Effects Of Silvex On Aquatic Biota[1]

EUGENE W. WHITNEY[2], RAY DON ESTES,
R. ONEAL SMITHERMAN, and
EDWARD O. GANGSTAD

Project Leader and Field Assistant, USDI,
Atlanta, Georgia, 30323;
Biologist, Louisiana State University, USDI,
Baton Rouge, Louisiana, 70803; and
Chief, Aquatic Plant Control Program, Office of the Chief of Engineers,
Washington, D. C. 20314, Respectively.

ABSTRACT

Following treatment of alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.) in ponds averaging 1.8 surface acres in size in Louisiana, benthic organisms increased in numbers and changed in species composition. The number of rotifers and crustaceans decreased temporarily after treatment with 2-(2,4,5-trichlorophenoxy)propionic acid (silvex), but within 72 hr their numbers increased and reached normal population levels within 3 weeks. Herbicide residue levels in the pretreatment samples were for the most part negative. Maximum residue levels in the fish were found 24 hr after treatment. These residue levels decreased to negligible amounts within 3 weeks. These data refer to a total treatment program in a closed system and proper adjustments must be made for application in field practice according to conditions that pertain.

INTRODUCTION

The purpose of this study was to determine the effects of silvex on the aquatic biota under controlled conditions of herbicide treatment for control of alligatorweed (4). Three ponds referred to as Harrelson, Johnson, and Jones having surface areas of 2.0, 1.7, 1.8 acres, respectively, were selected for this study. They had no known history of herbicide application and were heavily infested with alligatorweed. They contained harvestable populations of fish for determination of herbicide residues in fish flesh. Details of the degradation kenetics and persistence of silvex in water and hydrosoil samples taken from these ponds have been published (2). For the purposes of this study, these data refer to a total treatment effect in a closed system. In field practice, however, less than one-third of the surface area and less than one-ninth of the total volume is treated at one time. Commonly, there is also sufficient movement of water so that treated water is replaced in about 3 days.

METHODS AND MATERIALS

Treatment. Silvex (Kuron-Dow Chemical Company) was used at a rate of 8 lb acid equivalent per surface acre. The total pond area was treated as a single application for each date.

On 14 June 1966, all three ponds were treated. Seven weeks following the first treatment, 3 August 1966, the ponds were treated a second time. A third application was made in Jones Pond 6 September 1966; Harrelson and Johnson Ponds did not receive a treatment this time. The three study areas received two treatments each in 1967, one on 10 June and another on 8 September. Treatments were performed by personnel of the Bureau of Sport Fisheries and Wildlife and Louisiana State University. A modification of the techniques described by Burchfield, Johnson and Storrs was used to determine silvex as the PGBE and acid in fish samples (3).

FIELD SAMPLING

Fish. Fish population surveys were begun 15 August 1965 and continued until 15 August 1968 (Table 1). Fish were collected with a 125-ft gill net with graduated 1.0 to 5.0-inch bar mesh, a 15-ft seine, and a 56-ft bag seine. Gill net sets were made in each of the ponds for a 24-hr period. A series of seine hauls were taken at different locations in the ponds. Some difficulty was encountered with seining because of the dense growths of alligatorweed. Fish caught were weighed, measured, identified, and released into the pond.

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[1]Cooperative Study of the U. S. Army Corps of Engineers; U. S. Department of the Interior, Division of Fishery Services, Environmental Protection Agency, Southeast Water Quality Laboratory; and Louisiana State University.

[2]Deceased.

TABLE 1. FISH POPULATION SURVEY OF HARRELSON, JOHNSON, AND JONES PONDS AT BATON ROUGE, LOUISIANA DURING 1965-68.

Common Name	Scientific Name	Ponds											
		Harrelson				Johnson				Jones			
		65	66	67	68	65	66	67	68	65	66	67	68
Spotted Gar	*Lepisosteus oculatus*	X	X	X	X	X							
Bowfin	*Amia calva*	X	X	X	X	X							
Gizzard Shad	*Dorosoma copedianum*	X	X	X	X	X	X	X	X	X			
Chain Pickeral	*Esox niger*	X	X	X									
Golden Shiner	*Notemigonus crysoleucas*					X	X	X	X				
Bigmouth Buffalo	*Ictiobus cyprinellus*	X	X	X	X								
Yellow Bullhead	*Ictalurus natalis*									X	X		
Brown Bullhead	*Ictalurus nebulosus*	X	X		X	X	X	X	X	X			
Golden Topminnow	*Fundulus chrysotus*	X	X	X	X	X	X	X	X	X	X	X	X
Starhead Minnow	*Fundulus notti*	X	X		X	X	X	X	X	X	X	X	X
Mosquitofish	*Gambusia affinis*	X	X	X	X	X	X	X	X	X	X	X	X
Least Killifish	*Heterandria formosa*	X	X		X	X	X	X	X	X	X		
Warmouth	*Chaenobryttus gulosus*	X	X	X	X	X	X	X	X	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X	X	X	X	X	X	X	X	X
Orangespot Sunfish	*Lepomis humilis*	X	X	X	X	X	X	X	X				
Bluegill Sunfish	*Lepomis macrochirus*	X	X	X	X	X	X	X	X	X	X	X	X
Dollar Sunfish	*Lepomis marginatus*	X	X		X								
Longear Sunfish	*Lepomis megalotis*									X	X	X	X
Redear Sunfish	*Lepomis microlophus*	X	X		X	X							
Largemouth Bass	*Micropterus salmoides*	X	X	X	X	X	X	X	X	X	X	X	X
White Crappie	*Pomoxis annalaris*	X	X	X	X	X	X	X	X	X	X		
Black Crappie	*Pomoxis nigromaculatus*					X	X	X	X	X	X		

Fish samples for residue analyses were collected with 15 and 56-ft seines prior to treatment and at intervals of 12, 24 and 72 hr; 1, 3, 5 and 7 weeks; and at 5 months following treatment. Residue analyses were run on both predator and non-predator species. Largemouth bass (*Micropterus salmoides* Lacepede) were designated as the predator species and various sunfish (*Lepomis* spp.) as non-predators. Whole body fish samples were analyzed according to a modification of the method of Pope et al. (5).

Benthos. Pretreatment benthic samples were collected 15 August 1965, and then taken monthly until the first silvex treatment on 14 June 1966. The samples were collected with a sweep net and Peterson and Ekman dredges. For sampling purposes, the ponds were divided into quadrants, a dredge sample taken from each quadrant, and the four samples combined as a composite for each pond. Each dredge sample was placed in a bucket and sieved through a fine mesh hand screen. Organisms and debris were placed in a jar and taken to the laboratory for separation. In the laboratory, the dredge samples were washed through a number 30 mesh sieve. Organisms were separated from debris by use of an electro-shock apparatus or by the sugar flotation method (1). The dredge samples were combined with the sweep net samples and all organisms identified and counted.

RESULTS AND DISCUSSION

Alligatorweed. The alligatorweed was eliminated by herbicide treatment at Harrelson and Johnson Ponds. In Harrelson Pond, the plant was destroyed by the first treatment and in Johnson Pond, was reduced by the first treatment and eliminated by the second. Jones Pond was treated three times in 1966 and twice in 1967. The three treatments in 1966 reduced the weed coverage by 40% The two treatments in 1967 reduced the remaining plants by 75%. At the termination of this project, the plants in Jones Pond were still growing actively in several areas.

Fish Mortality. Observations were made during all spraying operations at the three study areas to note immediate effects on fish. Following the first treatment, 14 June 1966, a fish-kill was observed in Johnson Pond. On 3 August 1966, following the second treatment, fish were observed in distress at Jones Pond. Some fish remained in distress for 96 hr.

Jones Pond was treated a third time on 6 September 1966. Seven hr following treatment, the first fish reaction was observed. Mosquitofish, (*Gambusia affinis* Baird and Girard), moved away from the shoreline. At 10:00 p.m., bluegill and longear sunfish (*Lepomis megalotis* Rafinesque) began to congregate in the shallow end of the pond and at 1:30 a.m., dead sunfish were observed. On 10 June 1967, all three ponds were treated again. A limited fish kill was observed in Harrelson and Jones Ponds. In Harrelson Pond, bluegill (*Lepomis macrochirus* Rafinesque) fry and gizzard shad (*Dorosoma copedianum* LeSueur) fingerlings were found dead. In Jones Pond, numerous largemouth bass fingerlings and one adult bluegill were observed dead. On 8 September 1967, the three study areas were again treated, with similar results. A summary of fish mortality is given in Table 2.

Because of this fish mortality, bioassays were set up in ten 5-gallon aquaria in the laboratory in Louisiana State University. The aquaria were lined with 3-mill polyethylene plastic; five were partially filled with 3 gallons of water each from Jones Pond, and five were partially filled with the same amount of water from a pond not involved in the Kuron study. Five green sunfish 2 to 4 inches long were put in each aquarium. The aquaria were treated 24 hr later with concentrations of 15.0, 10.0, 5.0, and 1.0 ppm, and one control for each pond water. The aquarium with

TABLE 2. FISH MORTALITY FOLLOWING SILVEX TREATMENTS IN HARRELSON, JOHNSON, AND JONES PONDS IN LOUISIANA 1966-67 ACCORDING TO SIZE CLASSIFICATION.

Pond and Species	Number of Fish — Length of inches											
	1	2	3	4	5	6	7	8	9	10	11	12
Johnson Pond												
Gizzard Shad	—	—	12	74	—	—	—	1	—	—	—	—
Bluegill Sunfish	86	41	16	—	—	1	—	—	—	—	—	—
Orangespot Sunfish	51	14	6	—	—	—	—	—	—	—	—	—
Largemouth Bass	—	5	17	21	—	—	—	—	—	—	—	—
Jones Pond												
Gizzard Shad	—	—	—	—	—	—	—	8	—	30	372	4
Redear Sunfish	—	—	8	14	13	61	22	1	1	—	—	—
Longear Sunfish	—	—	—	1	4	—	—	—	—	—	—	—
Warmouth	—	—	—	1	2	1	2	—	—	—	—	—
Black Crappie	—	—	—	—	—	—	—	2	1	1	—	2
Largemouth Bass	—	—	—	27	46	6	—	—	—	—	—	6
Harrelson Pond												
Gizzard Shad	—	—	—	1	16	7	2	—	—	—	—	—
Redear Sunfish	48	13	6	—	—	—	—	—	—	—	—	—

15.0 ppm of silvex was the only one where fish gave any indication of being affected.

Bioassays in plastic pools set up alongside Jones Pond and a pond not involved in the Kuron study were conducted at the same time as the laboratory experiment. Three plastic pools were set up alongside each pond, partially filled with 750 gallons of water and let stand for 24 hr. Twenty bluegills ranging in size from 3 to 5 inches were put into each pool. Twenty-four hr later sufficient silvex was added to two pools to achieve initial concentrations of 4.0 and 2.0 ppm with one pool serving as the control. Because no mortality occurred, the median lethal dose (TLm) could not be determined. It is assumed that factors other than toxicity of the herbicide itself, were the cause of observed fish mortality in the pond study.

Fish Populations. On 15 August 1965, pretreatment fish population surveys were begun and continued periodically until the first silvex treatment on 14 June 1966. At that time, it was found that Harrelson Pond contained 18 species of fish in nine families; Johnson Pond contained 18 species of fish in nine families; and Jones Pond contained 15 species in six families. In September 1966 following the two herbicidal treatments, the area was surveyed again.

Benthos. The pretreatment benthic organism samples taken from 15 August 1965 to 14 June 1966, and post-treatment samples taken in 1966 and 1967 following treatment indicate some changes occurred in the invertebrate population. The overall pattern was one of increase in the total invertebrate numbers after treatment. This change probably resulted in part from the relatively high fish mortality following herbicide treatment. Summary of the data on benthic organisms is given in Table 3.

Silvex Residues. Data from predator, largemouth and warmouth (*Chaenobryttus coronarius* Bartram), and non-predator (sunfish) at Harrelson, Johnson and Jones Ponds for silvex residues are summarized in Tables 4, 5, and 6, respectively. The highest concentration of residue, 19.5 ppm, was determined in a non-predator (sunfish) sample taken in Jones Pond 24 hr following the second treatment. The highest concentration for predator fish was 16.0 ppm from a sample of largemouth bass also taken 24 hr following the second treatment at Jones Pond.

TABLE 3. AVERAGE NUMBER OF BENTHIC ORGANISMS PER SQUARE FT FOLLOWING TREATMENT OF HARRELSON, JOHNSON, AND JONES PONDS WITH SILVEX.

Benthic Organisms	Month of Sampling	Year of Sampling		
		1965	1966	1967
Oligochaeta	Sep	1	10	5
	Oct	1	5	3
	Dec	1	9	11
Dytiscidae	Sep	1	3	3
	Oct	1	6	4
	Dec	1	9	5
Ceratopogonidae	Sep	2	29	32
	Oct	5	28	39
	Dec	16	28	23
Pentaneura sp.	Sep	1	24	49
	Oct	9	11	13
	Dec	26	47	43
Chaoborus sp.	Sep	2	47	78
	Oct	5	28	66
	Dec	11	244	247

Following the second treatment, higher residue levels were reached in both the predatory and non-predatory species than during the first treatment. Residue levels in fish samples reached a maximum level in all three ponds 24 hr following first treatment. After 1 week, residues decreased to lower levels in non-predator species than in predator species. The data demonstrates there was no residue accumulation in the natural food chain from non-predator to predator fish.

LITERATURE CITED

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TABLE 4. RESIDUES (PPB) FOR THE PGBE AND ACID FORMS OF SILVEX FOUND IN FISH SAMPLES FOLLOWING HERBICIDE TREATMENT IN 1966 AND 1967 FOR HARRELSON POND, LOUISIANA.

Time of Sampling After Treatment Hr.	Wk.	Mo.	Predator PGBE	Predator Acid	Non-Predator PGBE	Non-Predator Acid
			FIRST TREATMENT 1966			
Pretreatment			ND[a]	6	—[b]	—
12	—	—	ND	3,000	1,200	6,900
24	—	—	9	5,000	ND	6,500
72	—	—	48	1,700	ND	180
—	1	—	ND	608	ND	ND
—	3	—	—	—	ND	44
—	5	—	ND	ND	ND	80
			SECOND TREATMENT 1966			
12	—	—	249	3,200	190	7,600
24	—	—	ND	4,400	ND	6,600
72	—	—	—	—	—	2,350
—	1	—	ND	177	14	250
—	3	—	—	577	1	196
—	7	—	—	—	—	36
—	—	3	—	—	—	116
—	—	6	36	2	40	2
			FIRST TREATMENT 1967			
Pretreatment			7	ND	ND	ND
24	—	—	6	600	10	670
72	—	—	10	120	ND	40
—	1	—	500	300	20	ND
—	7	—	ND	ND	ND	ND
			SECOND TREATMENT 1967			
24	—	—	ND	ND	110	1,460
72	—	—	80	25	ND	ND
—	1	—	ND	10	ND	6

[a]Analyses for the propylene glycol butyl ether esters or acid form of silvex not detected in fish samples.
[b]Fish samples not collected.

TABLE 5. RESIDUES (PPB) FOR THE PGBE AND ACID FORMS OF SILVEX FOUND IN FISH SAMPLES FOLLOWING HERBICIDE TREATMENT IN 1966 AND 1967 FOR JOHNSON POND, LOUISIANA.

Time of Sampling After Treatment Hr	Wk	Mo	Predator PGBE	Predator Acid	Non-Predator PGBE	Non-Predator Acid
			FIRST TREATMENT 1966			
Pretreatment			ND[a]	8	—[b]	—
12	—	—	10	4,700	68	6,100
24	—	—	28	4,300	137	11,000
72	—	—	ND	7,200	ND	1,100
—	1	—	21	2,500	ND	ND
—	4	—	ND	ND	ND	ND
—	7	—	—	—	ND	ND
			SECOND TREATMENT 1966			
12	—	—	40	5,900	46	10,500
24	—	—	74	13,500	388	8,100
—	1	—	100	321	ND	85
—	2	—	ND	148	—	—
—	3	—	—	—	ND	269
—	7	—	—	346	—	92
—	—	3	—	—	—	150
—	—	6	—	—	36	2
			FIRST TREATMENT 1967			
Pretreatment			55	2	125	ND
24	—	—	16	60	10	300
72	—	—	4	50	3	60
—	1	—	ND	12	ND	1
—	7	—	8	ND	ND	ND
			SECOND TREATMENT 1967			
24	—	—	20	400	190	300
72	—	—	10	50	15	100
—	1	—	35	70	ND	5
—	3	—	ND	ND	ND	ND

[a]Analyses for the PGBE or acid form of silvex not detected in fish samples.
[b]Fish samples not collected.

TABLE 6. RESIDUES (PPB) FOR THE PGBE AND ACID FORMS OF SILVEX FOUND IN FISH SAMPLES FOLLOWING HERBICIDE TREATMENT IN 1966 AND 1967 FOR JONES POND, LOUISIANA.

Time of Sampling After Treatment			Predator		Non-Predator	
Hr	Wk	Mo	PGBE	Acid	PGBE	Acid
			FIRST TREATMENT 1966			
Pretreatment			ND[a]	25	—[b]	—
			—	—	ND	4
12	—	—	18	4,500	33	3,800
24	—	—	23	6,000	29	7,000
72	—	—	—	—	ND	600
—	1	—	ND	465	ND	84
—	3	—	ND	216	ND	60
—	7	—	ND	12	—	—
			SECOND TREATMENT 1966			
12	—	—	704	15,000	62	19,000
24	—	—	464	16,600	23	19,500
72	—	—	321	13,600	9	2,800
—	1	—	41	1,300	12	606
—	3	—	—	615	—	ND
			THIRD TREATMENT 1966			
72	—	—	—	—	—	4,500
—	2	—	—	—	—	76
—	—	5	—	—	8	2
			FIRST TREATMENT 1967			
Pretreatment			ND	ND	ND	ND
24	—	—	29	874	155	740
72	—	—	10	—	ND	200
—	1	—	ND	100	228	62
—	7	—	ND	10	1	ND
			SECOND TREATMENT 1967			
24	—	—	115	660	50	890
72	—	—	10	ND	10	200
—	1	—	ND	ND	ND	200
—	3	—	ND	ND	ND	ND

[a]Analyses for the PGBE or acid form of silvex not detected in fish samples.
[b]Fish samples not collected.

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