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Potential Impact of Herbicide Overspray on Phytoplankton Blooms in Arkansas Ponds

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A common inquiry from pond owners is what impact a mistaken herbicide application might have on their fish. These calls frequently come following a fish kill that has occurred after a suspected herbicide overspray from a neighboring agricultural field. With few exceptions, the most commonly used row crop herbicides are harmless to fish. What is often then asked is whether the herbicides could have negatively impacted the phytoplankton bloom, leading to a fish kill due to low dissolved oxygen. The answer to this is a little more complicated.

An exercise was conducted to determine the potential risk to a common green alga from the accidental application of the most commonly used row crop (soybean, rice, cotton, corn) herbicides[1].

Image courtesy of Rick Wimberley

Glyphosate (Envy)
Imazathapyr (Pursuit)
Cyhalofop (Clincher SF)
Glufosinate (Cheetah)
Bispyribac sodium (Regiment)
Atrazine (AAtrex 4L)
Dimethenamid-p (Outlook)
Penidmethalin (Prowl 3.3 EC)
Clomazone (Command 3ME)
Propanil Propanil 4EC)
Fenoxaprop-p-ethyl (Ricestar HT)
Flumioxazin (Chateau)
Paraquat (Gramoxone SL 2.0)
Pyroxasulfone (Zidua)
2,4-D (Weed Rhap A-4D)
Quinclorac (Facet L)
Thiobencard (Bolerao 8 EC)
Metolachlor (Helmet)
Florpyrauxifen-benzyl (Loyant)
Fomesafan (Sinister)
Saflufenacil (Sharpen)
Acetochlor (Breakfree NXT)
Halosulfuron-methyl (Herbivore)
Dicamba (Vision)

Table 1. The most commonly used row crop herbicide active ingredients (example brand names in parentheses). The list was compiled through personal communication with University of Arkansas Cooperative Extension Service weed scientists.

Using the sample labels chosen, the maximum application rate was determined and then the amount of active ingredient (AI) applied was calculated in parts per million (ppm). It was assumed that the maximum legal, single application rate was applied evenly to a pond one foot deep. While most ponds are obviously deeper, an assumption was made that most of the algae that might be negatively impacted by an accidental application would be within the upper foot of the pond. For previous exercises of this kind, a water column of three feet deep has been typically assumed.

The formula used for liquid herbicide formulations to calculate the amount of active ingredient applied was:

(Lbs of AI per gallon x (max rate in OZ/128)) /2.72 = Max Rate Applied in ppm.

For herbicides in a powder form, the formula used was:
(Max rate in lbs/2.72) x (% AI/100) = Max Rate Applied in ppm.

After calculating the quantity of applied herbicide, a literature review was conducted to determine the EC50 of each active ingredient to a green alga, *Raphidocelis subcapitata* (formerly known as *Pseudokirchneriella subcapitita*) (Table 2). *R. subcapitata* is a green alga that

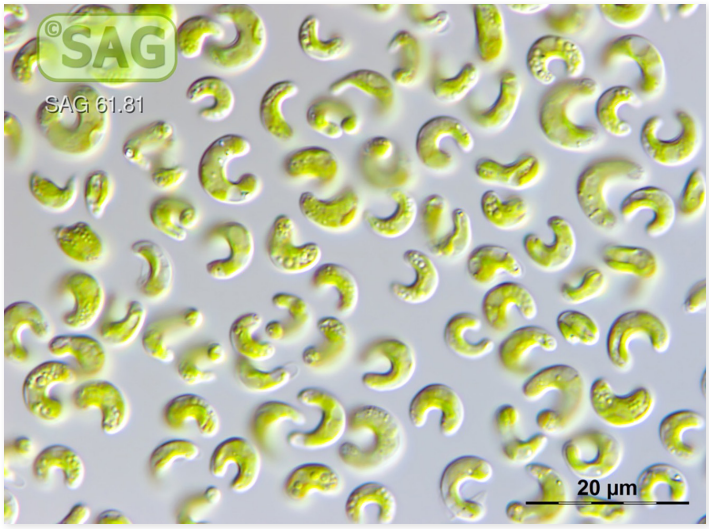

Image taken by M. Lorenz: 2016-02-25
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https://sagdb.uni-goettingen.de/detailedList.php?str_number=61.81

is commonly used as a representative alga in pesticide toxicity studies. The EC50 indicates the amount of active ingredient needed to reduce the growth of the algae by 50 percent when compared to a positive control sample in which chemical was not applied. These growth studies were typically conducted over a five-day period.

Table 2. The concentration of herbicide that causes an EC50 in the green algae, *R. subcapitata*, compared to the maximum amount of active ingredient that would be applied under maximum labeled rates. Also included is the fish LC50 for fish. Key for fish species tested is included.

Active Ingredient (Label)	Max Label Rate (oz/acre or lbs/acre	AI lbs/gal or %AI	Max Application Rate (ppm)	Green Algae EC50[2]	Fish Toxicity LC50 (ppm)[3]
2,4-D (Weed Rhap A-4D)	32 oz/acre	3.8 lbs/gal	0.3493	20.7	180 BG
Acetochlor (Breakfree NXT)	48 oz/acre	7 lbs/gal	0.9651	0.000143	1.6 BG
Atrazine (AAtrex 4L)	64 oz/acre	4 lbs/gal	0.7353	0.053	42 BG
Bispyribac-sodium (Regiment)	0.41875 lbs/acre	80%	0.0123	2.2	>100 BG
Clomazone (Command 3ME)	53.3 oz/acre	3 lbs.gal	0.4593	3.5	34 BG
Cyhalofop (Clincher SF)	15 oz/acre	2.38 lbs/gal	0.1025	78.2	0.76 BG
Dicamba (Vision)	32 oz/acre	3.8 lbs/gal	0.3493	3.7	135 BG
Dimethenamid-p (Outlook)	21 oz/acre	6 lbs/gal	0.3619	0.014	10 BG
Fenoxaprop-p-ethyl (Ricestar HT)	17 oz/acre	0.58 lbs/gal	0.0283	0.43	0.19 BG
Florpyrauxifen-benzyl (Loyant)	16 oz/acre	0.21 lbs/gal	0.0097	3.76	>120 C
Flumioxazin (Chateau)	0.75 lbs/acre	51%	0.1406	0.00102	21 BG
Fomesafen (Sinister)	16.8 oz/acre	2.87 lbs/gal	0.1385	0.17	99.5 FHM
Glufosinate (Cheetah)	29 oz/acre	2.34 lbs/gal	0.1949	7.9	75 BG
Glyphosate (Envy)	32 oz/acre	4 lbs/gal	0.3676	12.54	5.8 BG
Halosulfuron-methyl (Herbivore)	0.167 lbs/acre	75%	0.0460	4.1	>118 BG
Imazethapyr (Pursuit)	6 oz/acre	2 lbs/gal	0.0345	59	>110 BG
Metochlor (Helmet)	32 oz/acre	7.8 lbs/gal	0.7169	0.01	10 BG
Paraquat (Gramoxone SL 2.0)	64 oz/acre	2 lbs/gal	0.3676	0.32	13 BG
Pendimethalin (Prowl 3.3 EC)	76.8 oz/acre	3.3 lbs/gal	0.7279	5.4	0.199 BG
Propanil (Propanil 4EC)	192 oz/acre	4 lbs/gal	2.2059	0.029	0.43 CCF
Pyroxasulfone (Zidua)	4 oz/acre	0.85 lbs/gal	0.0098	0.00038	>1000 C
Quinclorac (Facet L)	43 oz/acre	1.5 lbs/gal	0.1853	100	>100 BG
Saflufenacil (Sharpen)	6 oz/acre	2.85 lbs/gal	0.0491	29	108 BG
Thiobencarb (Bolero 8 EC)	64 oz/acre	8 lbs/gal	1.4706	0.017	1.7 BG

BG- bluegill, FHM- fathead minnow, C- common carp, CCF- channel catfish

While the purpose of this publication is to explore the potential impact on a phytoplankton bloom from a misapplied herbicide, note that two of the active ingredients have the potential to harm fish. These active ingredients are pendimethalin and thiobencarb. A misapplication of pendimethalin under the outlined parameters would result in a pendimethalin concentration of 0.7279 ppm, with the same active ingredient possessing a LC50 for bluegill of 0.199 ppm. If a misapplication took place for this active ingredient, it could kill some fish in the affected pond. While the thiobencarb LC50 for channel catfish is slightly higher than the maximum application rate, it is close enough that there is not a safety factor. It should be noted algae have a great affinity for herbicides. They readily absorb herbicides which can decrease the exposure fish may experience.

The active ingredients where the maximum application rates are below the EC50 and are unlikely to have any appreciable impact on *R. subcapitata* and were not included in table 3. Those remaining are only those that might have a negative impact on the green algae if mistakenly applied to a pond at the maximum recommended application rate.

Active Ingredient (Label)	Max Rate Applied (ppm)	Green Algae EC50[2] (ppm)
Acetochlor (Breakfree NXT)	0.9651	0.000143
Atrazine (AAtrex 4L)	0.7353	0.053
Dimethenamid-p (Outlook)	0.3619	0.014
Flumioxazin (Chateau)	0.1406	0.00102
Fomesafen (Sinister)	0.1385	0.17
Metolachlor (Helmet)	0.7169	0.01
Paraquat (Gramoxone SL 2.0)	0.3676	0.32
Propanil (Propanil 4EC)	2.2059	0.029
Pyroxasulfone (Zidua)	0.0098	0.00038
Thiobencarb (Bolero 8 EC)	1.4706	0.017

Table 3. Active ingredients whose recommended maximum active ingredient application rate would exceed the EC50 concentration of *R. subcapitata*.

For clarity, the herbicides that might have a negative impact on a phytoplankton bloom are reordered by their ratio of maximum application rate to R. subcaptita EC50 (Table 4). The higher the number, the greater the negative impact could be.

At this point, it becomes a more difficult to connect an herbicide application to an actual phytoplankton bloom crash. From Table 4, it is apparent that some of the green algae EC50 concentrations are significantly lower than the maximum active ingredient application rate. For example, paraquat (Gramaxone) has an EC50 value of

Active Ingredient (Label)	Max Application Rate (ppm)	Green Algae EC50 (ppm)[2]	Max Rate: EC50 Ratio
Acetochlor (Breakfree NXT)	0.9651	0.000143	6749
Flumioxazin (Chateau)	0.1406	0.00102	137.8
Thiobencarb (Bolero 8 EC)	1.4706	0.017	86.5
Propanil (Propanil 4EC)	2.2059	0.029	76.07
Metolachlor (Helmet)	0.7169	0.01	71.69
Dimethenamid-p (Outlook)	0.3619	0.014	25.85
Pyroxasulfone (Zidua)	0.0098	0.00038	25.79
Atrazine (AAtrex 4L)	0.7353	0.053	13.9
Paraquat (Gramoxone SL 2.0)	0.3676	0.32	1.15
Fomesafen (Sinister)	0.1385	0.17	0.815

Table 4. Ratio of maximum application rate to *R. subcapitata* EC50.

0.32 ppm where the maximum application rate is slightly greater at 0.3676 ppm. It is likely that most accidental oversprays would only partially cover a pond, reducing the actual application rate to below 0.3676 ppm. Also, remember that the EC50 is not a measurement of the concentration where algae are killed, just the concentration where growth is suppressed by 50 percent.

For those herbicides in which the maximum active ingredient application rate is orders of magnitude higher than the *R. subcapitata* EC50, some comparison to registered algaecides (or herbicides with known algicidal properties) is useful (Table 5). The *R. subcapitata* EC50 value for acetochlor is more than 6700x lower than the maximum application concentration. When compared to the max rate: EC50 ratio value of 258 for copper sulfate, it seems probable that a misapplication of acetochlor to a pond could negatively impact the phytoplankton bloom.

Active Ingredient	Sample Label	Application Rate (ppm)	Green Algae EC50 (ppm)	Max Rate: EC50 Ratio
Copper	Copper sulfate	0.2-0.8 (as elemental copper)	0.0031	258
Hydrogen Peroxide	Pak27 (sodium carbonate peroxyhydrate)	0.3-1.7	0.18	9.44
Diuron	Diuron 80[4]	0.02	0.0024	8.33

Table 5. Application rate and *R. subcapitata* EC50 active ingredient concentration for EPA registered algaecides and herbicides with known algicidal properties.

Conclusion

It is undeniable that most farm pond fish kills are due to low dissolved oxygen events. Especially during the summer, phytoplankton are responsible for most of the dissolved oxygen present in ponds. Coincidentally, this is the time-period when water naturally holds less dissolved oxygen because of the temperature's effect on gas solubility. For the herbicide active ingredients listed in Table 3, especially acetochlor, it is conceivable that an overspray could negatively impact a pond's phytoplankton bloom, and therefore its dissolved oxygen concentrations. While it might be possible, it is unlikely that an accidental overspray of a pond with a common row crop herbicide will negatively impact the pond's phytoplankton population enough to cause a fish kill.

If you suspect that an overspray has occurred, contact the Arkansas State Plant Board at (501) 275-1598 and ask for the pesticide division. Consult FSA9601 Pesticide Spray Drift and Misuse Reporting Procedures for further information https://www.uaex.edu/publications/PDF/FSA-9601.pdf.

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[1]All labels are registered by the Arkansas State Plant Board for use in Arkansas. https://aad-web-ser.agri.arkansas.gov/.

[2]EC50s were determined by consulting PubChem, maintained by the National Center for Biotechnology Information. https://pubchem.ncbi.nlm.nih.gov/.

[3]LC50s were determined by consulting PubChem maintained by the National Center for Biotechnology Information or taken from the named herbicides Safety Data Sheet (SDS) https://pubchem.ncbi.nlm.nih.gov/.

[4]Diuron 80 is not labeled for aquatic use. The exception is a 24c, Special Local Needs label in Arkansas. The registrant is the Arkansas Bait and Ornamental Fish Grower Association, and its use is limited to ornamental and baitfish production ponds and cannot be used in ponds where the fish are destined for human consumption.

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