile concentration.

Magnesium is often found in high concentrations in U.S. soils. The concentrations in sediments from the Missouri and Kansas Rivers were not elevated. Concentrations in the common carp composites were comparable to the concentrations found in common carp at Flint Hills National Wildlife Refuge (Allen 1991a) and Kirwin National Wildlife Refuge (Allen 1991b) in Kansas, and probably are normal.

Mean concentrations of manganese in U.S. soils and sediments have been reported at from 330 to 4500 mcg/g, so the concentrations found in Missouri River and Kansas River sediments in 1991 were not elevated. Concentrations in the common carp composites were much lower than those found in Missouri River carp in 1988 (Allen and Wilson 1991), and were lower than some concentrations found in Kirwin and Flint Hills NWR carp in 1989 (Allen 1991a,b).

Nickel concentrations in sediments from the Missouri River and from the Kansas River at Lawrence were comparable to those found in U.S., western U.S., and northern Great Plains soils. The concentration in sediments at Bonner Springs was higher, but still well below the concentrations found in some western U.S. drainwater studies. Nickel concentrations in carp composites were well below the 2.0 mcg/g wet weight concentration that Jenkins (1981) said should be found in fish from unpolluted locations.

Non-radioactive strontium has very low toxicity to aquatic animals and man, but radioactive strontium is extremely toxic (Phillips and Russo 1978). Strontium apparently can be remobilized and recycled (Beddington *et al*. 1989). The mean strontium concentration in U.S. soils is 120 mcg/g, and in western U.S. soils the mean is 200 mcg/g. Much higher concentrations were found in some western U.S. drainwater studies (Harms *et al*. 1990, Severson *et al*. 1987). The concentrations in Missouri River and Kansas River sediments likely do not warrant concern.

Vanadium concentrations in Missouri River and Kansas River sediments were lower than the means found in U.S., western U.S., and northern Great Plains soils. Vanadium was not detected in the fish composites.

Zinc concentrations in Missouri River and Kansas River sediments were well above the mean concentrations in U.S., western U.S., and northern Great Plains soils. Zinc is well controlled metabolically, but the concentrations in the common carp composites from the two rivers were above the 34.2 mcg/g wet weight 85^{th} percentile concentration from the NCBP in 1984. The highest zinc concentrations in fish from the 1978-79, 1980-81, and 1984 NCBP sampling efforts were in common carp (Lowe *et al.* 1985, Schmitt and Brumbaugh 1990).

CHLORINATED HYDROCARBON COMPOUNDS

Results of chlorinated hydrocarbon analyses are shown in Table 6. The following organochlorine compounds were not detected in any sample: alpha BHC, beta BHC, gamma BHC, delta BHC, hexachlorobenzene, heptachlor, heptachlor epoxide, oxychlordane, toxaphene, aldrin, endrin, mirex, o,p'-DDT, o,p'-DDE, and o,p'-DDD. Only concentrations of chlordane compounds in fish composites were high enough to warrant concern. The National Academy of Sciences and National Academy of Engineering [(NAS/NAE) 1973] recommended that to protect aquatic life, the whole body wet weight concentration of all cyclodiene compounds together should not exceed 0.10 mcg/g. Chlordane concentrations were above 0.10 mcg/g in the carp composites from Kansas City and Bonner Springs. Arruda *et al.* (1987) hypothesized that the main sources of chlordane contamination of aquatic systems in Kansas are urban areas. Chlordane concentrations in fish in eastern Kansas likely will decline only gradually because of much past use of chlordane as a termiticide.

ALIPHATIC HYDROCARBON COMPOUNDS

Results of aliphatic hydrocarbon analyses are shown in Table 7. The total concentration of aliphatics in the carp composites from Elwood and Lawrence exceeded the 4.63 mcg/g wet weight concentration of crude oil that Woodward et al. (1981) found to negatively affect cutthroat trout (*Salmo clarki*). Woodward et al. (1983) studied effects of a petroleum refinery seepage on cutthroat trout, and found that body burdens associated with reduced fish health were 2.7 mcg/g for napthalenes (which are aromatics), and 0.971 mcg/g for aliphatics. However, in the fish composites $n\text{-}C^{17}$ comprised up to 59.7% of the total aliphatic concentration. Phytane, which is indicative of petrogenic contamination, comprised from 1.7% to 8.9% of the aliphatic compounds. Thus, the aliphatic concentrations found in all fish composites from the Missouri and Kansas rivers indicate petroleum pollution of the river. Chronic exposure of carp in the rivers to petroleum compounds is indicated by the relatively high proportions of pristane to $n\text{-}C^{17}$ and phytane to $n\text{-}C^{18}$ in the fish .

Table 6. Chlorinated hydrocarbon concentrations in Missouri River and Kansas River sediment and common carp samples in 1991. Concentrations are in mcg/g wet weight.

River	Location	Percent Moisture	Percent Lipid	Concentration: alpha Chlordane	Concentration: gamma Chlordane	Concentration: cis-Nonachlor
			Sediments			
Missouri	Elwood	19.4	-	ND	ND	ND
Missouri	Kansas City	26.9	-	ND	ND	ND
Kansas	Lawrence	36.9	-	ND	ND	ND
Kansas	Bonner Springs	41.8	-	ND	ND	ND
			Common Carp			
Missouri	Elwood	71.5	5.16	0.01	0.01	ND
Missouri	Kansas City	70.5	6.23	0.12	0.10	0.04
Kansas	Lawrence	71.2	7.43	0.01	0.01	ND
Kansas	Bonner Springs	70.8	8.35	0.04	0.04	0.01

River	Location	Concentration: trans-Nonachlor	Concentration: Chlordane Total	Concentration: Dieldrin	Concentration: Cyclodiene Total
		Sediments			
Missouri	Elwood	ND	ND	ND	ND
Missouri	Kansas City	ND	ND	ND	ND
Kansas	Lawrence	ND	ND	ND	ND
Kansas	Bonner Springs	ND	ND	ND	ND
		Common Carp			
Missouri	Elwood	0.01	0.03	0.04	0.07
Missouri	Kansas City	0.12	0.38	0.04	0.42
Kansas	Lawrence	0.01	0.03	0.03	0.06
Kansas	Bonner Springs	0.04	0.13	0.04	0.17

River	Location	Concentration: p,p'-DDT	Concentration: p,p'-DDE	Concentration: p,p'-DDD	Concentration: total PCBs
		Sediments			
Missouri	Elwood	ND	ND	ND	ND
Missouri	Kansas City	ND	ND	ND	ND
Kansas	Lawrence	ND	0.01	0.01	0.12
Kansas	Bonner Springs	ND	ND	ND	ND
		Common Carp			
Missouri	Elwood	0.01	0.13	0.01	ND
Missouri	Kansas City	ND	0.04	ND	ND
Kansas	Lawrence	ND	0.03	ND	ND
Kansas	Bonner Springs	ND	0.05	0.01	ND

Table 7. Aliphatic hydrocarbon concentrations in Missouri River and Kansas River sediment and common carp samples in 1991. Concentrations are in mcg/g wet weight.

River	Location	Percent Moisture	Percent Lipid	Concentration n-C^{12}	Concentration n-C^{13}	Concentration n-C^{14}
			Sediments			
Missouri	Elwood	19.4	-	0.057	0.167	0.292
Missouri	Kansas City	26.9	-	0.070	0.087	0.083
Kansas	Lawrence	36.9	-	0.090	0.172	0.198
Kansas	Bonner Springs	41.8	-	0.069	0.154	0.192
			Common Carp			
Missouri	Elwood	71.5	5.16	0.014	0.113	0.119
Missouri	Kansas City	70.5	6.23	0.015	0.043	0.048
Kansas	Lawrence	71.2	7.43	0.007	0.049	0.016
Kansas	Bonner Springs	70.8	8.35	0.004	0.013	0.016

River	Location	Concentration n-C^{15}	Concentration n-C^{16}	Concentration n-C^{17}	Concentration Pristane	Concentration n-C^{18}
			Sediments			
Missouri	Elwood	0.350	0.242	0.152	0.120	0.060
Missouri	Kansas City	0.038	0.033	0.029	0.021	0.014
Kansas	Lawrence	0.133	0.057	0.057	0.040	0.024
Kansas	Bonner Springs	0.211	0.084	0.153	0.059	0.042
			Common Carp			
Missouri	Elwood	0.292	0.269	4.024	0.077	0.443
Missouri	Kansas City	0.214	0.086	0.404	0.090	0.103
Kansas	Lawrence	0.100	0.065	1.414	0.063	0.108
Kansas	Bonner Springs	0.161	0.139	1.918	0.072	0.278

River	Location	Concentration Phytane	Concentration n-C^{19}	Concentration n-C^{20}	Concentration Total Aliphatics	n-C^{17} percentage of total
			Sediments			
Missouri	Elwood	0.071	0.026	0.008	1.545	9.8
Missouri	Kansas City	0.029	0.012	0.009	0.425	6.8
Kansas	Lawrence	0.040	0.024	0.015	0.850	6.7
Kansas	Bonner Springs	0.064	0.052	0.027	1.107	13.8
			Common Carp			
Missouri	Elwood	0.112	1.081	0.199	6.743	59.7
Missouri	Kansas City	0.155	0.457	0.132	1.747	23.1
Kansas	Lawrence	0.134	1.466	0.101	3.523	40.1
Kansas	Bonner Springs	0.300	2.238	0.244	5.383	35.6

AROMATIC HYDROCARBON COMPOUNDS

There are a number of possible sources of polycyclic aromatic hydrocarbon (PAH) contamination of aquatic systems. PAHs are toxic and carcinogenic to invertebrates, fish, and mammals, have low aqueous solubility, and are readily adsorbed on aquatic sediments (Neff 1985). PAHs have been tied to increased occurrences of tumors, lesions, hyperplastic diseases (Eisler 1987, Baumann et al. 1990), but concentrations in Missouri River and Kansas River sediments were low (Table 8). Not detected in any sample were the following compounds: napthalene, acenapthylene, acenapthene, biphenyl, fluorene, 1-methyl phenanthrene, anthracene, benzo (a) anthracene, dibenzo anthracene, benzo (k) fluoranthrene, benzo (a) pyrene, benzo (e) pyrene, indenopyrene, and benzo (ghi) perylene. The low concentrations of aromatics at all locations indicate that there was low exposure to petroleum contamination just prior to sampling.

Table 8. Aromatic hydrocarbon concentrations in Missouri River and Kansas River sediment samples in 1991.

River	Location	Percent Moisture	Concentration			
			1-Methyl Napthalene	2-Methyl Napthalene	2,6-Dimethyl Napthalene	2,3,4-Trimethyl Napthalene
Missouri	Elwood	19.4	ND	ND	0.029	0.026
Missouri	Kansas City	26.9	ND	0.011	0.011	ND
Kansas	Lawrence	36.9	ND	0.012	0.024	0.012
Kansas	Bonner Springs	41.8	0.010	0.016	0.022	0.013

River	Location	Concentration			
		Phenanthrene	Fluoranthrene	Benzo (b) Fluoranthrene	Pyrene
Missouri	Elwood	ND	ND	ND	ND
Missouri	Kansas City	0.016	0.021	ND	0.018
Kansas	Lawrence	0.010	0.012	ND	0.010
Kansas	Bonner Springs	0.017	0.020	0.011	0.018

River	Location	Concentration		
		Crysene	Perylene	Total Aromatics
Missouri	Elwood	ND	ND	0.055
Missouri	Kansas City	0.012	ND	0.089
Kansas	Lawrence	ND	ND	0.080
Kansas	Bonner Springs	0.018	0.017	0.162

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