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Effects of an Aquatic Plant and Suspended Clay on the Activity of Fish Toxicants

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ABSTRACT

Rotenone, antimycin, permethrin, pydrin, and Salicylanilide I were tested for their toxicities against fathead minnows (*Pimephales promelas*) in the presence of Canadian waterweed (*Elodea canadensis*) or suspended clay. The plants had little effect on the activity of rotenone and antimycin but substantially reduced the activity of permethrin and pydrin (synthetic pyrethroids). Bentonite severely inhibited the activity of all chemicals tested. Salicylanilide I was affected least and pydrin most (27 times as much pydrin was required when 1 g/liter of bentonite was present in 96-hour tests). The efficacy of the registered fish toxicants rotenone and antimycin is probably not significantly affected by vegetation under field conditions, but is greatly reduced by suspended bentonite clay.

Control of fish populations with chemicals has been a widely practiced and valuable management procedure for many years. Attempted eradications of fish populations in lakes and streams have met with varying degrees of success that ranged from complete kills to significant survival of target fishes (Anderson 1970; Spitler 1970; Lennon et al. 1971). Lennon et al. (1971) listed numerous variables that affect success of lake treatments, including vegetation and turbidity. Anderson (1970) and Spitler (1970) both indicated that a failure to obtain complete kills of fish with rotenone is sometimes associated with the presence of clay turbidity and vegetation.

Some laboratory studies have demonstrated that clay turbidity and vegetation reduce the activity of chemicals. Berger et al. (1969) showed that 5,000 mg/liter of clay significantly reduced the toxicity of antimycin to rainbow trout (*Salmo gairdneri*), but that 1,000 mg/liter had little effect. Launer and Bills (1979) found that both vegetation and certain suspended clays reduced the activity of 2-(digeranylamino)-ethanol (GD-174) against fish.

The present study was done to expand our knowledge of the effects of clay turbidity and of vegetation on the efficacy of fish toxicants. These variables were evaluated individually in standard toxicity tests with two registered and three candidate fish toxicants.

MATERIALS AND METHODS

The acute toxicity tests in this study were conducted with fathead minnows (*Pimephales promelas*) in soft water at 12 C according to the methods of the Committee on Methods for Acute Toxicity Tests with Aquatic Organisms (1975). Each container held 10 fish in 15 liters of water.

The vegetation used was Canadian waterweed (*Elodea canadensis*), collected locally from the Mississippi River, and sorted by hand to remove bare stems, plants that were not actively growing, and plants of other species. Plants for each test vessel were weighed to the nearest 0.1 g on a top-loading electronic balance. Vegetation and fish were added to the jars on the same day and the toxicant was added the following day. Tests were conducted with 4, 8, and 12 g (wet weight) of *Elodea* per liter of water.

The clays used in toxicity tests were kaolin (obtained from Matheson, Coleman, and Bell Manufacturing Chemists, Norwood, Ohio) and bentonite USP (obtained from American Drug Industries Inc., Chicago, Illinois). Amounts of clay were selected to yield turbidities of 50, 75, and 100 nephelometric turbidity units (NTU). Clays for individual jars were weighed to an accuracy of 0.01 g on the top-loading electronic balance. The actual weights of clay added to test jars were 0.05, 0.075, and 0.1 g/liter for kaolin and 0.25, 0.5, and 1.0 g/liter for bentonite. Clay slurries were well mixed and then added to jars

to this paper. This is the Great Lakes Re- ty of Michigan.

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Table 1. Sources and formulations of fish toxicants tested in combination with vegetation and suspended clay.

Chemical	Source	Formulation	Amount of active ingredient (percent)
Rotenone	S. B. Penick and Co. Lyndhurst, N.J.	Noxfish	5
Antimycin	Ayerst Laboratories New York, N.Y.	Fintrol concentrate	10
Permethrin	S. B. Penick and Co. Lyndhurst, N.J.	Technical	92.15
Pydrin	Shell Development Co. Modesto, Calif.	2.4 EC	30[a]
Salicylanilide I	Monsanto Agricultural Products Co. St. Louis, Mo.	Technical	99+

[a] Percentage is approximate; product is sold commercially as 2.4 lb active ingredient per gallon.

containing the fish. Toxicants were added either immediately after addition of the clay or on the following day; if clay was added on the following day, the solution was stirred vigorously with a glass rod to ensure suspension of all clay at the time the toxicant was added.

The chemicals tested included the two registered fish toxicants rotenone and antimycin, and three candidate fish toxicants—permethrin, pydrin, and Salicylanilide I. Permethrin and pydrin are synthetic pyrethroids, and Salicylanilide I is a nitrosalicylanilide that was tested and reported earlier by Marking (1972). The sources and formulations of toxicant chemicals are given in Table 1. All concentrations in results are expressed in terms of active ingredient. Technical materials, which were considered as 100% active, were dissolved in acetone and diluted with deionized water in the preparation of stock solutions. Each series of tests containing plants or clay was compared with a parallel series without the material being tested. The LC50 values and 95% confidence intervals were calculated by the methods of Litchfield and Wilcoxon (1949).

Compensation factors (the number by which the pertinent LC value for a reference test must be multiplied to achieve the same results in the presence of a particular environmental variable) were calculated by the following formula:

$$\text{Compensation factor} = \frac{\text{LC50 with plants or clay present}}{\text{LC50 without plants or clay present}}$$

Results and Discussion

Effects of Vegetation

Rotenone and antimycin were not greatly affected by *Elodea* within 24 hours of application. There was a trend toward increasing effects with time but, in many cases, the confidence intervals of tests containing plants overlapped the confidence interval of the reference (control) test (Table 2). Because most of the biological activity of these toxicants is exhibited in the first 48 hours, the impact of *Elodea* on their effectiveness should be small.

The pyrethroids were most affected by *Elodea*. At 96 hours, three to six times as much chemical was required to exert the same effect in the presence of the vegetation as without it. Pyrethroid chemicals tend to act slowly against fish over a period of several days, so the piscicidal properties of these compounds are probably greatly weakened by the presence of vegetation under field conditions.

Salicylanilide I was intermediate in the extent to which its activity against fish was affected by *Elodea*. The effects at 24 and 96 hours were almost identical for corresponding amounts of vegetation present and were directly proportional to the amount of vegetation present.

No attempt was made in this study to ascertain exactly how the vegetation exerts its effect on activity of the chemical. I assumed that the impact was due to uptake, metabolism, or both, rather than surface adsorption. If that assumption is correct, then the effect of vegetation would

Table 2. Toxicity of fish t... per liter) of *Elodea* in sof...

Chemical and amount of vegetation	L... con... (m...
Rotenone	
0	
4	
8	
12	
Antimycin	
0	
4	
8	
12	
Permethrin	
0	
4	
8	
12	
Pydrin	
0	
4	
8	
12	
Salicylanilide I	
0[b]	
0[c]	
4	
8	
12	

[a] Compensation factor =

[b] Reference series for te...

[c] Reference series for te...

Table 2. Toxicity of fish toxicants to fathead minnows in the presence of selected amounts (grams per liter) of *Elodea* in soft water at 12 C.

	Duration of test			
	24 hours		96 hours	
Chemical and amount of vegetation	LC50 and 95% confidence interval (micrograms/liter)	Compensation factor[a]	LC50 and 95% confidence interval (micrograms/liter)	Compensation factor[a]
Rotenone				
0	10.7 9.1–12.7		3.4 2.8–4.0	
4	14.0 11.9–16.4	1.31	4.0 3.3–4.7	1.18
8	12.2 11.0–16.6	1.14	4.3 3.8–4.9	1.26
12	11.0 8.8–13.7	1.03	5.6 4.7–6.5	1.65
Antimycin				
0	2.4 2.3–2.6		0.27 0.10–0.70	
4	2.8 2.6–2.9	1.17	0.46 0.23–0.91	1.70
8	2.9 2.6–3.1	1.21	0.55 0.20–1.50	2.04
12	2.8 2.5–3.0	1.17	0.82 0.46–1.43	3.04
Permethrin				
0	5.4 3.4–8.7		7.4 5.1–10.8	
4	10.5 3.0–34.0	1.94	31.0 25.6–37.4	4.19
8	6.9 3.0–15.7	1.28	42.0 29.3–60.1	5.68
12			38.0 30.8–46.8	5.14
Pydrin				
0			4.0 3.0–5.3	
4			12.9 10.8–15.4	3.22
8			24.9 20.1–30.8	6.22
12			22.1	5.52
Salicylanilide I				
0[b]	5.9 4.2–8.1		4.9 3.7–6.4	
0[c]	4.4 3.2–5.7		4.1 3.1–5.3	
4	7.5 6.2–9.0	1.27	7.0 5.7–8.6	1.43
8	9.1 7.5–10.7	2.07	8.0 6.2–10.3	1.95
12	13.0 10.8–15.5	2.95	11.1 9.3–13.2	2.71

[a] Compensation factor = LC50 with clay present/LC50 without clay present.
[b] Reference series for tests with 4 g/liter of *Elodea*.
[c] Reference series for tests with 8 and 12 g/liter of *Elodea*.

Table 3. Toxicity of fish toxicants to fathead minnows in the presence of selected amounts (grams/liter) of suspended bentonite in soft water at 12 C.

Chemical and amount of bentonite	Duration of test: 24 hours — LC50 and 95% confidence interval (micrograms/liter)	24 hours — Compensation factor[a]	96 hours — LC50 and 95% confidence interval (micrograms/liter)	96 hours — Compensation factor[a]
Rotenone				
0	12.1 9.6–15.3		8.0 6.0–10.7	
0.25	86.0 58.8–125.9	7.11	12.5 9.9–15.7	1.56
0.50	85.0 60.0–121.3	7.02	16.9 11.6–24.5	2.11
1.00	109.0 83.5–142.2	9.01	22.2 18.9–26.1	2.78
Antimycin				
0	1.4 0.92–2.1		0.18 0.15–0.23	
0.25			0.71 0.61–0.83	3.94
0.50	20.5 15.1–27.7	14.64	0.93 0.58–1.50	5.17
1.00	16.0 10.8–23.6	11.43	2.40 1.4–4.3	13.33
Permethrin				
0	20.0 11.2–36.0		3.5 2.6–4.7	
0.25	47.0 29.1–75.7	2.35	14.5 10.9–19.2	4.14
0.50	54.0 43.2–67.5	2.70	19.0 12.9–26.0	5.43
1.00	62.0 49.1–78.3	3.10	30.5 24.9–37.2	8.71
Pydrin				
0	4.6 3.0–7.2		1.1 0.8–1.5	
0.25	26.5 19.0–36.9	5.76	5.7 4.4–7.3	5.18
0.50	35.0 27.6–44.4	7.61	12.0 10.0–14.4	10.91
1.00	48.0 47.0–71.6	10.4	30.0 15.3–58.8	27.27
Salicylanilide I				
0[b]	6.5 5.2–8.0		6.2 5.1–7.6	
0[c]	4.6 4.1–5.2		4.5 3.6–5.6	
0.25	17.0 14.8–19.5	2.62	10.1 8.4–12.2	1.63
1.0	25.9 20.8–32.2	5.63	11.1 9.9–12.5	2.47

[a] Compensation factor = LC50 with clay present/LC50 without clay present.
[b] Reference series for tests with 0.25 g/liter of bentonite.
[c] Reference series for tests with 1.0 g/liter of bentonite.

be expected to increas
peratures and respirati
plant may also make a
One cannot assume th
are representative of th
macrophytes.

Effects of Suspended C

Kaolin was used in
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had no effect on any
not used for further te
Bentonite exerted a
the chemicals (Table
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bentonite. The maxi
occurred with pydrin
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the amount of pydri
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tenone and antimyci
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antimycin required tc
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toxicants. Of the che
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of fish toxicants.
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6 hours	
l	Compensation factor[a]
	1.56
	2.11
	2.78
	3.94
	5.17
	13.33
	4.14
	5.43
	8.71
	5.18
	10.91
	27.27
	1.63
	2.47

be expected to increase with increases in temperatures and respiration rates. The species of plant may also make a considerable difference. One cannot assume that the results given here are representative of the effects of all freshwater macrophytes.

Effects of Suspended Clay

Kaolin was used in tests of three chemicals (antimycin, permethrin, and pydrin). Because it had no effect on any of these chemicals, it was not used for further tests.

Bentonite exerted a significant effect on all of the chemicals (Table 3). In several tests, the amount of chemical required to kill fish was increased by about 10 times in the presence of bentonite. The maximum inhibition of activity occurred with pydrin; in a 96-hour test the highest level of bentonite tested (1 g/liter) increased the amount of pydrin required to kill fathead minnows by 27 times. The activity of both rotenone and antimycin was significantly and severely weakened in 24 hours, even at the lower concentrations of bentonite. The presence of 0.5 g/liter of benonite increased by 7 and nearly 15 times, respectively, the amounts of rotenone and antimycin required to kill fathead minnows. Clay turbidity is definitely an important factor to be considered in the use of these established fish toxicants. Of the chemicals tested, Salicylanilide I was least affected by bentonite. In most tests, the inhibition of biological activity of a particular chemical was positively correlated with the amount of suspended bentonite present.

The reduction in toxicity by bentonite in these tests confirms many field observations concerning rotenone and clay turbidity. The results on antimycin do not corroborate those of Berger et al. (1969) who found a much smaller effect; however, the type of clay used in their tests was not reported.

Vegetation and turbidity are only two of the many environmental factors which may act singly or in combination to limit the effectiveness of fish toxicants. Although vegetation does not appear to strongly influence rotenone and antimycin, it could be significant in combination with some other factor. The influence of vegetation is not likely to be assessed in on-site toxicity tests (Burress 1975) used to determine the proper concentration for treatments.

Turbidity would naturally be included in on-site toxicity tests in which the water to be treated is used, and therefore would be compensated by the effective concentration indicated by the test. A significant increase in turbidity between the time of the on-site tests and the treatment, however, would increase the likelihood that a treatment would fail to achieve the desired results.

The extreme effects of turbidity on the activity of pydrin probably preclude the use of that chemical in fish-population control. Inasmuch as Salicylanilide I was affected less than other chemicals by clay, it continues to be a viable candidate for use in turbid water.

The compensation factor values obtained in these laboratory tests are probably not directly applicable to field situations. Many variables are present in the field, any one of which may exert a different influence alone than when combined with other variables. The data presented here accentuate the importance of on-site toxicity tests to determine effective concentrations of piscicides.

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ERRATA

On page 69 of Vol. 2, No. 1, the two maps in Fig. 1 were inadvertently reversed. David Combs, co-author of the Combs and Peltz paper entitled "Seasonal Distribution of Striped Bass in Keystone Reservoir, Oklahoma" pointed out that, because of the error, the caption for Fig. 1 should read: "Spring (right) and summer (left) locations of tagged striped bass in Keystone Reservoir." Those who read the article carefully would discover the error but it could be confusing to someone skimming through the paper.