Journal of Fisheries & Livestock Production
ISSN: 2332-2608
Edziyie and Perschbacher, J Fisheries Livest Prod 2017, 5:2
DOI: 10.4172/2332-2608.1000230
Research Article Open Access

A Study on the Effects of Propanil on the Water Quality and Plankton Communities of Channel Catfish (*Ictalurus punctatus*) Pond Systems With and Without a Floating Algal Scum

Edziyie R[1]* and Perschbacher P[2]

[1]*Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*
[2]*Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, Pine Bluff, AR, USA*

Abstract

A study was conducted to compare channel catfish system water quality and plankton communities with and without a surface algal scum when exposed to various levels of propanil. The system with the scum suffered greater negative impacts than the system without scum. Other crop herbicides shown to impact phytoplankton, such as diuron, should also be investigated and are assumed to have greater effect on ponds with an algal scum.

Keywords: Propanil; Scum; Water quality; Phytoplankton; Microalgae

Introduction

Microalgae are beneficial to pond aquaculture: In moderate concentrations (250-500 μ/L chlorophyll *a*) they provide oxygen, utilize harmful ammonia and nitrites, improve discharge effluent through removal of nitrogen and phosphorus, and provide additional food sources [1]. Levels in excess of moderate concentrations can be harmful by reducing oxygen levels in respiration during the night, and through die-offs that rapidly lead to increased ammonia and nitrite levels. Blue-green algae (cyanobacteria) may also produce compounds that are passively absorbed and cause off-flavors in aquatic cultured organisms, such as fish and shrimp, and toxins that could affect consumers of the cultured products. Cyanobacterial in addition to releasing off-flavors and toxins, are prone to boom and bust cycles which typically include a surface scum phase (masses of floating phytoplankton). Scum formation is an indication of eutrophication and usually results in increased pH in aquatic systems and is a mechanism for domination of the cyanobacteria [2]. Only a few bluegreen (cyanobacteria) genera, mainly *Anabaena* and *Anacystis* (*Microcystis*), cause surface scums.

Propanil is an herbicide (3,4-dichloroaniline) used in rice culture to control many weeds by disrupting photosynthesis. As rice is grown in areas suitable for aquaculture (level land, clay soils, abundant water), application of propanil could drift or runoff into aquaculture ponds. Propanil is not toxic to fish at levels used on crop farms, but could impact plants and algae in fish ponds [3].

We looked at two ponds from one aquaculture pond system, channel catfish (*Ictalurus punctatus*), that differed by being with and without scum. Our previous work indicated impacts from propanil contamination depended on the level of chlorophyll *a*, with the greatest negative impacts in the mid-range (200 μ/L), as is typical of channel catfish systems [4]. However, these systems did not have a scum. We wanted to determine if water quality and plankton impacts from propanil differed between similarly-managed aquaculture ponds varying in dominant phytoplankton, including scum-formers. We also wanted to determine the impacts of different levels of propanil to these systems. Perschbacher et al. [5] found statistically significant propanil impacts occur at high levels, but not at lower levels found from drift projections (10% of application rate to rice fields) to channel catfish ponds, that mainly range from 6-8 ha in the Mississippi Alluvial Plain (Delta) of SE United States.

Methods

A trial was conducted between June and July using the outdoor plankton mesocosm facility (Figure 1) at the University of Arkansas at Pine Bluff (UAPB) Aquaculture Research Station and 500-L fiberglass mesocosms with a depth of 0.7 m. Water from 0.1 ha ponds with established fish and plankton communities was pumped into the mesocosms the day of each trial. The two ponds used were both channel catfish (*Ictalurus punctatus*) in industry standard stocking and management, without and with a surface algal scum. Water for all ponds was well water of hardness and alkalinity of 100-125 mg/L. Initial chlorophyll a levels were 160 μg/L in the channel catfish pond without scum and 244 μ/L in the catfish pond with scum. Phytoplankton were dominated by cyanobacteria in both, with *Oscillatoria* dominating

Figure 1: Mesocosm facility at UAPB Aquaculture Research Station.

***Corresponding author:** Edziyie R, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Tel: +233 32 206 0438; E-mail: reedziyie.fmr@knust.edu.gh

Received March 30, 2017; **Accepted** April 03, 2017; **Published** April 10, 2017

Citation: Edziyie R, Perschbacher P (2017) A Study on the Effects of Propanil on the Water Quality and Plankton Communities of Channel Catfish (*Ictalurus punctatus*) Pond Systems With and Without a Floating Algal Scum. J Fisheries Livest Prod 5: 230 doi: 10.4172/2332-2608.1000230

without scum and *Anabaena and Anacystis* dominating with scum. *Oscillatoria* is a filamentous cyanobacterium rarely forming scums, and *Anabaena* and *Anacystis* (especially *A. cyanea*, also known as *Microcystis cyanea*) *are* colonial coccoid cyanobacteria noted for forming scums. Propanil treatments were applied in triplicate to mesocosms (no substrate or fish) and based on surface area of the mesocosms were: control, 0.2, 0.4, 0.6, and full field rate of 4.5 kg/ha active ingredient.

Water quality monitoring of mesocosms consisted of: dissolved oxygen (D.O.), temperature, and pH using an Aquacheck Water Analyzer, total ammonia-nitrogen (TAN) using the Nessler method, and nitrite-nitrogen (NO_2-N). Unionized ammonia (UIA) was subsequently calculated. Measurements and water samples were taken with a water column sampler at approximately 0900 h the day before propanil was added and then at 24, 48, 72 h post application and longer until the mesocosms had recovered from the propanil treatment (judged by no significant differences with the control).

At similar intervals, phytoplankton and zooplankton water column samples were taken and analyzed following Perschbacher et al. [5,6]. APHA [7] was followed for a two-hour light and dark bottle primary productivity and respiration determination, and chlorophyll *a* modified to use ethanol as a solvent. Statistical analysis of each variable was by one-way ANOVA using SAS programs. LSD tests separated means at the 0.05 significance level.

Results

Few differences in the variables were seen prior to propanil addition, and those significantly different prior to propanil addition were not used. And although there were some similarities in the effects of the propanil on the ecosystem variables, the responses of the channel catfish pond systems with and without algal scum were quite different (Tables 1 and 2).

Variable	Time (h)	Control	0.2	0.4	0.6	Full
D.O. (mg/L	24	12.50a	10.20b	9.50bc	9.30c	8.70c
	48	12.70a	10.83b	9.67c	9.00d	8.03e
	72	12.30a	11.50b	10.07c	9.30d	7.50e
	96	11.30a	11.80a	10.90a	9.80b	8.20c
pH	24	10.11a	9.89a	9.91a	9.52b	9.86a
	48	10.41a	10.30ab	10.21b	10.06c	9.95c
	72	10.37a	10.31ab	10.25b	10.12c	9.88d
	96	9.62a	9.63a	0.54ab	9.50b	9.19c
TAN (mg/L)	24	0.18a	0.19a	0.17a	0.18a	0.17a
	48	0.19a	0.18ab	0.17ab	0.16b	0.19a
	72	0.20a	0.19a	0.19a	0.19a	0.19a
	96	0.16a	0.18a	0.16a	0.17a	0.17a
P.P (mgO_2/L/h)	24	0.46a	0.45a	0.41a	0.40a	0.40a
	48	0.21a	0.47b	0.34c	0.35ac	0.21a
	72	0.49a	0.44a	0.38a	0.37a	0.34a
	96	0.74a	0.75a	0.61ab	0.52b	0.35b
Chl. *a* (µg/L)	24	160a	152a	152a	148a	156a
	48	84a	129b	136b	125b	139b
	72	62a	71a	95ab	87a	135b
	96	44a	75a	75a	76b	80b
Respiration (mgO_2/L/h)	24	1.86a	1.66a	1.33b	1.12b	0.85b
	48	0.88a	1.06a	0.97a	0.88a	0.69a
UIA (mg/L)	24	0.152a	0.148a	0.135a	0.108a	0.154a
	48	0.162a	0.146a	0.148a	0.133a	0.154a
	72	0.174a	0.185a	0.169a	0.166a	0.149a
	96	0.111a	0.123a	0.100a	0.102a	0.074a

Table 1: Summary of ANOVA and LSD analyses on the effect of propanil on channel catfish pond system without algal scum.

Row means with different letters are significantly different (p=0.05).

Variable	Time (h)	Control	0.2	0.4	0.6	Full
D.O. (mg/L)	24	18.45a	13.33b	12.20c	12.20c	11.07d
	48	18.77a	13.13b	10.60c	9.50d	7.50e
	72	19.00a	12.87b	9.57c	9.50c	5.50d
	96	16.39a	13.00b	9.81bc	9.87bc	7.43c
	120	16.51a	15.73a	11.77b	13.04b	11.04b
pH	24	10.50a	10.08b	10.02b	9.99b	9.88c
	48	10.92a	10.38b	10.09c	9.86c	9.56c
	72	11.26a	10.64b	10.21bc	9.97c	9.13d
	96	11.41a	10.88ab	10.45b	10.22c	9.62c
	144	11.41a	11.22b	10.96c	10.92c	10.57d
TAN (mg/L)	24	0.18a	0.16a	0.19a	0.15a	0.17a
	48	0.16a	0.17a	0.19a	0.21a	0.31b
	72	0.14a	0.17a	0.19a	0.33b	0.51b
P.P. (mgO_2/h/L)	24	1.98a	1.26b	0.94c	0.62d	0.40d
	48	2.71a	1.27b	0.86bc	0.84bc	0.32d
	72	1.49a	1.21a	1.05a	0.70a	0.60a
	168	1.04a	2.15b	1.05a	0.60a	0.78a
Chl. *a* (µg/L)	24	244a	271a	306a	268a	220a
	48	338a	307a	264a	254a	203a
	72	384a	311b	270b	180bc	97c
	168	107ab	196a	61b	45b	25b
Resp. (mgO_2/L/h)	24	0.78a	0.61ab	0.67ab	0.50b	0.47b
	48	1.00a	1.31a	1.55a	1.23a	1.21a
UIA (mg/L)	24	0.171a	0.145a	0.169a	0.132a	0.144a
	48	0.161a	0.160a	0.167a	0.172a	0.225a
	72	0.142a	0.162a	0.172a	0.218a	0.261a
	96	0.164a	0.182a	0.176a	0.189a	0.207a

Table 2: Summary of ANOVA and LSD analyses on the effect of propanil on channel catfish pond system with algal scum.

Row means with different letters are significantly different (p=0.05).

Channel catfish system without algal scum D.O. was slightly depressed at all levels from 24-96 h, and then at all but the lowest levels at 96 h (Table 1). The pH was lower above the lowest concentration to at least 96 h Tan showed title effect. Primary productivity was higher at 48 and then lower at 96 h by up to ½ at all levels above the lowest. Respiration was depressed at 24 h above the lowest level and then higher in relation to concentration (by ½ at full). Chlorophyll a levels were elevated at 48 h in all levels by 1.5-1.65 in relation to concentration.

UIA showed little significant differences. Plankton was slightly impacted, but retained control conditions with the exception of the addition of some larger green (Chlorophyta) genera. Zooplankton were not affected, but were higher in the controls than the units with scum. Nitrite levels were little changed and not included in the table. Channel catfish system with algal scum (Table 2).

DO was depressed at all levels until 120 h. The pH was also reduced until at least 144 h. TAN was only higher at higher levels for 72 h. Primary productivity was reduced at all levels until 72 h, then increased at 168 h at the lowest level. Respiration was briefly inhibited at 24 h. Chlorophyll a levels were decreased to 72 h by about half, but increased by 2X at the lowest level. UIA levels were unchanged. Plankton was impacted by decreases in the dominant cyanobacteria and increases in green algae. Zooplankton were not affected, but were substantially lower in controls compared to the no scum condition. Nitrate was not listed in the table as slight differences were seen.

Discussion

D.O. Scum conditions resulted in lower oxygen concentrations at all propanil levels for 120 h. No scum conditions also resulted in an oxygen depression, but for only 24-96 h. There was a much slower recovery in oxygen levels for scum treatments compared to the treatments with no scum so that by 120 h only the scum treatments that received 0.2 propanil rate can recovered. The low oxygen levels measured in this study are consistent with findings from Boyd and Tucker [1] who mentioned that ponds with high algal biomass have wide swings in DO levels and usually experience phytoplankton die-offs that result in low oxygen levels. Work done by Hofstra and Switzer [8] also show that propanil inhibits photosynthesis and affects oxygen uptake in plants.

pH: Scum conditions reduced pH for 48 h at all levels. Non-scum conditions did not see a change in the lowest propanil level.

TAN: Scum conditions were similar to non-scum conditions and little affected. However, scum resulted in elevation of TAN at higher levels to 72 h.

Primary productivity: Scum conditions exhibited a lowering at levels to 72 h, then an increase at 168 h at the lowest propanil level. Non scum conditions resulted in an increase at 48 h, but then a decrease by up to one half compared to the control at all levels above the lowest at 96 h.

Respiration: In the scum condition, it was depressed briefly at the full treatment. In contrast in the no scum condition it was depressed at 24 h above the lowest propanil concentration in relation to propanil concentration (one half at full). Tucker [9] found no effect of propanil on respiration, however, he used a 3 h test in smaller containers in indoor conditions.

Chlorophyll *a*.: Scum conditions resulted in a decrease by up to 1/2 at 72 h, then an increase by a factor of 2 at the lowest level. No scum treatment was elevated at 48 h by 1.5-1.65 in relation to propanil concentration applied. This unexpected positive effect was also seen by Perschbacher et al. [6] with propanil. Increases in chlorophyll a levels were, however associated with changes in phytoplankton numbers and composition, as observed in both treatments. A change in composition in favor of green phytoplankton is likely to result in higher chlorophyll a levels as these contain relatively higher levels of chlorophyll a levels compared to blue-greens. Work done by Vincent [10] using the fluorescence method for chlorophyll a determination, showed that changes in concentration of photosynthetic pigments cannot simply be attributed to shifts in photosynthetic capacity but that there is a need to consider the relative proportion of species present. Felip and Catalan [11] also show that for the same biovolume of phytoplankton, the chlorophyll a content differed greatly due to light intensity, temperature and phytoplankton composition.

UIA: In both conditions little change was noted. However, non-statistically significant increases were seen in relation to propanil concentrations in the scum condition after 24 h.

Phytoplankton: Impacts were greater in the scum condition. *Anabaena* and *Anacystis* were lower in most treatments and smaller green algae genera such as *Scenedesmus* increased. The scum changed color from green to yellow to brown (death or crash phase) and finally to clear conditions in the full treatment. Boyd and Tucker [1] mention that usually the phytoplankton communities after a die-off are more diverse and an increase in green algae is a positive development as green phytoplankton as considered as better oxygenators than the blue-green algae. The no scum condition saw little effect on the dominant cyanobacterium *Oscillatoria*, and increases in large green species such as Pediastrum, as well as smaller green species.

Zooplankton: Zooplankton in the scum and no scum condition did not change. However, control concentrations were substantially higher in all groups compared to the scum condition.

Conclusions

The algal scum in the channel catfish system resulted in greater negative effects from propanil contact. The surface floating algae may have had greater contact and for a longer period of time than algae in suspension. Several authors have suggested that algae would change pesticide impacts due to the uptake of the pesticide by the algae (12-14). Also, cyanobacteria in a floating stage are susceptible to die-offs and at the end stage of the boom and bust cycling typical of certain genera at high algal concentration. Although no stressful conditions to cultured species were observed in either scum or no scum conditions, the very favorable initial levels in all parameters are misleading. For example, if the D.O. was 6 mg/L in the scum condition to start rather than 12.5 mg/L, at 48 h in the higher propanil treatments the D.O. would be halved or 3 mg/L which would be stressful. UIA is another major stressor, toxic at all levels, and the doubling (although not significant statistically) in the higher propanil treatments in the scum condition to over 0.2 mg/L is problematic. The crash in the scum condition most probably caused the worsened levels of most parameters, and was mild for a crash.

Not all impacts were negative. High pH, which typically occurs in very rich aquaculture pond water, shifts the proportion of TAN (combined unionized and ionized ammonia) toward toxic UIA (unionized ammonia). Propanil led to reduced pH levels from lowered primary productivity. Propanil also produced a shift in the algal community from cyanobacteria to green algae [15]. As mentioned in the introduction, cyanobacteria of surface scum forming genera are undesirable, often leading to boom and crash cycles, off-flavors and odors, and possible toxins.

Aquaculture ponds in rice-growing regions may be exposed to propanil at low levels (0.1 mg/L, equivalent to the 0.2 treatment in this study) from drift or runoff. Other row crop herbicides shown to be of concern are diuron typically used in cotton production and atrazine for corn [16,17]. Significantly, when the water body experiences algal scums, greater negative effects may be observed from these herbicides. Of most concern would be lowered dissolved oxygen in the ponds. Careful monitoring of ponds exposed to these herbicides for several days will be advisable.

Acknowledgements

Our sincere gratitude to IFAFS, CSREES, AFC, and UAPB for their financial and other support provided for this project. We are greatly indebted to Dr. Gerald Ludwig and Dr. Andrew Goodwin for their support and advice.

References

1. Boyd, Claude E, Tucker CS (1998) Pond aquaculture and water quality management. Kluwer, MA.
2. Paerl HW, Ustach JF (1982) Blue-green algal scums: an explanation for their occurrence during freshwater blooms. Limnology and oceanography 27: 212-217.
3. Leboulanger C, Rimet F, Lacotte MH, Berard A (2001) Effects of atrazine and nicosulfuron on freshwater microalgae. Environment International 26: 131-135.
4. Edziyie R, Perschbacher P (2010) Mesocosm studies on the effect of propanil on the water quality and plankton communities in four species' pond systems. Journal of Fisheries and Livestock Production.
5. Perschbacher P, Stone N, Ludwig G, Guy C (1997) Evaluation of the effects of common aerially-applied soybean herbicides and propanil on the plankton communities of aquaculture ponds. Aquaculture 157: 117-122.
6. Perschbacher P, Ludwig G, Slaton N (2002) Effects of common aerially-applied rice herbicides on the plankton communities of aquaculture ponds. Aquaculture 214: 241-246.

7. American Public Health Association (1995) Standard methods for the examination of water and wastewater. (19th edn.), American Public Health Association,Washington.

8. Hofstra G, Switzer CM (1968) The phytotoxicity of propanil. Weed Science 16: 23-28.

9. Tucker CS (1987) Short-term effects of propanil on oxygen production by plankton communities from catfish pond. Bulletin of Environmental Contamination and Toxicology 39: 245-250.

10. Vincent WF (1983) Fluorescence properties of the freshwater phytoplankton: three algal classes compared. British Phycological Journal 18: 5-21.

11. Felip M, Catalan J (2000) The relationship between phytoplankton biovolume and chlorophyll in a deep oligotrophic lake: decoupling in their spatial and temporal maxima. Journal of Plankton Research 22: 91-106.

12. Day K, Kaushik BV (1987) The absorption of fenvalerate to laboratory glassware and the alga Chlamydomonas reinhardtii and its effects on uptake of the pesticide by Daphnia galeata mendotae. Aquatic Toxicology 10:131-142.

13. Waiser MJ, Roberts RD (1997) Impacts of herbicide and fertilizer on the microbial community of a saline prairie lake. Canadian Journal of Fisheries and Aquatic Science 54: 320-329.

14. Edziyie R (2004) The effect of propanil on five pond plankton communities. University of Arkansas at Pine Bluff, Pine Bluff, AR.

15. Stampfli NC, Knillmann S, Matthias B, Beketov MA (2011) Environmental context determines community sensitivity of freshwater zooplankton to a pesticide. Aquatic Toxicology 104: 116-120.

16. Perschbacher P, Ludwig G (2004) Effects of diuron and other aerially-applied cotton herbicides on the plankton communities of aquaculture ponds. Aquaculture 233: 197-203.

17. Perschbacher P, Ludwig G, Edziyie R (2008) Effects of atrazine drift on production pond plankton communities and water quality using experimental mesocosms. Journal of the World Aquaculture Society 39:126-130.