Occurrence of Selected Organochlorine Compounds in Fish Tissue from Eastern Iowa Streams, 1995

U.S. Department of the Interior–U.S. Geological Survey

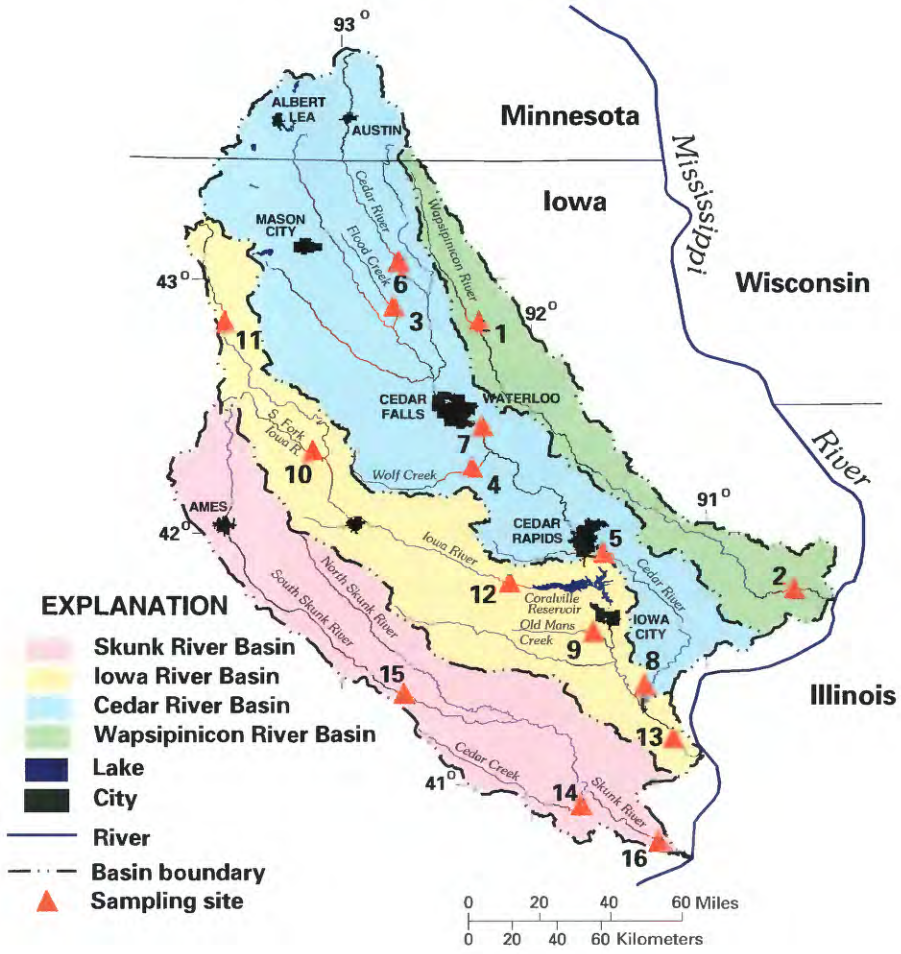
Introduction

Human activities have caused dramatic changes to our Nation's landscape for over a century. Use of synthetic organic compounds in agriculture and industry has resulted in the accumulation and persistence of some of these compounds in natural systems. Concern has arisen over the contamination of our Nation's waters and the organisms that depend on them.

The U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) Program in 1991 to describe the status and trends in the quality of a large part of the Nation's surface- and ground-water resources, and to identify the major factors that affect the quality of those resources. NAWQA assessment activities in the Eastern Iowa Basins (EIWA) study unit began in 1994 and are being conducted from the USGS office in Iowa City, Iowa. Aquatic ecological investigations are a basic part of this assessment. Initial results are presented in this Fact Sheet on the occurrence of several organochlorine compounds in fish tissue from the EIWA study unit.

The EIWA study unit (see map) includes the Wapsipinicon, Cedar, Iowa, and Skunk River Basins, which drain about 19,500 square miles in eastern Iowa and southern Minnesota (Kalkhoff, 1994). The Cedar River joins the Iowa River about 30 miles upstream from the mouth of the Mississippi River, whereas the other three rivers flow directly into the Mississippi River.

The Eastern Iowa Basins study unit



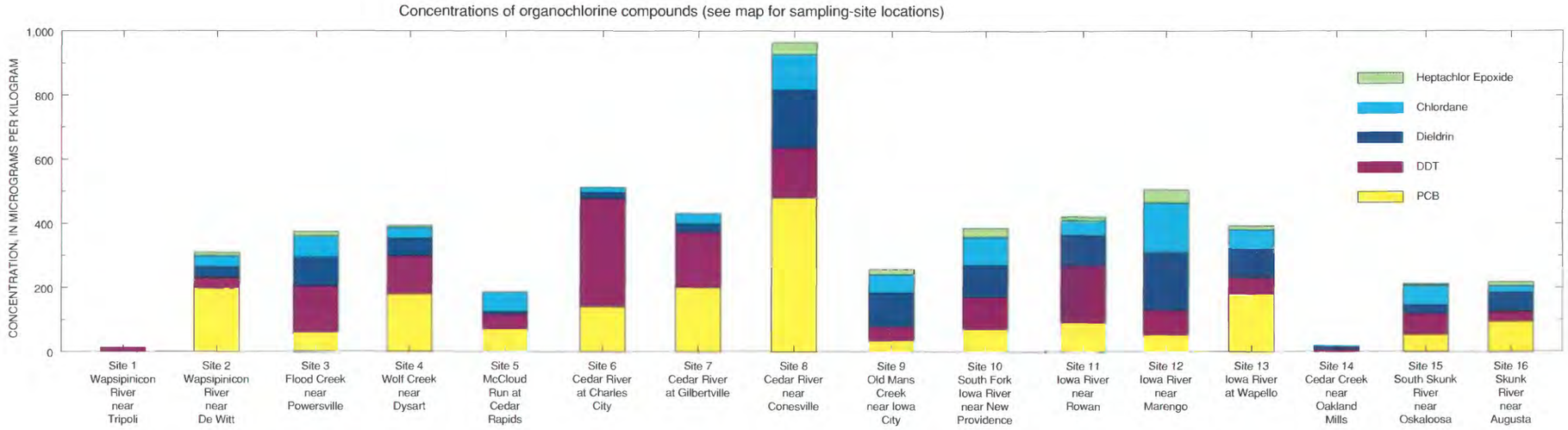
Old Mans Creek near Iowa City

About 93 percent of the land is used for agricultural activities, with most major urban settings being located in the Cedar River Basin. Row crops, predominantly corn and soybeans, and cover crops, including small grains, constitute the major land cover in the study unit. Land adjacent to streams and rivers is characterized by both forested and crop lands.

Sampling Procedures

Fish-tissue and bed-sediment samples were collected at 16 sites in late September 1995. Sites were selected in areas that were representative of the river basin and had fish available for sampling.

Fish were collected using electroshocking equipment carried on either a backpack, barge, or boat. Common carp (*Cyprinus carpio*) was the target species; however, carp were not found in sufficient abundance in several smaller streams. Instead, white suckers (*Catostomus commersoni*) were collected from the Wapsipinicon River near Tripoli, Flood Creek near Powersville, and McLoud Run at Cedar Rapids.



Tissue samples consisted of a composite of 8 to 12 whole fish. Length, weight, and gender were determined for each fish. Fish also were examined for external and internal anomalies, including tumors and lesions, which can be an indication of contamination. Samples were analyzed for 28 organochlorine compounds by the USGS National Water Quality Laboratory in Arvada, Colorado.

Description of Organochlorine Compounds

Twelve organochlorine compounds of interest are presented as two insecticide groups, two individual insecticides, and one industrial chemical. Most information on organochlorine compounds summarized below is from Budavari (1989).

***Chlordane*:** Five chlordane isomers—cis-chlordane, trans-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor—were detected in the study year. The concentrations of chlordane isomers were summed and presented as the total chlordane concentration for each site. Chlordane was used as an insecticide and acaricide until 1980, when it was banned except for subsurface termite control and limited use on nonfood plants.

***DDT*:** Concentrations of p,p'-DD and three DDT degradation products—p,p'-DDE, o,p'-DDD, and p,p'-DDD—were detected during the study. The concentrations of all four compounds were combined and are presented as the total DDT concentration for each site. DDT was used as an insecticide until 1972 when it was banned except for limited use. The stability of DDT and its resistance to biodegradation in the environment have resulted in the persistence of DDT residues in water, soil, and biota.

Electrofishing with barge-mounted electroshocker

***Dieldrin*:** Dieldrin was used as an insecticide, particularly for corn rootworms and cutworms. Dieldrin also is a degradation product of the insecticide aldrin. In the mid-1970's, both dieldrin and aldrin were banned except for limited use.

***Heptachlor Epoxide*:** Heptachlor epoxide is a degradation product of the insecticide heptachlor. Similar to chlordane, heptachlor was banned in the early 1980's except for subsurface termite control and limited use on nonfood plants.

***Polychlorinated Biphenyls (PCBs)*:** The long-term stability of PCBs has contributed both to the industrial and commercial usefulness of PCBs, and to the long-term adverse health and environmental effects of these compounds. PCBs had a variety of uses, including hydraulic-fluid additives and pesticide extenders. The manufacturing and distribution of PCBs were prohibited in 1979, but PCBs are still present in electrical transformers and capacitors, vacuum pumps, and gas-transmission turbines.

Concentrations of Organochlorine Compounds

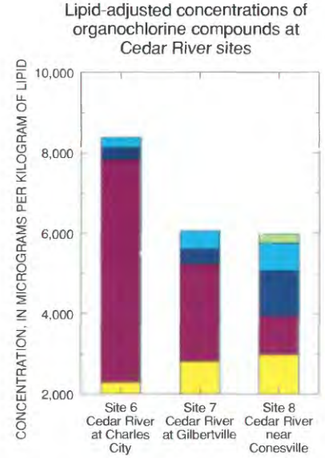
Concentrations of organochlorine compounds detected in fish tissue from many eastern Iowa streams and rivers indicate the long-term effects of previous human activities, which are not often detected by chemical analyses of water or sediment. With the exception of McLoud Run at Cedar Rapids, streams and rivers sampled during the study drain agricultural lands. Land use has not changed substantially since these compounds were commonly used, although prior coal mining activities upstream from Cedar Creek near Oakland Mills (site 14) have ceased. Despite similar land-use characteristics throughout the study unit, concentrations of organochlorine compounds in fish tissue vary widely. In the graph above, organochlorine concentrations are presented in micrograms per kilogram (µg/kg), units that are equivalent to parts per billion.

Fish tissue from the Wapsipinicon River near Tripoli (site 1) was comparatively uncontaminated, containing only a small amount of a DDT degradation product. This condition may be due to a greater abundance of forested lowlands in this basin. The higher concentrations of contaminants in fish tissue from the Wapsipinicon River near De Witt (site 2), near the mouth of the river, indicate that concentrations of these contaminants, particularly PCBs, increase in a downstream direction.

Similar to the pattern found in the Wapsipinicon River, downstream increases in the concentrations of most contaminants were found in the Cedar River (sites 6–8). With the exception of DDT-related compounds, fish tissue collected from the most downstream site (Cedar River near Conesville, site 8) contained the highest concentrations of contaminants found in the Cedar River Basin. Although tissue from the Conesville site had the highest total concentration of organochlorine compounds of all sites in the study, median concentrations for the Cedar and Iowa River Basins are similar.

Total contaminant concentrations were similar in fish tissue collected from the three Iowa River sites, including near Rowan (site 11), near Marengo (site 12), and at Wapello (site 13). Total-DDT and PCB concentrations decreased in the Iowa River from Rowan to Marengo. In contrast, concentrations of dieldrin, chlordane, and heptachlor epoxide increased downstream from Rowan, and tissue concentrations of those insecticides in the Iowa River near Marengo were among the highest observed in the study. From Marengo to Wapello, the concentration of PCBs increased, whereas concentrations of the four insecticides decreased. The increased PCB concentration in the Iowa River at Wapello may be a result of input from the Cedar River, which joins the Iowa River about 13 miles upstream from Wapello; tissue from the Cedar River near Conesville contained a much higher PCB concentration than tissue from the Iowa River sites at Marengo or Wapello. Relative decreases of insecticide concentrations in fish tissue downstream from Marengo may be associated with Coralville Reservoir, located on the Iowa River between Marengo and Wapello. Insecticides adsorbed to sediment particles may be settling in this 23-mile-long reservoir, resulting in lower contaminant concentrations in water leaving the reservoir compared with water entering the reservoir (Schnoor, 1981).

Like the Wapsipinicon River near Tripoli site, tissue concentrations of contaminants in Cedar Creek near Oakland Mills (site 14) were low. Although dominated by agricultural activities, the Cedar Creek Basin contains more forested land than other basins in the study unit, which may result in reduced surface-water contamination.



The use of DDT has been banned since 1972, and high concentrations of the parent compound would not be expected in fish tissue collected in 1995. Most of the detections in this study were of DDT degradation products. However, concentrations of p,p'-DDT were detected in fish tissue in three streams: Flood Creek (13 µg/kg), McLoud Run (9.5 µg/kg), and Wolf Creek (5.3 µg/kg). The occurrence of p,p'-DDT in fish populations in this study was limited to smaller streams, representing both urban (McLoud Run) and agricultural (Flood Creek and Wolf Creek) settings.

Organochlorine contaminants are lipophilic compounds that accumulate in the fatty tissues of animals. Thus, the concentration of organochlorine compounds in whole fish samples would be expected to increase with the lipid (fat) content of the fish. The percentage of lipid content in fish varies among species and populations of fish. In eastern Iowa, the percentage of lipid content in composite whole-fish samples ranged from 1.4 to 16.1 percent, with fish from the Cedar River near Conesville containing the highest lipid content, followed by South Fork Iowa River, Iowa River near Rowan, and Flood Creek. When contaminant concentrations are adjusted for lipid content, the only noteworthy pattern difference is in the distribution of total DDT and PCBs in fish from the Cedar River. The lipid-adjusted concentration of total DDT is high in the Cedar River at Charles City, but is relatively lower in the Cedar River near Conesville when compared with the two upstream sites, suggesting DDT sources in upstream parts of the basin. When total PCB concentrations are adjusted for lipid content, the range of values among the three Cedar River sites is less than the unadjusted range of values, possibly indicating diffuse sources of PCB contamination. The lipid-adjusted concentration of PCBs in tissue from the Cedar River at Gilbertville is about the same as that from the Cedar River near Conesville, which may indicate sources of PCBs upstream from Gilbertville.

Boat outfitted with electrofishing equipment

A nationwide study in 1984 by the National Contaminant Biomonitoring Program (NCBP) of the U.S. Fish and Wildlife Service also analyzed fish tissue for organochlorine contamination (Schmitt and others, 1990). Fish-tissue samples also were collected in other parts of the country as part of the NAWQA Program in 1992–1994 (Lisa Nowell, U.S. Geological Survey, written commun., 1996). When compared with median data from both studies, tissue collected during the EIWA study contained higher concentrations of dieldrin and similar concentrations of DDT (see table). The NCBP study found higher PCB concentrations than the EIWA study, but similar levels of chlordane. When compared to the other NAWQA results, median values for heptachlor epoxide and chlordane were higher in the EIWA study, but values for PCBs were similar.

Despite lower analytical detection limits for bed-sediment samples, the frequency of organochlorine compound detections in fish tissue far exceeded those for sediment samples. In fish-tissue samples, 4 or 5 organochlorine compound groups were detected at 14 of the 16 sites. Only three organochlorine compound groups were detected in bed-sediment samples at a total of four sites: dieldrin in the Iowa River near Rowan (3.0 µg/kg), total chlordane in McLoud Run (3.7 µg/kg), and total DDT in the Iowa River near Rowan (8.9 µg/kg), Cedar River at Charles City (2.8 µg/kg), and Wolf Creek (2.7 µg/kg).

Field processing of fish sample

Summary and Conclusions

Comparatively high chlordane and heptachlor epoxide concentrations were found in fish tissue from eastern Iowa streams and rivers that drain mixed urban-residential and agricultural settings. However, dieldrin concentrations in fish appear to be associated primarily with agricultural areas. The distribution of PCBs appears more pervasive, suggesting multiple sources associated with human activities. Higher PCB concentrations were generally found at sites in the Cedar River Basin, the largest and most populated basin in the study, than in the other three river basins. PCB concentrations in fish from downstream segments of the study's four major rivers were high compared to upstream sites.

Results from this study indicate that the distribution and fate of organochlorine contaminants are better understood by concentrations accumulated in fish rather than by concentrations in sediment or water, in which these contaminants are rarely detected. However, few people in Iowa regularly consume carp, and the transferability of these results to potential contamination of game fish in eastern Iowa is uncertain because the edible portion (filet) was not analyzed separately, and lipid content varies considerably among fish species.

—Linda R. Roberts

Median concentrations of organochlorine compounds in fish tissue from studies by NCBP (80 fish species), other NAWQA study units (carp and white sucker data only), and the EIWA study unit

[Values in micrograms per kilogram]

Compounds	Study		
	NCBP (1984)	NAWQA (1992–1994)	EIWA (1995)
Heptachlor Epoxide	<10	<5.0	11
Chlordane	40	<5.0	52
Dieldrin	10	<5.0	56
DDT	120	41	71
PCB	200	67	81

Selected References

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Information on technical reports and hydrologic data related to the NAWQA Program can be obtained from:

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U.S. Geological Survey
PO Box 1230
Iowa City, IA 52244

Cedar River near Conesville