Recent research from Mississippi State University and the USDA Wildlife Services National Wildlife Research Center has confirmed what many researchers suspected early on regarding the role of fish-eating birds in spreading vAh (Jubirt et al. 2015, Cunningham et al. 2018). These studies revealed that when double-crested cormorants, wood storks, American white pelicans, and great egrets consume fish infected with vAh they can serve as a reservoir for this disease. Following consumption of vAh infected fish, these bird species shed viable vAh in their feces.

Since there is real potential for fish-eating birds to spread vAh from one pond to another (or one farm to another) during an outbreak, it is important for commercial producers to actively harass birds from ponds experiencing an outbreak. In many instances when there is a disease outbreak, the tendency is to not worry about harassing or lethally taking birds that are consuming fish that are sick or dying in the pond. Unfortunately, management of this problem at the farm level is not easy. Further field studies evaluating the transmission of this disease on commercial farms could help us better understand the dynamics of how vAh is spread.

Fig 1. Fish-eating birds on a catfish farm in Mississippi (photo credit: Dr. Les Torrans). Fish-eating birds will often congregate on the banks of ponds experiencing outbreaks of disease.

Further Reading:
Jubirt MM, Hanson LA, Hanson-Dorr KC, Ford L, Lemmons S, Fioranelli P, Cunningham FL. 2015. Potential for great egrets (*Ardea alba*) to transmit a virulent strain of *Aeromonas hydrophila* among channel catfish (*Ictalurus punctatus*) culture ponds. *Journal of Wildlife Diseases*. 51:634-639.
Cunningham FL, Jubirt MM, Hanson-Dorr KC, Ford L, Fioranelli P, Hanson LA. 2018. Potential of double-crested cormorants (*Phalacrocorax auritus*), American white pelicans (*Pelecanus erythrorhynchos*), and wood storks (*Mycteria Americana*) to transmit a hypervirulent strain of *Aeromonas hydrophila* between channel catfish culture ponds. *Journal of Wildlife Diseases*. 54(3):548-552.

Controlling blue-green algal blooms in aquaculture ponds using hydrogen peroxide

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Excessive blue-green algae (i.e., cyanobacteria) can harm aquatic organisms, including farmed fish. Although algal populations may be beneficial as they acquire excess nutrients, including potentially toxic forms such as nitrite and ammonia, and produce oxygen through photosynthesis, large algal blooms may lead to anoxia as decaying cells are decomposed by bacteria. In addition, some select strains of blue-green algae may produce chemicals that harm fish health (e.g., microcystins, nodularins) or cause fish filets to taste muddy (i.e., geosmin, 2-methylisoborneol). Both situations can cause significant economic losses to fish farmers around the world.

As our understanding of nuisance algal blooms continues to grow, so too do the means to combat these events. Developed methods can often be placed into the groupings of chemical, biological, and physical controls. Of these, chemical controls have been used to great effect; however, there is concern that some approved algaecides may persist in the environment for extended periods of time and, in certain situations, are too broad-spectrum in their toxicity to be practical. Consequently, alternative chemicals are actively being researched. And, although many algaecides exist, hydrogen peroxide (H_2O_2) has proved quite effective at reducing blue-green algae (Kay et al. 1982), and is currently an approved FDA aquaculture drug (FDA 2007). This contribution assesses the utility of H_2O_2 as an algaecide, its application rate, and other factors which may impede its effectiveness.

Hydrogen peroxide is an effective oxidizer, capable of reducing algal blooms. Moreover, as hydrogen peroxide breaks down to water and oxygen, it leaves behind no chemical residuals. Thus, it is considered a relatively environmental-friendly alternative to existing chemical treatment options. Research on the use of H_2O_2 in aquaculture indicates that it selectively reduces odor and toxin producing blue-green algae to low concentrations while having a negligible effect on beneficial types of algae (Fig. 1). A recent study describing a 7-day field mesocosm experiment conducted by the lab of Dr. Alan Wilson at Auburn University's School of Fisheries, Aquaculture, and Aquatic Sciences (http://wilsonlab.com/) indicated that a treatment of ~7 mg/L H_2O_2 immediately reduced cyanobacteria (measured as phycocyanin; Fig. 1B), yet caused a slight increase in other phytoplankton, including green algae (also called chlorophytes; measured as chlorophyll a, Figure 1A). Other studies have also shown that fast-growing green algae often quickly dominate algal communities following a H_2O_2 application (Drábková et al. 2007b, Sinha et al. 2018).

Recommended treatment rates for H_2O_2 vary in the literature. Barrington et al. (2011), who worked with wastewater effluent ponds that often contain high concentrations of organic matter (thus making them a good comparison to productive farm ponds), recommended using 1.1×10^{-4} g H_2O_2 per 1 µg/L of chlorophyll, equating to 44 mg/L H_2O_2 used in the experimental treatment. This study found large reductions in all phytoplankton (-70%), including blue-green algae (-57%). However, such a dosage is arguably too high to be applied to aquaculture ponds as chlorophyll values can exceed 370 µg/L during the growing season (Buley and Wilson; unpublished raw data), which would calculate to a very high dose of 41 mg/L H_2O_2. These concentrations may be too costly or have damaging effects on farmed fish, although short-term doses of H_2O_2 (50-1000 mg/L) are approved for use as a therapeutic treatment (Syndel 2018). Moreover, recent research has shown that much lower H_2O_2 concentrations will reduce algal blooms. For example, Matthjis et al. (2012) showed 2 mg/L H_2O_2 quickly reduced the abundance of blue-green algae by 99% after 7 weeks; however, there was a noticeable H_2O_2 effect on green algae. Finally, the previously mentioned experiment by Yang et al. (2018) showed that a ~7 mg/L H_2O_2 dose promoted a shift in the phytoplankton community of an aquaculture pond from blue-green algae to green algae and flagellated crytophytes.

Various environmental factors may influence the effectiveness of H_2O_2 against blue-green algae. For example, sunlight contains UV radiation that causes hydroxyl (OH) and hydroperoxyl (OOH) radical production (i.e., the main drivers of algal cell degradation). Drábková et al. (2007a) found a 10x difference in the deterioration abilities of H_2O_2 with and without

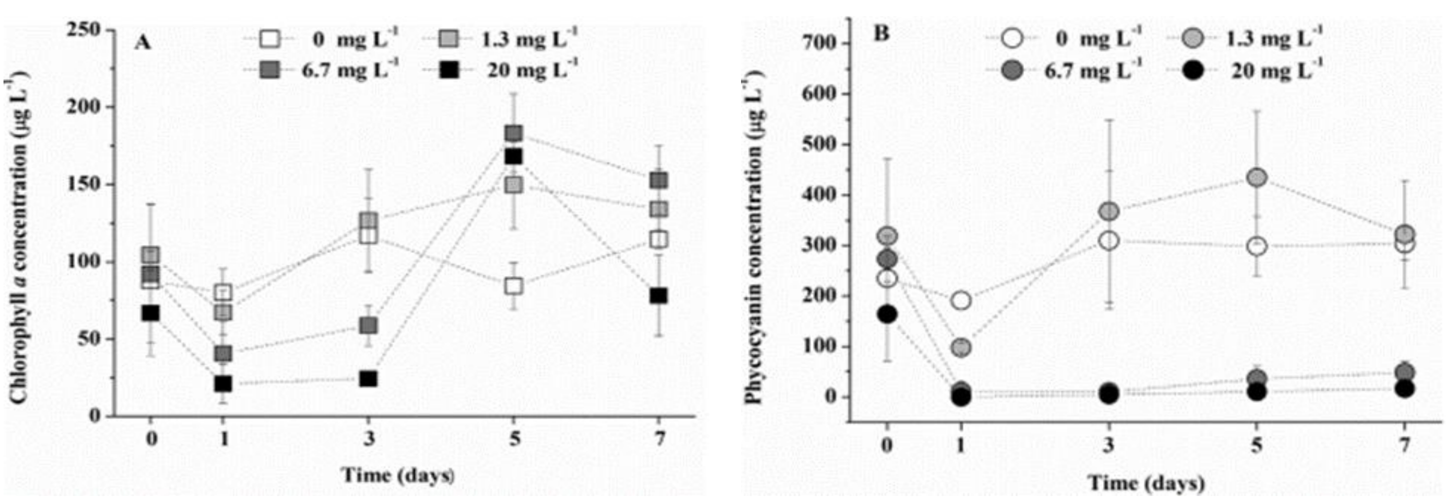

Figure 1. Concentrations of (A) phytoplankton (measured as chlorophyll *a*) and (B) blue-green algae (measured as phycocyanin) during a 7-day field, mesocosm study conducted at Auburn University that assessed various concentrations of hydrogen peroxide (data from Yang et al. 2018). Results are expressed as the daily treatment mean ± 1 standard deviation.

in the deterioration abilities of H_2O_2 with and without light. In addition, iron also facilitates radical production, and systems with high iron (specifically Fe^{II}) may need lower concentrations of H_2O_2 to achieve the same desired effect (Drábková et al. 2007a). Bloom resurgence may also occur, especially if H_2O_2 is applied at low doses (Matthijs et al. 2012). Repeated applications of H_2O_2 may be needed, but should done carefully as to not cause hypoxic conditions through the degradation of organic matter. Lastly, applying H_2O_2 or any other algaecide to treat blue-green algae may result in lysed compounds (e.g., toxins and off-flavor) into the water column. For instance, Yang et al. (2018) observed an increase in extracellular microcystin one day after treatment with a ~7 mg/L dose of H_2O_2, but found that microcystin concentrations reduced after a 7-day period. These and other factors should be taken into account before applying H_2O_2 to active production ponds.

Conclusions

Hydrogen peroxide has been shown to be a strong algaecide alternative in aquaculture given that it has been effective against blue-green algae and promoted beneficial phytoplankton taxa at relatively low concentrations. Based on prior studies (Yang et al. 2018), we suggest the use of a ~7 mg/L dose of H_2O_2 under high ambient sunlight to treat highly productive aquaculture ponds experiencing blooms of blue-green algae.

Further Reading

Barrington, D.J., Ghadouani, A., Ivey, G.N., 2011. Environmental factors and the application of hydrogen peroxide for the removal of toxic cyanobacteria from waste stabilization ponds. Journal of Environmental Engineering 137, 952–960.

Drábková, M., Admiraal, W., & Marsálek, B., 2007a. Combined exposure to hydrogen peroxide and light-selective effects on cyanobacteria, green algae, and diatoms. Environmental Science and Technology 41, 309–314.

Drábková, M., Matthijs, H.C.P., Admiraal, W., & Maršálek, B., 2007b. Selective effects of H_2O_2 on cyanobacterial photosynthesis. Photosynthetica 45(3): 363-369.

FDA, 2007. 35% Perox-Aid. Retrieved Dec-21-18 from URL: https://animaldrugsatfda.fda.gov/adafda/app/search/public/document/downloadFoi/808

Kay, S.H., Quimby, P.C., & Ouzts, J.D., 1982. H_2O_2: A potential algaecide for aquaculture. Proceedings: Southern Weed Sciences Society 35th Annual Meeting New Perspectives in Weed Science. 275-289.

Matthijs, H.C.P., Visser, P.M., Reeze, B., Meeuse, J., Slot, P.C., Wijn, G., Talens, R., & Huisman, J., 2012. Selective suppression of harmful cyanobacteria in an entire lake with hydrogen peroxide. Water Resources 46, 1460–1472.

Sinha, A.K., Eggleton, M.A., & Lochmann, R.T., 2018. An environmentally friendly approach for mitigating cyanobacterial bloom and their toxins in hypereutrophic ponds: Potentiality of a newly developed granular hydrogen peroxide-based compound. Science of the Total Environment 637-638, 524-537.

Syndel, 2018. 35% Perox-Aid. Retrieved Nov-29-18 from URL: https://www.syndel.com/products/fish-egg-treatments/35-perox-aid-hydrogen-peroxide-22/35-perox-aid-89.html

Yang, Z., Buley, R.P., Fernandez-Figueroa, E.G., Barros, M.U.G., Rajendran, S., & Wilson, A.E., 2018. Hydrogen peroxide treatment promotes chlorophytes over toxic cyanobacteria in a hyper-eutrophic aquaculture pond. Environmental Pollution 240, 590–598.

Disease Survey Report: 2018

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The 4th Annual Disease Survey for commercial catfish farms was sent out to all Alabama catfish farmers in early November 2018. from the Alabama Fish Farming Center. The following tables summarize the results based on the replies of 76 commercial catfish farms in west Alabama. The survey also shows a continued significant discrepancy in the number of acres reported to the National Agricultural Statistics Service (NASS) survey (15,100 acres) in 2018 and the Fish Center survey (17,151 acres).

Number of Farms Reporting	76
Total Number of Acres	17,151
Total Number of Ponds	1,519
Number of Acres of Hybrids	2,619
Average Stocking Rate (weighted avg)	7,584

Table 1. Structure of the Alabama catfish industry in 2018.