

Southern Regional Aquaculture Center



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Revised

Nitrite in Fish Ponds

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Nitrite enters a fish culture system after feed is digested by fish and the excess nitrogen is converted into ammonia, which is then excreted as waste into the water. Total ammonia nitrogen (TAN; NH_3 and NH_4^+) is then converted to nitrite (NO_2) which, under normal conditions, is quickly converted to non-toxic nitrate (NO_3) by naturally occurring bacteria (Figure 1). Uneaten (wasted) feed and other organic material also break down into ammonia, nitrite, and nitrate in a similar manner.

Brown blood disease occurs in fish when water contains high nitrite concentrations. Nitrite enters the bloodstream through the gills and turns the blood to a chocolate-brown color. Hemoglobin, which transports oxygen in the blood, combines with nitrite to form methemoglobin, which is incapable of oxygen transport. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate oxygen concentration in the water. This accounts for the gasping behavior often observed in fish with brown blood disease, even when oxygen levels are relatively high.

Nitrite problems are typically more likely in closed, intensive culture systems due to insufficient, inefficient, or malfunctioning filtration systems. High nitrite concentrations in ponds occur more frequently in the fall and spring when temperatures are fluctuating, resulting in the breakdown of the nitrogen cycle due to decreased plankton and/or bacterial activity. A reduction in plank-

ton activity in ponds (because of lower temperatures, nutrient depletion, cloudy weather, herbicide treatments, etc.) can result in less ammonia assimilated by the algae, thus increasing the load on the nitrifying bacteria (Figure 1). If nitrite levels exceed that which resident bacteria can rapidly convert to nitrate, a buildup of nitrite occurs, and brown blood disease is a risk. Although nitrite is sel-

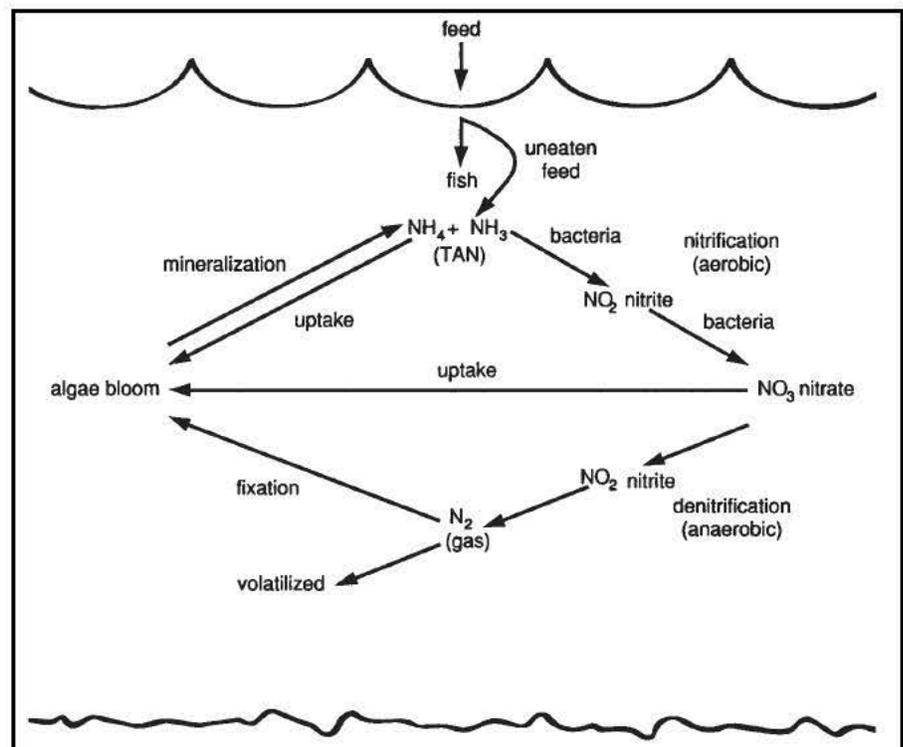


Figure 1. Nitrogen cycle in a fish pond.

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dom a problem in systems with high water exchange rates or good filtration, systems should be monitored year-round, and managed when necessary, to prevent severe economic loss from brown blood in any fish culture facility.

Susceptibility of fish species to nitrite toxicity

Largemouth and smallmouth bass, as well as bluegill and green sunfish, are resistant to high nitrite concentrations. The Centrarchids apparently are able to effectively prevent nitrite from entering the gills, but most other warmwater fishes grown in the Southeast apparently concentrate nitrite in the blood. Catfish and tilapia, for example, are fairly sensitive to nitrite, and trout and other coolwater fish are sensitive to extremely small amounts of nitrite. Goldfish and fathead minnows fall in between catfish and bass in their susceptibility to brown blood disease resulting from high nitrite levels. Striped bass and its hybrids appear sensitive to nitrite, but little is known about the relative sensitivity compared to other species.

Treatment and prevention

Since this is a nitrogen-related problem, the most obvious preventive measure is to reduce or minimize the amount of nitrogen incorporated into the system by reducing feeding rates. However, in modern intensive pond or closed system fish culture with high densities and rapid growout, longterm feed reduction is not considered by most farmers as a viable option. Luckily, although we often cannot prevent the occurrence of high nitrite, its effects can be minimized or neutralized safely and economically. Sodium chloride (common salt, NaCl) is used to "treat" brown blood disease. Calcium chloride can also be used but is typically more expensive. The chloride portion of salt competes with nitrite for absorption through the gills.

Maintaining at least a 10 to 1 ratio of chloride to nitrite in a pond effectively prevents nitrite from entering catfish. Where catfish (or other fish) have bacterial and/or parasite diseases, their sensitivity to nitrite may be greater, and a higher chloride-to-nitrite ratio may be needed to afford added protection from nitrite invasion into the bloodstream. As a general rule, catfish producers strive to maintain at least 100 ppm chloride in pond waters as "insurance" against high spikes of nitrite concentration. Culturists of other species may want to assume that nitrite is a potential problem and use salt as an insurance buffer as well.

How to calculate the amount of salt needed

Before treatment rates can be calculated, chloride and nitrite concentrations in the water, as well as pond or tank volume, must be determined. Commercially available water quality test kits can be used. Contact your Extension fisheries or aquaculture specialist for assistance in locating sources for test kits and conducting and interpreting these tests.

The amount of salt needed for the pond can be calculated using the following formulas:

Formula 1

(10 x pond nitrite concentration) - (pond chloride concentration) = parts per million (ppm) of chloride to add to the pond

The number "10" used in this formula is the minimum desired chloride:nitrite ratio number. It is used here to get a 10 to 1 chloride to nitrite ratio. If a higher ratio is desired, substitute the higher number for the 10.

If the answer is zero or a negative number, chloride concentration is sufficient to prevent brown blood disease.

Use the answer from Formula 1 above in the following formula:

Formula 2

Surface acres x average depth in feet x ppm of chloride to add to the pond x 4.5 = pounds of salt (NaCl) needed to add to the pond

You need 4.5 pounds of salt to increase the chloride concentration by 1 ppm in an acre-foot of water.

Example

The following readings are obtained from a 20-acre catfish pond with an average depth of 4 feet:

4 ppm nitrite
15 ppm chloride

Use Formula 1:

(10 x 4 ppm nitrite) - 15 ppm chloride in the pond = 40 - 15 = 25 ppm chloride to add to the pond

Now use Formula 2:

20 acres x 4 feet average depth x 25 ppm chloride to add to the pond x 4.5 = 9,000 pounds of salt needed to add to the pond

Application of salt

Distribute the salt evenly and quickly when fish are suffering from brown blood disease. Farmers have used feed trucks, airplanes, paddle wheels, and front-end loaders to distribute salt. It takes about 24 hours after salt is applied to a pond for the brown blood condition to be alleviated.

A good water quality monitoring program can help prevent brown blood disease. Pond water should be checked for nitrite two to three times a week during fall and spring, and at least weekly the remainder of the year. We recommend maintaining a chloride-to-nitrite ratio of at least 10:1 for catfish. Check ponds daily during a known high nitrite incident, even if adequate chlorides are in the ponds. Also check chloride after periods of heavy rain or active flushing from well water; both these events can dilute chloride concentrations and reduce the chloride:nitrite ratio.

Nitrite can increase very suddenly, so it is advisable to keep a 100 ppm chloride concentration at all times to act as a buffer when nitrite suddenly increases. This is a standard practice in the catfish industry, and incidents of brown blood disease in catfish ponds have become very rare. As an example, if your water has a chloride concentration of 20 ppm and you want to increase it to 100 ppm, simply add 80 ppm chloride to your pond. Use Formula 2 to calculate the pounds of salt needed.

Another way to help manage brown blood disease is by checking total ammonia nitrogen (TAN) concentrations in ponds every week. Every 1 ppm TAN can convert to 3 ppm nitrite in a relatively short period. High TAN levels can alert the farmer to anticipate nitrite problems within a few

days, and nitrite problems can thus be predicted and then prevented.

In many areas, water contains high natural concentrations of chloride, and addition of salt as "insurance" is not needed. Water should still be monitored frequently, however, since chloride levels can fluctuate widely and frequently.

Outlook

Brown blood disease can be prevented, or at least minimized, by close monitoring of nitrite, chloride, and TAN, and by maintaining the proper chloride-to-nitrite ratio. If brown blood disease does occur, the condition can be reversed by adding salt to the water. Catfish (and likely other fish) surviving brown blood disease or nitrite stress are more sus-

ceptible to bacterial infections, anemia (white-lip or no-blood), and other stress-related diseases. Secondary problems, such as *Aeromonas* and *Columnaris* bacterial infections, often occur 1 to 3 weeks after brown blood disease occurs.

Research is currently underway to determine whether even higher levels of chloride may be beneficial in reducing sub-lethal, chronic stress on fish from nitrite or other stressing factors. Results have thus far indicated significant advantages to maintaining chloride levels as high as practically possible.

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