

Nature's Nitrogen Cycle

Tending to our "Microscopic Garden"

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Nature has this wonderful way of refreshing our environment for us. There are many "cycles" in nature that aids both plant and animal to survive on this earth. You can't get a group of pond keepers together without the subject of the "cycle" coming up. The "cycle" is commonly known to those of us who keep fish as the "nitrogen cycle". This micro-world is essential when keeping fish in a pond and it is important that we understand how it works so that we can provide the best possible support system for it to thrive. Even though this process is a natural occurring phenomena in nature, it is up to the pond keeper to give this micro-world a place to live and encourage it's healthy survival.

For us northern climate pond keepers, each spring as we start up our ponds for the season, most likely we will all deal with the nitrogen cycle as many ponds are shut down for the winter and any viable bacteria is either dead or, after cleaning the pond, non-existent.

Basically this "cycle" is the natural process which systematically eliminates toxic ammonia by converting it to progressively less toxic compounds.

Four Phases:

- Fish excrete ammonia as waste from their gills, kidneys and normal respiration; decaying plant material also add to ammonia levels in the pond.
- A species of bacteria called NITROSOMONAS converts this ammonia into nitrite.
- A second bacteria called NITROBACTER converts this nitrite into nitrate.
- Algae and aquatic plants utilize some nitrate. Plants are consumed by fish. The "cycle" repeats.

Driving Factors:

- Heat: Both types of bacteria are living organisms. As the temperature rises the bacteria become more energetic up to a maximum temperature of 80 degrees. Above 80 degrees these bacteria are very aggressive, but oxygen levels in the water are greatly depleted. The lack of ample oxygen becomes a limiting factor. Below 50 degrees very little nitrification occurs.
- Oxygen: The chemical process used by both species of bacteria is oxidation. Like most living organisms, without sufficient oxygen present these organisms eventually die.
- KH-Carbonate Hardness (buffering PH): Without ample supply of this additional "food supply" for the bacteria, these bacteria die off and the result is termed a "filter crash".

Our pond systems are not a "natural" environment no matter how hard we try to get it that way. Nature refreshes our natural water ways and lakes and renews that eco-system. Nature also controls how many fish can survive in a given body of water.. If a natural system is over-crowded, nature removes life so the system can survive. Our ponds, on the other hand, are closed re-circulating systems and often overstocked with fish and plants so we must oversee what nature cannot do in this artificial world.

This micro-world consists of several types of bacteria that when they interact with each other, will keep our water quality in balance thus keeping our fish safe and healthy. This "cycle" is most important when fish are present in the pond so, for the sake of this article, we'll start there.

AMMONIA:

Ammonia is a gas that is water soluble. That means it remains in the water. When ammonia is present, fortunately nature provides certain bacteria which will chemically transform this toxin to Nitrite (by-product of the Nitrosomonas activity). Those bacteria are called "Nitrosomonas". Nitrosomonas need a surface to cling to and grow on (colonize). This would be your pond walls, rocks, filters provided, etc, even the inside walls of your plumbing will be a home to Nitrosomonas. Ammonia is the energy source for Nitrosomonas. Oxygen saturation in the pond water is extremely important to the survival of this bacteria. Without it this bacteria will turn anerobic and will cause stress and illnesses in your fish.

- Acceptable test results: Zero
- Ammonia is very toxic to fish
- Ammonia is the first waste product of your fish and decaying organic matter
- Often the cause of the 1st mortalities in new ponds (new pond syndrome)
- Ammonia is directly irritating to fish gills and tissues and can cause burns
- Ammonia is controlled (eliminated) from the pond water by beneficial bacteria called Nitrosomonas

Byproduct of the Nitrosomonas bacteria when consuming Ammonia is NITRITE

NITRITE:

Nitrite will then be converted to Nitrates by another bacteria called Nitrobacter. Here we can see delays in colonization of this bacteria. Mother nature has thrown us a bit of a curve when it comes to nitrobacter. This bacteria growth is inhibited by the presence of AMMONIA in the water so this is the reason you will not see control of Nitrites until your ammonia levels are almost at zero. Once the ammonia levels are reduced to zero, then and only then, can nitrobacter begin to replicate and grow. This bacteria also requires a food source (nitrite), oxygen and a clean hard surface on which to live. Nitrites are also very toxic to fish. The presence of Nitrites in the water is absorbed into the gills of the fish and will interfere with the fish's ability to carry oxygen throughout the blood stream. This is called "brown blood disease". The fish essentially suffocates to death.

- Acceptable levels of Nitrite = Zero
- The bacteria responsible for transforming Nitrites to Nitrates is Nitrobacter
- Nitrite spikes are common in cooler water with heavy feeding & low PH levels
- Not immediately as toxic as Ammonia, but will suppress immune systems and Nitrite poisoning is possible (brown blood disease). Protect fish with a .1% salt solution.
- Other than certain fertilizer tablets, Nitrite is caused almost exclusively by Nitobacter bacteria active in the bio filter
- Nitrite Management is most effectively controlled by the use of a good bio filter system; water changes may become necessary with a newly established pond

The byproduct of Nitrobacter converting nitrites is NitrAte, which is then released into the water.

NITRATE:

Nitrates are the end product of Nitrobacter consuming Nitrites. Nitrates are the final product in the successful reduction of nitrogen from Ammonia to Nitrite to Nitrate. What we do know about the effects of Nitrates on fish is that its presence at higher levels (above 120 ppm) are Toxic to fish. What is now accepted is that the presence of Nitrates in the water will inhibit good growth and cause severe stress in fish which in turn will lead to illnesses such as bacterial infections (ulcers). It has long been assumed that some level of nitrates (20-60 ppm) can and are tolerated by fish. It has also been assumed that, since nitrAte is a form of fertilizer, that it can be diminished with the presence of plants in the pond. Depending on your fish load and the quantity and type of plants in your pond, this may or may not control the nitrates in your pond environment. This is one reason why routine water changes are so very important.

Removing (pumping out) water from the pond and replacing it with fresh treated water will dilute the presence of nitrates. Please do not believe that simply “topping off” the pond is considered a water change. Also very effective in NitrAte control is a type of filter referred to as a Trickle Tower or Wet/Dry filter systems.

- Acceptable levels of NitrAte = 20-40 ppm
- The bacteria responsible for creating NitrAtes is Nitrobacter
- Presence of excessive levels of NitrAtes in the water can retard healing, stunt growth and interfere with antibiotic treatments
- High levels of NitrAtes are more toxic under conditions of low oxygen levels in the pond.
- Control NitrAte levels with routine water changes
- NitrAtes are used by plant life (especially algae) and that plant life is then consumed by fish, thus the “cycle” repeats

FISH & DECAYING ORGANICS = AMMONIA = NITRITE = NITRATE

Not only does the pond keeper need to care for the water environment to keep fish healthy and alive, good water care practices will also keep your bacteria alive and healthy which in turn supports your water quality and your fish health and growth. In ponds without fish, the “Cycle” is important in keeping the pond fresh and sweet smelling.

Controlling AMMONA and NITRITE:

- Provide a good home for your bacteria to grow. A good bio-filter (outside the pond); Don't use chlorinated tap water to clean your bio-filter - chlorine will kill viable bacteria
- High oxygen saturation in the pond water (oxidation)
- Removing organics (decaying matter & fish waste) from the pond water system regularly
- Water changes
- Fresh test kits –Ammonia; Nitrite, Nitrate, PH & KH - replace every spring
- Use of salt at .1% (1 pound per 100 gallons) will temporarily protect fish from nitrate spikes

Note: Cleaning the surfaces that are the home to colonizing bacteria should never be striped clean of bacteria – Only remove some of what has collected by gentle rinsing. If you can visualize this bacteria growing in layers, you want to remove only the excess growth so the lower layers of bacteria can receive oxygen to survive. If the bacteria gets to heavy (thick) the lower layers cannot receive oxygen and will turn anerobic.

Controlling NITRATE levels in the pond:

- Frequent Water Changes
- Introduce plant life and encourage some algae growth
- Trickle Tower (wet/dry) filter system to degas NitrAtes

FISH HEALTH ISSUES RELATING TO THIS NITROGEN CYCLE (water quality):

I believe we can see now how the Nitrogen Cycle greatly effects the health of our fish and our ponds. Keeping that cycle viable is part of why we perform water changes, clean our filters and test our pond water. Don't think of these tasks as “Chores”, but rather like tending any garden. You are providing a good environment for microscopic bacteria to grow. Just because you can't see them, doesn't mean they don't need to be cared for and protected just as you care for your fish and water plants. Providing a good place for these little creatures to survive and multiply is probably the most important task a pond keeper can perform for the continued health of fish and pond.

If your fish show the following:

New, small fish die off within 2-3 weeks;
Redness of fins – red veining on body;
General poor health;
Excess mucus production;
Flashing;
Pinecone disease;
Fish isolating themselves from other fish;
Unexplained deaths;
Lethargy, lack of energy;
Slowed growth;
Delayed wound healing;
Dramatic increased vulnerability to disease;
Gasping at surface or congregating near waterfalls;
Not eating;

Test, test, test.

Any of the health signs noted above should prompt the pond keeper to test for all parameters we have discussed today. Any of these parameters that are “out of acceptable ranges” can and will cause fish to become ill or, at the very least, place your fish at the “edge” where growth and immune systems are compromised. The slightest change in water temp or outside stressors can then push a fish over the edge into illness and/or death suddenly. If all water quality parameters are within “normal” acceptable ranges then it is safe to assume a parasite is at work in your pond or a major stressor (such as a severe cold snap in weather) has occurred while you weren’t looking and testing.

- Replace your test kits in the spring
- Perform Ammonia, Nitrite, Nitrate, PH and KH tests weekly (new pond)
- Perform Ammonia, Nitrite, Nitrate, and PH tests as indicated (established pond)
- Perform KH test weekly always

I hope this basic information about how your pond balances itself and what measures you can take as the pond keeper to encourage nature to perform at its maximum level, will take some of the drudgery out of the maintenance chores we all must perform while tending to a healthy pond. Next time you are out there cleaning your pond and filters (in 50 degree - or less - weather) and/or netting out the debris that has settled to the pond floor, just keep in mind you are really tending to your “microscopic garden” and maybe those chores will have more of a purpose for you.

Author’s Note: Recent studies are discovering that more than these specific bacteria colonies do exist beyond what is mentioned in this article which seem play an important role in maintaining this delicate “cycle”.