RESIDUAL PESTICIDES IN FISHES FROM LAKE CHICOT, ARKANSAS

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ABSTRACT

Samples of fish from isolated and flow-through portions of Lake Chicot, Arkansas, were analyzed for residual pesticide concentrations from 1978 and 1981. Where appropriate ecologically, fish flesh, viscera and whole fish, were analyzed for the common organochlorine insecticides DDT [1,1,1-trichloro -2,2bis(p-chlorophenyl)-ethane], DDE [1,1-dichloro-2,2-bis(p-chlorophenyl)-ethyene], DDD [1,1-dichloro -2,2-bis(p-chlorophenyl)-ethane], toxaphene (chlorinated camphene), chlordane, heptachlor, heptachlor epoxide, dieldrin, and endrin. DDT, DDT metabolites, and heptachlor were significantly (α = 0.05) higher in spotted gar *(Lepisosteus oculatus)* and yellow bullhead catfish *(Ictalurus natalis)* than in other species examined. Pesticide concentrations did not exceed the acceptable levels established by the U.S. Environmental Protection Agency although toxaphene levels in one white crappie (*Pomoxis annularis)* and one freshwater drum *(Aplodinotus grunniens)* were as high as 0.01 μg/g. Bottom feeding and piscivorus fishes had consistently higher concentrations of pesticides than fishes belonging to other feeding groups. The main body of the lake, with a large drainage area (930 km²) had higher concentrations of suspended solids than did the isolated northern basin and produced fish with significantly (α = 0.05) higher levels of toxaphene, DDD, and DDT. Insecticide concentrations were consistently greater in viscera with toxaphene, DDT, DDE and DDD levels significantly (α = 0.05) greater than in either whole fish or fish flesh samples. Eight years after banning, residual pesticides in fish from both basins of Lake Chicot were still significantly (α = 0.05) higher during years of increased runoff, indicating the importance of watershed management practices on longterm downstream water resources.

INTRODUCTION

Although the use of organochlorine pesticides from 1940 to the early 1970's provided greater crop yields, low degradability resulted in worldwide contamination by residual pesticides (Breidenbach, *et al.*, 1964; Woodwell, *et al.*, 1971; Crump-Wiesner, *et al.*, 1974). Bioaccumulation of these pesticides in terrestrial and aquatic ecosystems occurred to the point that reproductive processes were affected in several species of wildlife by mid-1960's (Walker, *et al.*, 1973; Hickey *et al.*, 1966). Although use of organochlorine pesticides has ceased, concentrations of these compounds are still high in fish and wildlife in areas where extensive application occurred.

Lake Chicot is located in the alluvial plain of the Mississippi River in eastern Arkansas, an area noted for its agricultural productivity. Because of the intensive agriculture in this region, numerous organochlorine pesticides were applied for several decades to control insect pests. The purpose of this study was to examine residual pesticide concentrations in Lake Chicot fishes, a group of vertebrates known to bioaccumulate many pesticides. Fish pesticide concentrations were compared by species, yearly watershed runoff, lake basin, and ecological and anatomical groupings.

MATERIALS AND METHODS

Lake Chicot (19.3 km²), an oxbow lake of the Mississippi River (Fig. 1) located in east Chicot County, Arkansas, is 27 km long and averages approximately 0.8 km in width. The watershed draining into the lake is primarily in intensive agriculture with principal crops being cotton *Gossypium hirsutum,* rice *Oryza sativa,* and soybeans *Glycine max.* Prior to 1927, Lake Chicot was a single body of water with limited inflow from Connerly Bayou and outflow via Ditch Bayou. Floods in 1927 deposited large quantities of materials across the lake immediately north of the mouth of Connerly Bayou and formed a sizable sand spit. Simultaneously, the normal lake level was lowered as both Connerly and Ditch Bayou were deepened by scouring. In 1948, additional materials were added to the sand spit by Arkansas Game and Fish Commission to form a levee that bisected the lake into two basins: an isolated northern basin (3.9 km²) and a larger flow-through southern basin (15.4 km²). Watershed enlargement, both intentional and by the 1927 flood event, increased the drainage area of the southern basin from approximately 100 km² to 930 km². The isolated northern basin has only ephemeral runoff from a small predominantly agricultural watershed of <100 km².

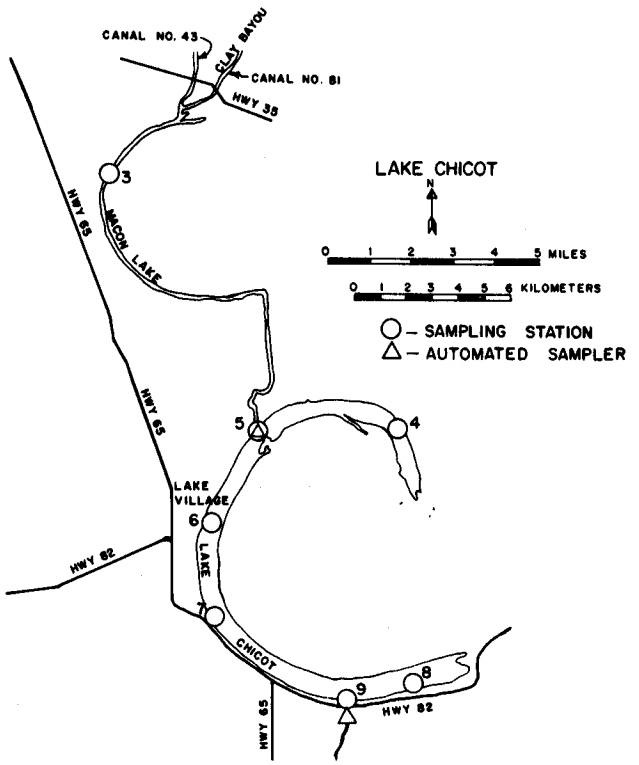

Figure 1. Map of Lake Chicot, Arkansas, depicting fish sampling sites and automatic water sampling sites.

Fish were collected at selected sites (Fig. 1) by seining and gill or hoop netting. They were wrapped in aluminum foil, and packed in ice for transport. Samples were then frozen and transported to the Soil-Plant Analysis Laboratory, Northeast Louisiana University, Monroe, Louisiana where they were analyzed for DDT, DDE, DDD, endrin, dieldrin, toxaphene, chlordane, heptachlor, and heptachlor epoxide using analytical procedures as described by the U. S. Environmental Protection Agency (1971). One hundred and thirty-six samples of flesh, viscera, or whole fish were analyzed from Lake Chicot from 1978 through 1981 (Table 1). Prey fish which are typically eaten whole were analyzed as whole fish samples. Smaller size groups were comprised of a minimum of 10 individuals per sample. "Game" fishes such as largemouth bass and channel catfish were analyzed as separate flesh and viscera samples. An analysis of variance was used to test for yearly, lake, species, feeding groups and type of sample (flesh, viscera, whole fish) effects for all pesticides. A Duncan's multiple range test was used for differences in yearly means, means for each species, lake means, and sample type means.

Table 1. Fish species analyzed for organchlorine pesticides in Lake Chicot, Arkansas from 1978 through 1981.

Species	Samples Collected Northern Basin	Southern Basin	Feeding* Group
Dorosoma cepedianum	6	3	f
Aplodinotus grunniens	5	6	b
Ictiobus bubalus	4	4	b
Ictiobus cyprinellus	0	2	b
Lepomis gulosus	2	0	o
Lepomis macrochirus	6	1	o
Lepomis megalotis	2	0	o
Lepomis humilis	1	1	o
Lepomis cyanus	0	2	o
Pomoxis annularis	6	10	p
Micropterus salmoides	5	0	p
Ictalurus melas	0	3	b
Ictalurus punctatus	20	12	b
Ictalurus natalis	2	0	b
Morone chrysops	10	0	p
Lepisosteus oculatus	2	2	p
Cyprinus carpio	7	10	b
Notropis umbratilis	0	1	o
Labidesthes sicculus	0	1	o

* b = bottom feeders, p = piscivores, f = filter feeders, o = omnivores.

RESULTS AND DISCUSSION

Concentrations of organochlorine pesticides were generally similar from species to species. Heptachlor, however, was significantly higher in yellow bullhead catfish *(Ictalurus natalis)* than in the other species of fish examined while spotted gar *(Lepisosteus oculatus)* had significantly higher levels of DDE and total DDT metabolites. Pesticide concentrations in whole fish samples never exceeded the upper limit (0.1 μg/g) established by U. S. Environmental Protection Agency (1973). However, two specimens, a white crappie *(Pomoxis annularis)* from the southern basin and a freshwater drum *(Aplodinotus grunniens)* from the northern basin, had toxaphene levels of 0.01 μg/g. When grouped by feeding habits, bottom feeding fish, including yellow bullheads and freshwater drum, and piscivorus fishes such as the spotted gar and white crappie had significantly (α = 0.05) higher concentrations of pesticides (Fig. 2). Piscivorus fish occupy a high position in the food chain and might be expected to have elevated levels of pesticides through step-wise bioaccumulation through the food chain. Bottom feeding fish have greater exposure to pesticides concentrated in the sediment-water interface and likely accumulate pesticides from mud ingested with their food.

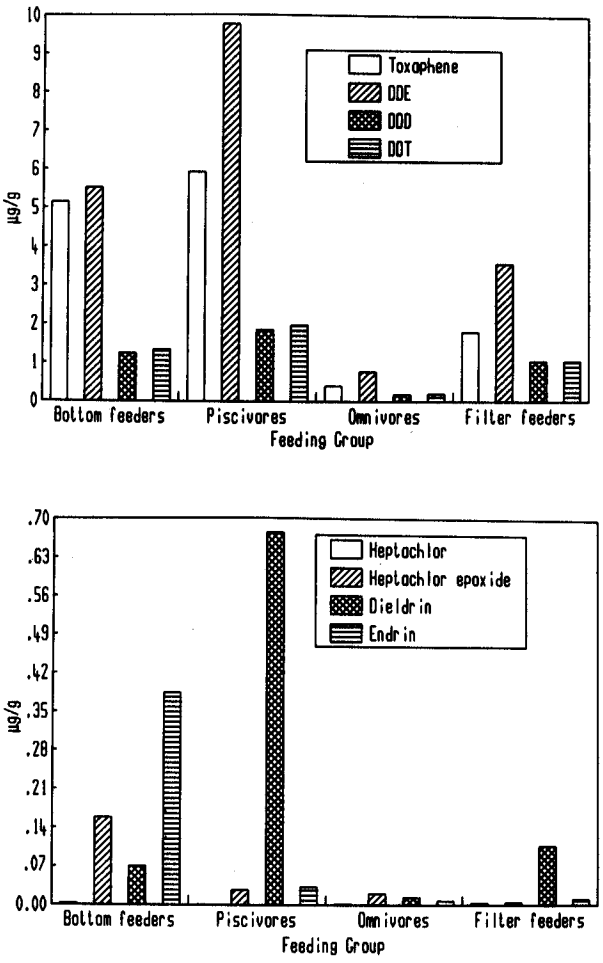

Figure 2. Concentrations of pesticides in fish categorized by feeding group (trophic level), from Lake Chicot, Arkansas, 1978 thru 1981.

Basin to basin comparisons revealed significantly (α = 0.05) higher concentrations of toxaphene, DDD, and DDT in the flow-through southern basin. This observation was expected since the southern basin receives a greater amount of agricultural runoff. Year to year comparisons showed significantly (α = 0.05) higher amounts of toxaphene, heptachlor, DDD, DDE, and DDT in 1979 and 1980 than in the other years (Table 2). Stage-discharge records indicated runoff amounts in 1979 were 413 percent greater than in 1977. Both 1979 and 1980 had increased runoff as a result of high ground water levels (Schiebe, *et al.*, 1984). There were significantly yearly and basin effects; however, there was not a significant year-basin interaction.

Organochlorines have been shown to concentrate in the fatty tissues of several species of animals (Matsumura, 1976; Murty, 1986). Viscera samples had higher concentrations of all pesticides than did flesh or whole fish samples. Viscera were also significantly (α = 0.05) higher in concentration of toxaphene and DDT and its metabolites. Humans consume the fleshy portions of fish so pesticides concentrations may not pose as great a problem to humans as to other predators.

Table 2. Pesticides with significantly different average concentrations in fish by year in Lake Chicot, Arkansas.

Pesticide	Year*			
Toxaphene	79	80	78	81
Heptachlor	80	79	78	81
DDT Metabolites	79	80	81	78
DDE	79	80	81	78
DDD	80	79	78	81
DDT	79	80	78	81

* Underscore indicates no significant differences between years.

SUMMARY

An analysis of flesh, viscera or whole fish samples from 19 species of fish from Lake Chicot, Arkansas indicated significantly ($\alpha = 0.05$) higher concentrations of heptachlor, and DDT metabolites especially DDE in yellow bullhead catfish and spotted gar than in other species. Pesticides never exceeded the recommended maximum concentrations set by the EPA (1973). Bottom feeding and piscivorus fishes had higher levels of pesticides than did other groups of fish. Lake to lake differences were observed for toxaphene, DDD and DDT. Toxaphene, heptachlor, DDD, DDE and DDT were significantly ($\alpha = 0.05$) higher in samples collected during 1979 and 1980, years which followed periods of unusually high runoff; there were no significant year-basin interactions. While all pesticides analyzed were concentrated in viscera at relatively high levels, only toxaphene, DDD, DDE, and DDT were significantly ($\alpha = 0.05$) higher in viscera than in flesh or whole fish samples.

Fish were found to be excellent indicators of residual pesticides as are other top consumers in the food chain. Even year to year changes could be detected when sample size and species variety were large enough for statistical analysis. Residual pesticides were still measurable and accumulating in fish in Lake Chicot five to eight years after these pesticides were banned. With no further application of these pesticides, gradual degradation should continue to reduce concentrations in this ecosystem.

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