More on Ammonia, pH & Water Temperature

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When raising fish there is nothing worse than seeing your fish suddenly die without any apparent reason. Teachers sometimes remark that their perfectly good fish that were fine yesterday suddenly looked sick and died this morning.

One point that many people overlook in fish culture is the relationship between ammonia levels, water temperature and pH. If neglected or not understood their inter-relationships can lead to fish mortality.

Action steps

- *To achieve a healthy aquarium it is essential to establish a well balanced biological ecosystem within the aquarium.* In Maryland, Special Blend (SB) and Nite-Out II (NOII) are used.
- *This involves developing three biological processes, a) establishing waste degrading heterotrophic cultures (SB), b) establishing ammonia removing nitrifying autotrophic cultures (NOII), and c) establishing denitrifying heterotrophic cultures (SB).*
- *The waste degrading heterotrophs in SB convert the organic waste matter to; H_20, CO_2, ammonia, new cell mass, and reserve polymers that contribute to bio film formation on filter media. Nitrifying cultures (NOII) convert the ammonia first to nitrite, then to nitrate. A second group of heterotrophic cultures in SB convert nitrate to harmless nitrogen gas through a process called denitrification.*
- *To assure a healthy aquarium you must establish these essential biological processes at the earliest stage of the fish growth process.*
- *It is important to understand that nitrifying cultures are extremely slow growing bacteria requiring a minimum of 12-24 hours for one cell division to occur, under ideal condition. Unfortunately cold water slows all biological processes so be sure to feed these important bacteria to the tank water and filter ASAP.*

Ammonia

Ammonia is produced through the biological removal of waste organic matter and is one of the byproducts of the biological oxidation reduction process (where ammonia comes from).

All fish give off ammonia. It comes off their gills and waste. Uneaten fish food turns into ammonia as it breaks down *through tank biology*. If left to build up over time without nitrifying bacteria to convert it into nitrites and nitrates it will cripple your system and kill your fish. *This biological process* is known as the Nitrogen Cycle. At the water temperatures we raise trout it can take six to eight weeks for a tank to fully cycle.

- *The time period to achieve nitrification is dramatically reduced through the addition of Nite-Out ll "<u>nitrifying bacteria</u>". Add Nite-Out ll cultures to tank water and to the filter media at the start of the trout grow process, and at any sign of increased ammonia.*
- *In addition, you must always check, adjust and add KH alkalinity to maintain a minimum level of 100 to 150 ppm as KH is the primary energy requirement for the nitrification process. These ammonia removing nitrifying cultures require 7.1 pounds of KH alkalinity (carbonate alkalinity) for every pound of ammonia biologically removed in the nitrification process.*
- *If the KH level is depleted "nitrification will stop" just like a car running out of gas, and will not restart until KH levels are adequate.*

Ammonia concentration in a new aquarium is a chemical that has to be watched closely to make sure the levels do not reach a point where they start killing fish. The death of many species of fish can start at as low as .6 **p**arts **p**er **m**illion (ppm). In established systems the ammonia level normally reads 0 ppm. When you test for ammonia with your aquarium test kit, the reading you actually have is a combination of ammonium (NH_4^+ or ionized ammonia) and ammonia (NH_3 or unionized ammonia) known as **T**otal **A**mmonia **N**itrogen (TAN). Ammonia is the toxic part of the TAN. Ammonium even at high concentrations does not cause mortality in fish. Understanding the difference between the two is crucial to figuring out how much toxic ammonia you really have in your system. How much of the TAN you have that is toxic is greatly related to the pH of the water, and to a much lesser extent the temperature. The higher the pH the greater amount of the TAN is ammonia. Water with a temperature of 82° F (28° C), a pH of 7.0, and a TAN of 5 ppm has only .03 ppm ammonia. . At a pH of 6.0, and 10 ppm of TAN, the ammonia is only .007 ppm. Above a pH of 8.0 the toxicity of TAN rapidly rises!

- *Nitrification will occurs at a faster rate and is much more stable in an alkaline environment; maintain a minimum pH of 7.0, with a target of 7.2 to 7.5 for optimum performance of the combined biological process.*

<u>The pH of Ammonia</u>

Pure ammonia actually has a basic or alkaline pH. In theory, ammonia should raise the pH of an aquarium. However, virtually all processes in the aquarium that produce ammonia, as well as the breakdown of ammonia, produce hydrogen cations. Since pH is the negative log of hydrogen cation concentration, increasing this lowers the pH, negating the mildly basic pH of ammonia. While ammonia has a basic pH, the processes that create it in an aquarium produce enough hydrogen ions to overcome this and lower the pH.

<u>Sources of Ammonia</u>

Ammonia comes from several biological processes in the aquarium. Most of these processes come down to breaking down proteins. In a fish's metabolism, they break down proteins from the food they eat and produce toxic ammonia as a byproduct. This releases ammonia, and hydrogen ions. Since ammonia is a weak base, the hydrogen ions have a stronger effect on pH, so this process ultimately lowers the pH. Rotting plant and animal matter, as well as decaying fish food, also undergo a similar process that produces ammonia and hydrogen ions.

The Ammonia Cycle

In a healthy aquarium, bacteria break ammonia down into less toxic forms. A first set of bacteria break ammonia down into nitrite. A second group of bacteria turn the nitrite into nitrate. The various bacteria also release even more hydrogen ions throughout this process which lowers pH. The process typically takes several weeks to a month to establish in new aquariums. Without this process, toxic ammonia would continue to build up until the water became toxic to fish.

- *Special Blend & Nite-Out ll reduce the nitrogen cycle time. At room temperature this can occur with 48 hours, however, this process takes more time at the 52-54 degrees water temperatures of our tanks. Bacteria should be added to the filter and tank water at the very start of the fish grow process. About 80% of the biological removal process takes place in the filter system.*

How pH Effects Ammonia

While the processes that create ammonia affect pH, the aquarium's pH can also influence the ammonia. In an acidic aquarium, ammonia actually becomes less toxic to fish. It is never good to have ammonia in an aquarium, but it is "less bad" in an acidic situation. In water with alkaline or basic pH, ammonia is more toxic.

- ***Achieving nitrification (conversion of ammonia to nitrite and nitrate) in cold water is difficult and low pH suppresses the nitrification process. It is better to set a target range for pH of 7.0-7.5 at which point the nitrifying bacteria are better able to control ammonia***

How Temperature and pH Effect Ammonia

Ammonia varies in toxicity at different pH and temperature of the water. For example, ammonia (NH_3) continually changes to ammonium (NH_4^+) and vice versa, with the relative concentrations of each depending on the water's temperature and pH... At higher temperatures and higher pH, more of the nitrogen is in the toxic ammonia form than at lower pH.

At what point should you get concerned about ammonia levels becoming a threat to your fish given that ammonia is constantly being produced? The answer to this question will depend on the temperature and pH of your tank water, how many fish are in your tank and how much uneaten fish food remains in the system.

Total Ammonia Nitrogen (TAN) - ppm *Use this table to find out when ammonia levels will start to become toxic to your fish*											
Temp (°C)	pH										
	6.0	6.4	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4
4	200	67	29	18	11	7.1	4.4	2.8	1.8	1.1	0.68
8	100	50	20	13	8.0	5.1	3.2	2.0	1.3	0.83	0.5
12	100	40	14	9.5	5.9	3.7	2.4	1.5	0.95	.61	0.36
16	67	29	11	6.9	4.4	2.7	1.8	1.1	0.71	0.45	0.27
20	50	20	8.0	5.1	3.2	2.1	1.3	0.83	0.53	0.34	0.21
24	40	15	6.1	3.9	2.4	1.5	0.98	0.63	0.4	0.26	0.16
28	29	12	4.7	2.9	1.8	1.2	0.75	0.48	0.31	0.2	0.12
32	22	8.7	3.5	2.2	1.4	0.89	0.57	0.37	0.24	0.16	0.1

This chart identifies the level of ammonia you can tolerate in your fish tank before it affects the fish. You will notice that at very warm water temperatures a small amount of ammonia can be toxic to your fish. At the opposite end of the spectrum in very cold water, the opposite is true. Fish can tolerate higher levels of ammonia the cooler the water. This is also true for dissolved oxygen. Cold water can store more dissolved oxygen than the same volume of warm water. The good news is that the water temperatures and pH levels at which our trout are raised tend to reduce the effect of harmful ammonia. If you encounter an ammonia spike that is causing fish mortality you may try lowering the water temperature 2- 4 degrees to see if the fish start to recover.

Understanding the relationship between ammonia, pH and water temperature will help you control and manage your system and avert fish loss.

Note: The Total Ammonia Nitrogen table is printed by permission of Frank Gapinski of Eco Films, an independent production house based in Queensland's Sunshine Coast, Australia. Ph: 07 54749893 email inquiries: frank@ecofilms.com.au.