Bull. Environ. Contam. Toxicol. (1987) 39:245-250

Bulletin of Environmental Contamination and Toxicology

Short-Term Effects of Propanil on Oxygen Production by Plankton Communities from Catfish Ponds

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The commercial pond culture of channel catfish Ictalurus punctatus has become an important agricultural enterprise in Mississippi. Many catfish ponds are adjacent to land used to culture rice Oryza sativa. Rice cultural practices normally do not interfere with catfish production. However, pesticides usually are applied to this crop by airplane and these chemicals may drift over nearby catfish ponds.

During the spring and early summer of 1985 and 1986, several commercial catfish producers in west-central Mississippi suspected that drift of the herbicide propanil [N-(3,4-dichlorophenyl) propanamide] from spraying operations over nearby rice fields caused depletion of dissolved oxygen in fish ponds during the night or early morning after spraying. Presumably, these oxygen depletions were caused by decreased photosynthetic oxygen production by the pond phytoplankton community or by increased plankton community respiration. The claims that propanil drift caused these depletions could not be substantiated because the effect of propanil on net oxygen production by phytoplankton is unknown and the amount of herbicide reaching the ponds was not quantified.

This study was undertaken to describe the short-term effects of propanil on net oxygen production by plankton communities from catfish ponds. Such information should assist extension service and state regulatory personnel in assessing the significance of propanil drift into catfish ponds.

MATERIALS AND METHODS

Samples of water were collected during June and July 1986, from 11 experimental channel catfish culture ponds on the Delta Branch Experiment Station, near Stoneville, Mississippi. For each of the 11 trials, about 15 L of water was collected from the pond and transported to the laboratory. The water sample was then siphoned into 14 300-mL BOD bottles allowing water to overflow at least two volume-turnovers in each bottle. The initial dissolved oxygen

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concentration was determined in two randomly selected bottles using a YSI Model 58 polarographic oxygen meter equipped with a BOD bottle probe. The remaining 12 bottles were treated in duplicate with six propanil concentrations. Propanil was obtained as a commercial product (Stam®, Rohm and Haas, Philadelphia, Pennsylvania, USA) and diluted in N,N-dimethylformamide (DMF). Results of preliminary tests indicated that DMF in concentrations up to 500 µL/L did not affect net oxygen production or respiration rates of plankton communities. Six working solutions of Stam® in DMF were formulated such that when 100 µL of the appropriate solution was added to the water sample in a BOD bottle, the nominal propanil concentrations were 0, 10, 20, 40, 80, or 160 µg/L. Immediately after adding the propanil, bottles were sealed, returned to the pond, and incubated at a depth (to mid-bottle) of 15 cm. Bottles were incubated for 3h (0700 to 1000h CST) and then dissolved oxygen concentrations were determined as above. All trials were carried out on cloudless days. Water temperature at 15 cm depth was measured immediately before and after incubation and reported as the average of these measurements. Chlorophyll _a_ concentrations for the 11 samples were determined in duplicate by spectrophotometry after extraction into chloroform-methanol (Wood 1985).

Nominal effective concentrations of propanil estimated to cause a 25% (EC25), 50% (EC50), or 75% (EC75) reduction in net oxygen production over the 3-h incubation period were calculated using the Statistical Analysis System probit procedure (SAS, 1982). The "no observed effect concentration" (NOEC) was determined using Dunnett's procedure and a 5% level of significance. The NOEC is the highest propanil concentration tested in each trial that resulted in no significant difference from the control in net oxygen production (Gelber et al. 1985).

RESULTS AND DISCUSSION

Propanil was a potent inhibitor of photosynthetic oxygen production. A typical dose-response curve is given in Figure 1. The 3-h EC50 values for the 11 communities tested ranged from 51 to 109 µg propanil/L (Table 1). Propanil concentrations from 24 to 54 µg/L were estimated to cause a 25% reduction in oxygen production and the no observed effect concentrations were 10 µg/L or less for all but two of the samples tested (Samples 2 and 10; Table 1).

In preliminary tests, six series of samples (Samples 1, 2, 3, 5, 6, and 10; Table 1) were incubated in the dark for 6h at 25°C. Propanil concentrations up to 160 µg/L did not significantly affect oxygen consumption by community respiration. Thus, the observed decreases in net community oxygen production caused by propanil are the result of inhibition of photosynthetic oxygen production rather than increased community respiration.

Although samples from only 11 ponds were tested, the relative effect of propanil on oxygen production appears to be independent

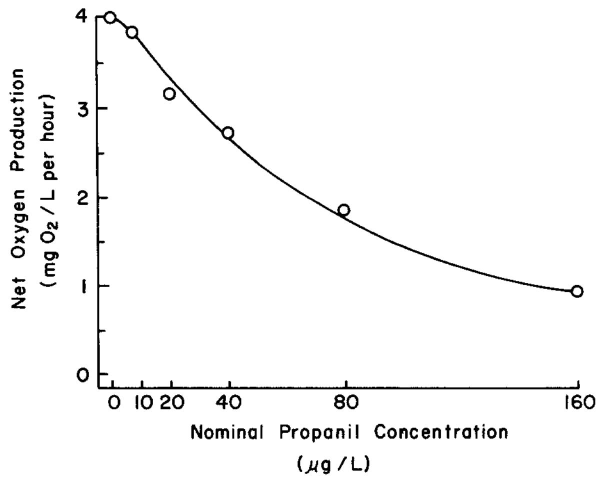

Figure 1. A typical dose-response curve describing the effect of propanil on net oxygen production. The phytoplankton community predominantly consisted of Lyngbya and Closterium (Sample 7, from Table 1).

of the general taxonomic composition of the phytoplankton community. Samples 1-5 contained communities of diatoms (Bacillariophyceae) or mixed assemblages of diatoms and green algae (Chlorophyta), whereas samples 6-11 were communities dominated by blue-green algae (Cyanobacteria). Nevertheless, the EC50 values for these communities were similar, ranging from 51 to 109 μg/L and 52 to 100 μg/L, respectively. The relative effect of propanil on oxygen production was also not related to community density since no significant correlation ($r = 0.008$, $P>0.1$) was found between phytoplankton density (as estimated by chlorophyll a concentration) and EC50 values.

The effect of propanil on phytoplankton photosynthesis is probably short-lived because propanil is rapidly metabolized by aquatic microorganisms (Dahchour et al. 1986). However, during the first day or two after contamination, even low concentrations of propanil (50 μg/L or less) could have profoundly adverse effects on dissolved oxygen dynamics in catfish ponds. Commercial catfish culture ponds usually have dense phytoplankton blooms and dissolved oxygen concentrations reach high levels (10-15 mg/L) during afternoons, but may fall to critically low levels (2-4 mg/L or less) during the night (Tucker and Boyd 1985). Even a modest inhibition of photosynthesis could cause an unexpected depletion of dissolved oxygen and fish death. This problem will be exacerbated during periods of cloudy weather when rates of gross photosynthesis already are lower than usual.

Although low concentrations (20-50 μg/L) of propanil can cause significant reductions in oxygen production, a substantial amount

Table 1. Highest no observed effect concentration (NOEC) and three-hour EC-values for propanil applied to phytoplankton communities from channel catfish culture ponds. Upper and lower 95% fiducial limits are given in parentheses. Chl a = Chlorophyll *a*.

Sample	Temp (°C)	Propanil concentration (μg/L) NOEC	EC25	EC50	EC75	Chl a (μg/L)	Predominant phytoplankton
1	27	10	25(23-28)	51(46-56)	101(90-117)	70	*Trachelomonas*, pennate diatoms
2	28	20	54(49-61)	109(98-129)	220(186-271)	270	*Closterium*, *Melosira*, pennate diatoms
3	26	0	36(32-41)	82(73-93)	184(155-227)	270	*Melosira*, pennate diatoms
4	29	10	28(24-31)	58(53-64)	122(107-143)	370	*Cryptomonas*, *Melosira*, Chlorophyta species
5	26	10	37(32-41)	92(80-107)	230(187-302)	630	*Closterium*, mixed Chlorophyta species
6	29	0	27(24-30)	59(54-66)	130(113-155)	130	*Oscillatoria*, *Melosira*
7	28	10	28(24-32)	72(63-83)	184(151-234)	260	*Lyngbya*, *Closterium*
8	28	0	26(22-30)	64(56-72)	156(131-193)	290	*Oscillatoria*, *Melosira*, centric diatoms
9	32	10	38(33-42)	87(77-100)	203(168-255)	310	*Rhaphidiopsis*
10	29	20	47(41-52)	100(89-115)	216(181-270)	450	*Microcystis*
11	29	10	24(22-28)	52(47-57)	108(95-126)	990	*Anabaena*

of the commercial product is required to achieve these concentrations because drift would be significantly diluted upon entering catfish pond water. For example, a typical catfish culture pond has a surface area of about 7 ha with an average depth of about 1 m. To realize a concentration of 25 μg propanil/L, a total of 1.75 kg of propanil must enter the pond. It is unlikely that this amount of drift will reach a pond except under unusual conditions.

Assuming there is evidence that propanil has entered a pond, proving that inadvertent drift caused an oxygen depletion will be difficult. As noted previously, propanil rapidly decomposes in aquatic environments, and samples collected and analyzed just hours after pond contamination may not accurately indicate the amount of propanil that entered the pond. Further, episodes of low dissolved oxygen concentrations are common in catfish ponds during the warmer months and it will be difficult to unequivocally attribute an isolated episode to inadvertent contamination.

The 96-h LC50 of propanil to channel catfish is about 6 mg/L (Wellborn et al. 1984). Thus propanil is only moderately toxic to the fish. However, this study has shown that propanil is a potent inhibitor of phytoplankton photosynthesis. Aerial applicators and catfish farmers near rice fields should be aware of the possibility that propanil can cause catastrophic losses of catfish through the indirect effects of the chemical on the dissolved oxygen status of the pond. Rice farmers and aerial applicators should notify owners of catfish ponds adjacent to fields that are to be sprayed and take steps to minimize drift into ponds. Catfish producers should carefully monitor dissolved oxygen concentrations in ponds suspected of receiving drift and be prepared to mechanically aerate affected ponds.

Acknowledgments. I thank Steven Lloyd and Judy Norwood for the statistical analyses. This material is based on work supported in part by the United States Department of Agriculture under Agreement No. 84-CSRS-2-2363. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the Mississippi Agricultural and Forestry Experiment Station and does not imply its approval to the exclusion of other products that may also be suitable.

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Received January 20, 1987; accepted April 22, 1987.