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CONTINUED DDT PERSISTENCE IN MISSISSIPPI RIVER DELTA STREAMS: A CASE STUDY

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ABSTRACT

Fish samples representative of several trophic levels were taken from the Wolf and Loosahatchie Rivers of western Tennessee during the early 1980s. Results indicate that DDT, with metabolites DDD and DDE, remains common in fish tissues in these areas and approaches the levels recommended as maxima for human consumption by the U.S. Food and Drug Administration. Samples of top carnivores and forage fishes, particularly the gizzard shad, *Dorosoma cepedianum*, commonly exceeded 500 ppb DDE. The results are discussed in light of sediment disturbing activities.

INTRODUCTION

The synthetic organochlorine insecticide DDT (dichlorodiphenyl trichloroethane) was discovered to be a remarkable residual insecticide at Basle, Switzerland in 1939 (Brown, 1978; EPA, 1976). In 1963, 155 million pounds of DDT were sold, of which approximately 39% (60 million pounds) were used in the continental United States. In a 1964 survey of 56 United States' rivers, 42% contained DDT (Weaver et al., 1965). In addition, several studies revealed egg-shell thinning in a number of raptors, especially fish-eaters, as well as deaths in amphibian and reptile populations attributable to DDT and metabolites, particularly DDE (Fleet et al., 1972; Ames, 1966; Brown, 1951). Use of the insecticide was suspended in the United States in 1972, although several thousand tons are still applied worldwide in insect and disease control programs (Brown, 1978). On cropland in the United States, DDT was often applied on highly erodible soils, and/or excessive slopes. The insecticide was displaced from croplands under those conditions to area streams and rivers, predominantly adsorbed to eroded soil particles (USDA-ARS and US EPA, 1975).

This report describes a portion of fish tissue analysis studies conducted in the Wolf and Loosahatchie River Basins of western Tennessee (Fig. 1) by federal, state, and local agencies during the 1978-1981 period (USDA-SCS, 1985; Sinclair and Higgs, 1980; Simco, 1979). These studies were used to determine the persistence of historically applied pesticides in the aquatic food chains of these river systems, particularly organochlorines such as DDT.

STUDY AREA

The study area is located in southwest Tennessee and northwest Mississippi. The drainage area of the Wolf River consists of about 520,200 acres (208,000 ha), while the Loosahatchie River drains about 474,600 acres (189,900 ha). The rivers are within the eastern half of the Gulf Coastal Plain physiographic area. The present land forms are the result of erosion which has dissected this plain. The valleys are well incised, and streams have moderately wide valley floors. The streams have dentritic drainage patterns with rounded hills and ridges with moderately sloping valley walls. The Gulf Coastal Plain is further subdivided into the West Tennessee Uplands and the West Tennessee Plain. A small portion of the eastern end of the basin lies in the Uplands. This area is characterized by hilly to rolling topography and flat flood plains. Most of the basins are in the Plain which is gently rolling with small ridges and drainage divides.

The hilly topography, high rainfall index and inherent erosion characteristics of upland soils formed from these geologic formations contribute to excessive erosion rates. Sediment deposited in channels and on flood plain land range from silts drived from loess to fine and medium sand derived from underlying coastal plain formations. Flood plain soils are classed as recent geologic deposition of unconsolidated silty, andy alluvium and colluvium. These soils may be highly unstable if stripped of protective vegetation and accompanying root systems (USDA-SCS, 1985) and serve as the vehicle for transport of adsorbed pesticide pollutants into surface waters (USDA-ARS and EPA, 1975).

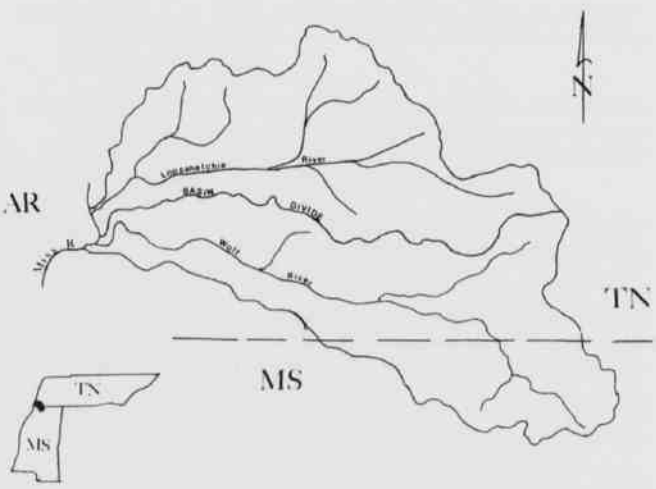

Figure 1. The study area of the Wolf and Loosahatchie River Basins of Western Tennessee and northern Mississippi.

METHODS AND MATERIALS

Fish samples were collected through use of fish toxicants (5% rotenone), standard minnow seines (4.5 m x 1.2 m x 0.3 cm and 6.1 m x 1.2 m x 0.3 cm) and a Coffelt electrofishing boat. Specimens were identified using Pflieger (1975), Douglas (1974), Buchanan (1973), and Cook (1959). Trophic level classifications followed information contained for each species in these references and are a follows; Category A = detritivores/omnivores (bottom feeders), Category B = herbivores (plant material/plankton feeders), Category C = lesser carnivores, and Category D = top carnivores. These are summarized in Table 1. Individual fish were prepared for analysis by removing edible portions (filets) from all fish regardless of size and freezing until delivery to the laboratory. No organs were included.

Laboratory analysis used gas chromatrography electron capture detection as outlined in the Pesticide Analytical Manual, Vol. I and II (Food and Drum Administration, 1970 et seq.) and in accordance with established methodology (APHA, 1985). All laboratory analyses were done by Woodson-Tenent Laboratories, Inc., an affiliate of National Health Laboratories, Inc., 345 Adams Street, Memphis, Tennessee

(Bassett, 1980, pers. comm.). Action levels referred to herein, follow Food and Drug Administration (1980) guidelines as established and revised according to the criteria specified in Title 21, *Code of Federal Regulations,* Parts 109 and 509.

Table 1. Fish species analyzed for pesticide residues by trophic categories from the Wolf and Loosahatchie river basins, Tennessee.

CATEGORY	DESCRIPTION	SPECIES INCORPORATED
A	Detritivores/omnivores (bottom feeders)	Common carp, *Cyprinus carpio* Bigmouth buffalo *Ictiobus bubalus* Smallmouth buffalo, *Ictiobus cyprinellus* Spotted sucker, *Minytrema melanops* Black bullhead, *Ictalurus melas*
B	Herbivores (plant-plankton feeders)	Gizzard shad, *Dorosoma cepedianum*
C	Lesser carnivores/ omnivores (predators, opportunists)	White crappie, *Pomoxis annularis* Channel catfish, *Ictalurus punctatus* Blue catfish, *Ictalurus furcatus* Warmouth, *Lepomis gulosus* Largemouth bass (<9"), *Micropterus salmoides* Bluegill, *Lepomis macrochirus* Longear sunfish, *Lepomis megalotis* Green sunfish, *Lepomis cyanellus*
D	Top carnivores (fish eaters and decomposers)	Bowfin, *Amia calva* Flathead catfish, *Pylodictus olivaris* Spotted gar, *Lepisosteus oculatus* Largemouth bass (>9"), *Micropterus salmoides*

RESULTS

Concentrations of DDT and metabolites in the tissues of Wolf and Loosahatchie River fishes were summarized in Table 1 for upper reaches. Results from lower reach stations have been previously reported and are subject to the non-agricultural influences of the Memphis metropolitan area (Sinclair and Higgs, 1980; Simco, 1979).

In general, results display the bioaccumulation tendency of DDT and metabolites in the aquatic food chain in these systems (ARS, 1979; EPA, 1976), and support the conclusion of Macek and Korn (1970) that bioaccumulation occurs predominantly through the food chain rather than direct absorption (Johnson and Finley, 1980). Exceptions to this conclusion in these systems occurred in levels recorded for forage feeders (planktivores), predominantly gizzard shad, *Dorosoma cepedianum,* and in the metabolite concentrations in bottom feeders, *Minytrema melanops* and *Cyprinus carpio.* In the former case, DDE concentrations exceeded those noted in either detritivores or carnivores. In the latter case, DDT concentrations exceeded DDD concentrations, a reversal of the most commonly encountered situation due to the rapid uptake and degradation of DDT (Menzie, 1980; Addison and Willis, 1978; Johnson et al., 1971). However, DDT concentrations were typically higher than DDD concentrations during recent spring and summer sampling of the lower reaches of both of these systems (Simco, 1979).

DISCUSSION

In 118 American rivers surveyed in 1968, highest DDT concentrations were 316 ppm in Beauliue River, Florida, and 840 ppm in Kansas River, Kansas (Lichtenberg et al., 1970). Since banning in 1972, several documented effects of DDT and metabolites in the aquatic environment have lessened or improved. There is not enough data to determine if the levels in Tennessee and Mid-South fishes are decreasing, however, the insecticide has remained in detectable concentrations in these areas. Highest levels were noted in the Wolf and Loosahatchie Rivers in the herbivores, predominantly gizzad shad, *Dorosoma cepedianum.* This species is planktivorous as an adult, taking the majority of its food by filter feeding (Pfleiger, 1975). Brown (1978) pointed out that many phytoplankton species were resistant to DDT at 15 ppm concentration, though growth decreased slightly at 0.1 ppm. Also, most (70%) of the *D. cepedianum* specimens used were in size classes > 7 inches (17.5 cm) and were too large to be considered prey for secondary consumers (Jenkins and Morais, 1976). Therefore, the bioconcentrations in *D. cepedianum* did not pass on through the food chain and was not reflected in pesticide concentrations in trophic category C (lesser carnivores).

Table 2. DDT and metabolite concentrations in fishes of the upper Wolf and Loosahatchie River Basins, Tennessee and Mississippi.

CATEGORY/TROPHIC LEVEL[1]	RESIDUE (ppb)			
	DDT	DDD	DDE	tDDT
A = Detritivores/Omnivores (bottom feeders)	85	63	370	518
B = Herbivores (plankton feeders)	<10	412	1085	1500[2]
C = Lower Carnivores (predators/opportunists)	<10	63	338	400[2]
D = Top Carnivores	<10	107	710	820[2]

[1]See Table 1

[2]Estimated

Concentrations in the bottom feeders (trophic category A) revealed greater levels of DDT than DDD, a reversal of the trend seen at other trophic levels. One explanation for this may lie in the fact that within the sediments DDT and metabolites tend to concentrate in the top 2 cm or that area most disturbed or ingested by bottom feeders (Brown, 1978).

In conclusion, the study reveals that although concentrations do not exceed the 5 ppm action level of the Food and Drug Administration (1980), DDT remains in the sediments of major river courses and continues to enter aquatic food chains. Actions which disturb sediments, including normal feeding by bottom feeders, also resuspend DDT in the water column where it becomes available to other trophic levels (USA-COE, 1985; Yokley and Gooch, 1976). These systems have been altered in the past by both the channelization (deepening and widening with heavy equipment) and hand clearing of log jams, falling trees, etc.

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