1996

Chemical Residues in Representative Fish Species Surveyed from the North and South Platte River Systems in Keith and Lincoln Counties, Nebraska

Michael P. Gutzmer
Nebraska Public Power District, mgutzmer@newcenturyenvironmental.com

Dale G. Luce
Nebraska Public Power District

1996. *Transactions of the Nebraska Academy of Sciences*, 23: 59–64

CHEMICAL RESIDUES IN REPRESENTATIVE FISH SPECIES SURVEYED FROM THE NORTH AND SOUTH PLATTE RIVER SYSTEMS IN KEITH AND LINCOLN COUNTIES, NEBRASKA

Michael P. Gutzmer and **Dale G. Luce**

Nebraska Public Power District
1414 15th Street
Columbus, Nebraska 68601

ABSTRACT

In 1993 and 1995 Nebraska Public Power District and Central Nebraska Public Power and Irrigation District sampled 18 and 16 sites in the North and South Platte river systems, respectively. Column- and bottom-feeding fish such as walleye, white bass, carp, and channel catfish were sampled and analyzed for the presence of total polychlorinated biphenyls (PCBs), total mercury, and a variety of pesticides. PCBs and total mercury exceeded EPA action levels in Lake Maloney and Sutherland Reservoir in both years. Lake McConaughy fish also exhibited PCBs in 1993 and elevated mercury levels in both years. Organochlorine pesticides and some of their derivatives showed up in all fish at all locations in 1995.

† † †

Polychlorinated biphenyls (PCBs) production lasted from 1929–1977 but they are exceptionally persistent in the environment, even more persistent than the chlorinated hydrocarbon insecticides (Cassarett and Doull, 1975; Ghirelli et al., 1983). PCBs are mixtures of up to 209 different compounds. PCBs have been used primarily as dielectric insulating materials in capacitors and transformers, plasticizers in plastic and rubber products, in paper manufacturing, and for other industrial purposes. The diversity of their use patterns, the large quantities used, and their stability have led to widespread occurrence of these compounds in soil and water.

The human-health effects of PCBs are well established. Fish from rivers throughout the United States have been found with PCB concentrations from 5 to 20 ppm (Cassarett and Doull, 1975). Investigations have shown that PCBs interfere with reproduction in phytoplankters. PCBs are lipophilic and very stable, which enables them to bioaccumulate in fish tissue, but long-term effects on organisms are unknown.

Mercury is another contaminant of concern that can bioaccumulate in fish tissue. Mercury is transported to aquatic ecosystems via surface runoff and through the atmosphere. It is complexed to organic and inorganic particles. Mercury in natural waterways is frequently methylated by microbes in the sediments (Bryan, 1976). Methyl mercury is also bioaccumulated in fish tissue.

The bioaccumulation of the insecticide dieldrin and other chlorinated hydrocarbons is well documented by environmental residue data. Bioaccumlation ratios relate organism residue level to environmental residue levels and are higher in aquatic ecosystems as opposed to terrestrial ecosystems. Investigations of uptake and accumulation of selected contaminants are fundamental to understanding the effects on specific organ systems in fish. Once absorbed, the contaminant is usually bound to a protein and transported by the blood to fatty tissue or to the liver for transformation and/or storage (Heath, 1995). The biological concentration factor (BCF) describes the extent to which external substances accumulate in aquatic organisms. It is a unitless value obtained by dividing the concentration in one or more of the tissues by the average concentration in the water. Veith et al. (1979) suggest the term "bioconcentration" be limited to the accumulation of a chemical directly from the water but exclude that obtained from food, while "bioaccumulation" would refer to accumulation from both food and water.

"Biomagnification" is best reserved for the process of acquiring a greater body burden from being at a higher trophic level. Of course, a fish may be "practicing" both bioconcentration directly from the water and biomagnification from eating lower on the food chain. It might be noted here that not all substances lend themselves to biomagnification. For example, mercury

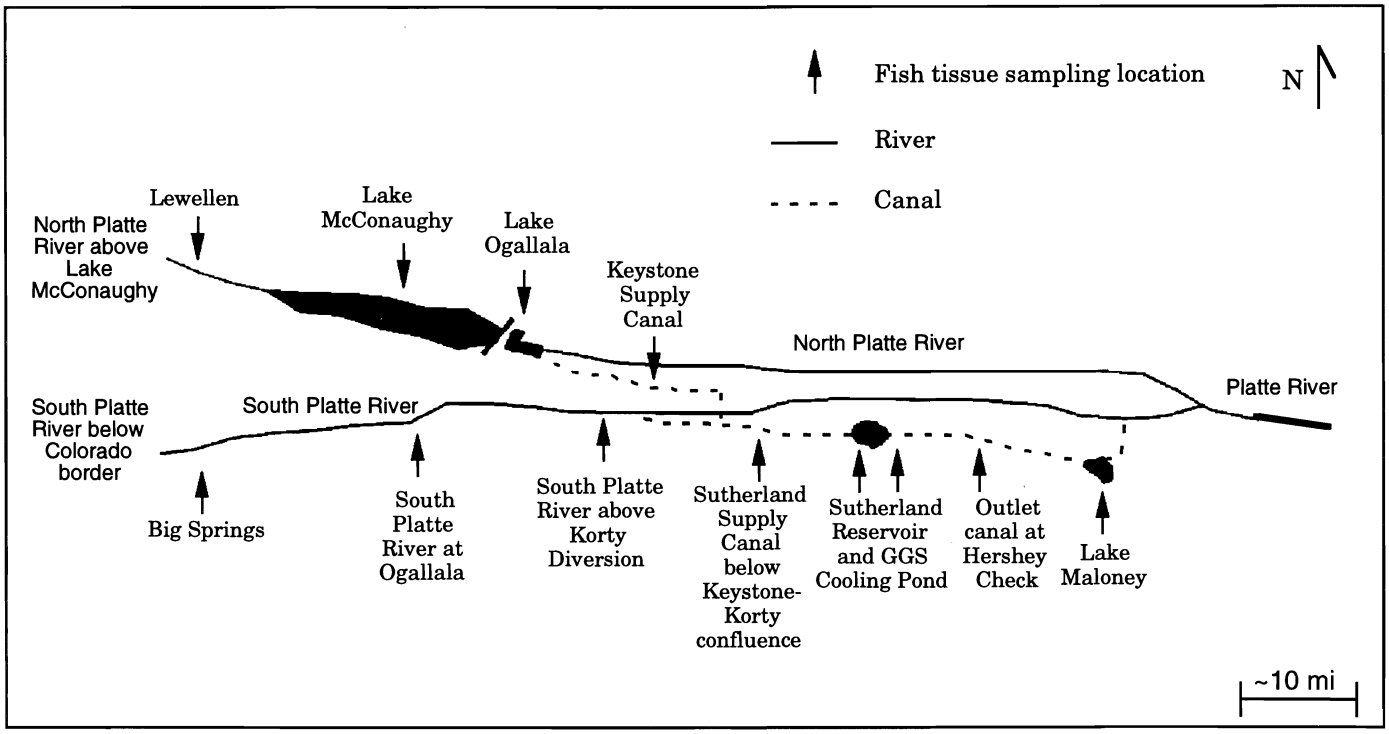

Figure 1. Fish sampling locations for contaminant analysis.

biomagnifies easily, whereas cadmium and lead seemingly do not; nor do the body concentrations of the latter two metals increase with age or size of the fish as does mercury (Spry and Wiener, 1991). Moreover, fish eliminate methyl mercury very slowly compared to uptake rate (McKim et al., 1976).

The Nebraska Department of Environmental Quality (NDEQ) and the Nebraska Department of Health (NDOH) issued fish-consumption advisories in 1993 for several water bodies in Nebraska. Three water bodied operated by Nebraska Public Power District (NPPD) and Central Nebraska Public Power and Irrigation District (CNPPID) were included in the advisory list (i. e., Sutherland Reservoir, Lake McConaughy, and the South Platte River near Paxton). These advisories were based on PCB in fish tissues which exceeded the Environmental Protection Agency (EPA) action level (0.046 mg/kg). Other advisories in Nebraska were based upon high levels of mercury and dieldrin.

NPPD and CNPPID initially conducted fish-tissue sampling and analysis in 1993 because of advisories issued by state regulatory agencies and overall concern for the waterways within FERC Projects 1835 (NPPD) and 1417 (CNPPID). The survey provided a comprehensive sample of fish throughout the water bodies associated with the Projects and the Platte River system. The survey also examined contaminant levels in several species of fish (the advisories were based upon samples from only channel catfish and carp). Column- and bottom-feeding species observed in this study were channel catfish, *Ictalurus punctatus*; carp, *Cyprinus carpio*; walleye, *Stizostedion vitreum*; white bass, *Morone chrysops*; and white sucker, *Catostomus commersoni*.

The presence of PCBs and their derivatives as well as mercury and dieldrin are a well-documented condition in many water bodies in the state of Nebraska (Callam et al., 1995). Contaminant sampling was similar in 1993 and 1995. The major objectives of this study were to: 1) analyze tissue for PCBs, mercury, and dieldrin from fish collected from the FERC Project 1835; 2) determine if contaminants are present in fish in the North and South Platte rivers upstream from Project 1835; and 3) evaluate similarities and differences in fish tissue concentrations collected in 1993 versus 1995.

STUDY AREA AND METHODS

The study area is located in Keith and Lincoln counties of Nebraska. NPPD's FERC Project 1835 includes a diversion structure on the North Platte River at Lake Ogallala near Keystone, Nebraska, and a diversion on the South Platte River between the towns of Paxton and Roscoe. The supply canals from these structures join south of the South Platte River near Paxton to form the Sutherland Supply Canal, which flows east to Sutherland Reservoir. Water from Sutherland Reservoir is conveyed to Lake Maloney and then through a canal to the North Platte Hydro Unit (Fig. 1). This powerhouse discharges water into a tailrace that empties into the South Platte River ap-

Table 1. Concentrations of Total PCBs and Total Mercury by NPPD and CNPPID in 1993. U = undetected; * indicates a value over the Hg action level of 0.25 mg/kg; # indicates a value over the PCB action level of 0.046 mg/kg.

Sample			
Location	**Species**	**Total PCBs (mg/kg)**	**Total Hg (mg/kg)**
Johnson Reservoir	white bass	U	0.16
Johnson Reservoir	channel catfish	U	0.08
Jeffrey Reservoir	white bass	0.090#	0.40*
Jeffrey Reservoir	channel catfish	0.100#	0.45*
Lake Maloney	walleye	0.150#	0.05
Lake Maloney	channel catfish	0.058#	0.11
Outlet Canal	channel catfish	0.071#	0.17
Cooling Pond	channel catfish	U	0.06
Sutherland Reservoir	walleye	U	0.06
Sutherland Reservoir	channel catfish	0.063#	0.14
Supply Canal	carp	U	0.11
South Platte River - Korty	carp	0.095#	0.16
South Platte River - Ogallala	carp	U	0.16
South Platte River - Big Springs	carp	U	0.16
Lake McConaughy (dam)	walleye	U	0.20
Lake McConaughy (dam)	white bass	0.040	0.37*
Lake McConaughy (dam)	channel catfish	0.040	0.08
Lake Ogallala	channel catfish	0.011	0.23

proximately three miles upstream from its confluence with the North Platte River

In 1993 NPPD and CNPPID jointly sampled and analyzed fish tissue taken from Jeffrey and Johnson reservoirs, which are formed from water diverted from the North Platte River. Twelve sites were sampled in 1993 (Table 1) and eight sites were sampled in 1995 (Table 2). Jeffrey and Johnson reservoirs and the South Platte River at Big Springs were not sampled in 1995 because they were determined to be representative of the various water bodies in the region and provide some explanation of the chemicals found bioconcentrated in fish samples collected by NDEQ. Fish at all locations were collected with one or a combination of methods such as gillnetting, electroshocking, seining, and/or hook and line.

Each sample consisted of three to five fish of the same species from the respective sampling sites. Fillets were taken from the edible portions of the fish sampled. Length and weight measurements of each fish used in a composite were recorded on a field sheet. As required, carp and walleye ranging from 16 to 21 inches in total length were used in the composite samples. When carp could not be collected, channel catfish, white bass, and white sucker which fell within a size range from 14 to 21 inches were used. In all samples, the total length of the smallest specimen was not to be less than 75 percent of the total length of the longest specimen. For non-carp samples the weights of fish used were required to range from ¾ pound to 4 pounds. Aluminum foil was used to wrap the composite sample of fish, which was placed in a plastic bag, labeled, and cooled with ice. Fish were filleted in the field, with the scales removed from scaled fish and skin removed from the ictalurids. Samples were frozen as soon as possible after collection. All samples collected by NPPD were analyzed by Barringer Laboratories of Golden, Colorado. Duplicate samples were collected in 1993 and 1995. The parameters analyzed, methodology (see Environmental Protection Agency, 1987), and detection limits utilized by the analytical laboratory were as follows:

Parameter	**Methodology**	**Detection Limit**
PCBs (Arochlors 1242, 1248, 1254, 1260)	EPA 8080	30 µg/kg
Chlordane isomers	EPA 8080	10 µg/kg
Dieldrin	EPA 8080	1.3 µg/kg
Mercury	EPA 245.1 (HNO_3 digestion)	40 µg/kg

RESULTS

A total of 18 samples were collected throughout the Project waters and the Platte River system in 1993 (Table 1). The analyses indicated that some column-feeding species did contain PCBs in excess of the EPA action level. A white bass composite sample from Jef-

Table 2. Concentrations of Total PCBs and Total Mercury sampled in fish tissue by NPPD in 1995. U = undetected; * indicates a value over the Hg action level of 0.25 mg/kg; # indicates a value over the PCB action level of 0.046 mg/kg.

Sample		Total PCBs	Total Hg
Location	**Species**	**(mg/kg)**	**(mg/kg)**
Lake Maloney	channel catfish	0.055#	U
Lake Maloney	walleye	U	1.6*
Lake Maloney	white bass	0.027	0.1
Outlet Canal	channel catfish	0.093#	U
Cooling Pond	channel catfish	0.048#	0.1
Sutherland Reservoir	channel catfish	0.079	U
Sutherland Reservoir	walleye	U	U
North Platte River	carp	U	0.1
Lake McConaughy (Otter Creek)	channel catfish	U	U
Lake McConaughy (Otter Creek)	white bass	U	0.2
Lake McConaughy (near dam)	smallmouth bass	U	0.2
Lake McConaughy (near dam)	channel catfish	U	U
Lake McConaughy (near dam)	walleye	U	0.1
Lake Ogallala	channel catfish	U	U
Lake Ogallala	walleye	U	U
Lake Ogallala	white sucker	U	U

frey Reservoir contained 0.09 mg/kg total PCBs. A walleye sample from Lake Maloney contained 0.15 mg/kg, which far exceeds the 0.046 mg/kg EPA action level. Channel catfish from Jeffrey Reservoir (0.1 mg/kg), Lake Maloney (0.058 mg/kg), and Sutherland Reservoir (0.063 mg/kg) were also in excess of EPA action levels. Carp sampled from the South Platte River upstream from the Korty Diversion contained PCBs at 0.095 mg/kg. Total mercury was found to be in excess of the EPA action level in a white bass (0.40 mg/kg) and channel catfish (0.1 mg/kg) from Jeffrey Reservoir. Lake McConaughy had a white bass sample that contained 0.37 mg/kg total mercury. During the 1993 survey, water and sediment samples were collected from Sutherland Reservoir and the Gerald Gentleman Station (GGS) cooling pond. These samples revealed no PCB contamination (Gutzmer and Harris, 1995).

A total of 16 samples were collected in 1995 (Table 2). The analyses indicated that some column-feeding species (carp as well as channel catfish) did contain PCBs in excess of the EPA action level. Channel catfish from Lake Maloney (0.055 mg/kg), the outlet canal (0.097 mg/kg), cooling pond (0.048 mg/kg), and Sutherland Reservoir (0.079 mg/kg) contained PCBs in excess of the EPA action level (0.046 mg/kg). These samples also had mercury in excess of the EPA action level from a walleye sample (1.6 mg/kg) in Lake Maloney. Elevated levels of mercury were also found in white bass (0.2 mg/kg) smallmouth bass (0.2 mg/kg) and walleye (0.1 mg/kg) in Lake McConaughy. Pesticide analysis revealed 4.7–140 micrograms per kilogram (μg/kg) of 4.4′-DDE (Dieldrin) in all fish sampled (Table 3), which is below the action level of 1029 μg/kg for DDE.

DISCUSSION

PCB levels in excess of the action level were found in channel catfish collected from both Lake Maloney and Sutherland Reservoir in 1993 and 1995. Lake Maloney walleye had PCBs and mercury detected in their tissue in 1993 but were not above action levels, but in 1995, Lake Maloney walleye had mercury in excess of the action level of 0.25 mg/kg. Lake McConaughy and Lake Ogallala had fish samples with PCBs detected, however they did not exceed EPA action levels.

Mercury was detected in fish tissue in both 1993 and 1995. Mercury particulates from air emissions at GGS may have accounted for some of the mercury concentrations noted in fish from Lake Maloney both years. Plumes from NPPD's Gerald Gentleman Station's stacks have been observed moving in an eastward direction and could be a factor. Fly ash used for road and bank stabilization around Sutherland Reservoir may also contain elevated mercury concentrations and could contribute to mercury bioconcentration. Traces of mercury were also detected in fish samples both years above GGS in Lake McConaughy (all fish samples in 1993 and in walleye and small mouth bass in 1995). However, mercury has been observed in several Nebraska lakes and streams (Callam, 1994), leading one to identify mercury accumulation in fish

Table 3. Pesticide concentrations (µg/kg) sampled in fish tissue by NPPD in 1995.

	Lake Maloney Channel catfish	Lake Maloney Walleye	Lake Maloney White bass	Outlet Canal Channel catfish	Cooling Pond Channel catfish	Suth. Res. Channel catfish	Suth Res. Walleye	Method Detection Level
Analyte mg/kg	U	U	U	U	U	U	U	2.5
Aldrin	U	U	U	U	U	U	U	2.5
Alpha-BHC	U	U	U	U	U	U	U	2.5
Beta-BHC	U	U	U	U	U	U	U	2.5
Gamma-BHC/Lindane	U	U	U	U	U	U	U	2.5
Delta-BHC	U	U	U	U	U	U	U	25
Chlordane	U	U	U	U	U	U	U	2.5
Alpha-Chlordane	4.3	U	U	U	U	U	U	2.5
Gamma-Chlordane	U	U	U	U	U	U	U	2.5
Alpha-Chlordene	U	U	U	U	U	U	U	2.5
Gamma-Chlordene	U	U	U	U	U	U	U	5.0
4.4´-DDD	U	U	5.7	13	6.9	17	U	5.0
4.4´-DDE	4.7	7.8	21	110	60	140	17	5.0
4.4´-DDT	U	U	U	U	U	U	U	5.0
Dieldrin	U	U	U	U	U	U	U	2.5
Endosulfan I	U	U	U	U	U	U	U	2.5
Endosulfan II	U	U	U	U	U	U	U	5.0
Endosulfan Sulfate	U	U	U	U	U	U	U	5.0
Endrin	U	U	U	U	U	U	U	5.0
Endrin Aldehyde	U	U	U	U	U	U	U	5.0
Endrin Ketone	U	U	U	U	U	U	U	5.0
Heptachlor	U	U	U	U	U	U	U	2.5
Heptachor Epoxide	U	U	U	U	U	U	U	2.5
Methoxychlor	U	U	U	86	73	U	U	25
Cis-Nonachlor	U	U	U	U	U	U	U	2.5
Trans-Nonachlor	U	U	U	U	U	U	U	2.5
Oxychlordane	U	U	U	U	U	U	U	2.5
Toxphene	U	U	U	U	U	U	U	250
Clordene	U	U	U	U	U	U	U	2.5

flesh as a regional, not a local problem.

Limited data (Veith et al., 1979) suggest that within a species, age and body size have little effect on BCF of various chemical residues like PCBs and mercury. However, an increase in temperature increases the BCF approximately twofold for each 10°C difference, and an oscillating temperature causes more uptake than one which is constant. One would expect more constant temperatures and less daily oscillation in Sutherland Reservoir because of induced thermal effects by Gerald Gentleman electric power generation station. This should lead to less PCB and mercury accumulation, but our data suggest the contrary.

The organochlorine pesticide 4,4´-DDE was found in all fish at all locations. Organochlorine pesticides have been shown to elicit histopathological effects to fish livers and in acute concentrations cause a slowing (brachycardia) of the heart with an increase in ventilation (Cassarett and Doull, 1975). Another organochlorine, 4,4´-DDD, was found in fish at most locations, with the exception of walleye analyzed from Lake Maloney and Sutherland Reservoir. The only other chemical contaminants observed were alpha-chlordane in Lake Maloney channel catfish and methoxychlor in channel catfish in the cooling pond and outlet canal. The presence of these in various locations also indicates various contaminants are not coming from a single source.

The persistence of various chemicals in the environment is evident from our sample results, however no direct tie to NPPD operations could be made addressing the presence of these throughout the system. The documentation of all the chemicals found above the Station in Lake McConaughy indicates various chemical residues continue to be present in column- and bottom-feeding fish throughout the entire Platte River system in western Nebraska.

ACKNOWLEDGMENTS

We would like to thank the Nebraska Public Power District for funding the project both years and Central Nebraska Public Power and Irrigation District for their funding and assistance in 1993.

We would also like to thank members of the Environmental and Advanced Technology Division of NPPD: Doug Harris, Dave Overhue, Justin King, William Hay, Jon Gjersvik, Willie Schlecht, and others for their assistance during the field collections. We would also like to thank Mark Peyton at CNPPID for his assistance during fish-tissue collection and Mike Callam and Rick Holland for their constructive review of this manuscript.

LITERATURE CITED

Bryan, G. W. 1976. Some aspects of heavy metal tolerance in aquatic organisms. *In*: A. P. M. Lockwood (ed.), *Effects of pollutants on aquatic organisms*. Cambridge, Cambridge University Press.

Callam, M., J. Lund, D. Bubb, and D. Schumacher. 1995. *Findings of the 1994 regional ambient fish tissue and follow-up programs in Nebraska.*

Cassarett, L. J., and J. Doull. 1975. *Toxicology: the basic science of poisons*. New York, Macmillan Publishing Co.: 778 pp.

Environmental Protection Agency. 1987. SW-846, *Test methods for evaluating solid waste*, 3rd ed. Washington D. C., National Technical Information Service.

Ghirelli, R. P., F. H. Palmer, T. L. Spielman, M. Jung, R. L. Severeid, G. W. Bowes, and D. B. Cohen. 1983. *Polychlorinated biphenyls*. California State Water Resources Control Board, Special Projects Report 83.

Gutzmer, M. P., and D. D. Harris. 1995. Unpublished data. Nebraska Public Power District.

Heath, A. G. 1995. *Water pollution and fish physiology*, 2nd ed. Lewis Publishers: 359 pp.

McKim, J., G. Olsen, G. Holcombe, and E. Hunt. 1976. Long-term effects of methylmercuric chloride on three generations of brook trout (*Salivelinus fontinalis*): Toxicity, accumulation, distribution and elimination. *Journal of Fish Research Board of Canada* 33: 2726.

Spry, D. J., and J. Wiener. 1991. Metal bioavailability and toxicity to fish in low alkalinity lakes: A critical review. *Environmental Pollution* 71: 243.

Veith, G. D., D. L. DeFoe, and B. V. Bergstedt. 1979. Measuring and estimating the bioconcentration factor of chemicals in fish. *Journal of the Fish Research Board of Canada* 36: 1040.