

The fundamental nitrification process of a closed system

Aquarium Bacteria in general

Nitrifying/De-Nitrifying bacteria occur in two forms, **Autotrophic and Heterotrophic**.

Autotrophic bacteria synthesize their own food, and they require oxygen so they are termed aerobic. Heterotrophic bacteria cannot synthesize their own food so they need organic material such as fish waste, dead bacteria, fish and plant matter, etc, some of these are aerobic, although many are facultative anaerobes, (can survive in either the presence or absence of free oxygen molecules) Anaerobes are organisms that do not require free oxygen for growth and multiplication.

Nitrifying Bacteria (Consume NH_3 and NaNO_2 , Ammonia and Nitrite)

Nitrosomonas europa and Nitrobacter which were once believed to be, are **NOT** the nitrification bacteria in freshwater, and are often still used in over the counter bacteria supplements such as Seachem stability, Fluval Cycle etc, this type of bacteria is **harvested from soils** and cannot survive long periods in aquatic environments although will consume ammonia and nitrite for a short time

Ammonia is converted to nitrite by bacteria of the **Nitrosomonas marina-like strain**. Nitrite is converted to nitrate by bacteria closely related to **Nitrospira moscoviensis and Nitrospira marina**. This data is now accepted and confirmed **scientific fact**, and is now used in products such as DR Tims, Tetra safestart and ATM Colony, these products legitimately cycle tanks with an ammonia source in **days not weeks**.

Biological supplements aside, In a new aquarium, it can take up to **eight weeks** for these bacteria populations to reach a level capable of eliminating ammonia and nitrite at 100% efficiency depending on several factors such as **pH, and temp** which I will get into later

True nitrifying bacteria colonize surfaces, **they are sticky**, they exude protein coatings that allow them to build up into a slimy film that we tend to term a **biofilm**. **They do not live in the water column whatsoever**, moving old tank water brings **no beneficial bacteria**. They live mainly on filter media as well as the substrate where moving water brings a constant supply of oxygen and food. Nitrospira (Nitrite-Nitrate) are inhibited and **cannot multiply in water with significant concentrations of ammonia**, populations of Nitrospira become dormant when ammonia is present in high concentrations. Therefore water changes during the cycle is encouraged heterotrophs notwithstanding, and if not at least **test for ammonia levels**.

Water changes must be performed without the introduction of **chlorinated water**, best treated before it enters the aquarium. **pH has a direct effect on nitrifying bacteria**. Nitrifying bacteria has a **100% effectiveness at a pH of 8.3**, and this level of efficiency decreases as

the pH lowers. At pH 7.0 efficiency is only 50%, at 6.5 only 30%, and at 6.0 only 10%. Below 6.0 the bacteria enter a state of dormancy and completely cease multiplying. Fortunately, in acidic water (pH below 7.0) ammonia automatically ionizes into ammonium which is basically harmless like nitrates unless they get to insane levels which rarely ever happens.

Nitrite will not be produced when the ammonia-oxidizing bacteria are in “hibernation,” this decrease in their effectiveness poses no immediate danger to the fish and other life forms. Temperature also affects the rate of growth. Optimal temperature is between 77 and 86F. At 64F it will be 50%. Above 95F the bacteria has extreme difficulty multiplying and working. At both 0C/32F (freezing) and 100C/212F (boiling) all nitrifying bacteria die. Nitrosomonas marina and Nitrospira bacteria cannot survive drying out; without water, they will die. Tap water with chlorine or chloramine will kill these bacteria as it is designed to. Many antibacterial medications will negatively impact the nitrifying bacteria to varying degrees, Copper treatments will not unless dosed high enough to harm scaled fish.

Ammonia levels in a neutral PH between 0.5 and 1 ppm can result in long-term or permanent gill damage, although Ammonia is never healthy at any levels that can be detected by our standard test kits. The fastest uptake of ammonia in an aquarium occurs with live plants; ammonia can be both assimilated (as a nutrient in the ionized form ammonium) and taken up (as a toxin, NH₃) by plants, Autotrophic bacteria only consume ammonium, but as the ammonium levels lower more ammonia gets converted into it until 0ppm is reached. Nitrite at 0.25 ppm begins to affect fish after a short period, at 0.5 ppm it becomes dangerous; and at 1.0 ppm it is often fatal. Plant do not uptake nitrite but luckily its easily negated with Cl⁻ (chloride), which can be found in regular aquarium salt, however calcium chloride, (most buffer recipes) is the better option, chloride prevents methaemoglobinemia (brown blood disease) by binding the nitrite ion. High levels of nitrate, above 40 ppm, have been shown to slow fish growth, suppress breeding, and depress the immune system making the fish much more susceptible to disease. Live plants and regular partial water changes both work to achieve this desired state in a balanced aquarium.

Nitrifying bacteria cannot grow without ammonium, or oxygen and therefore to cycle a betta bowl you need a filter system to oxygenate the water. Without a filter you will not move the oxygenated / ammonia to the bacteria.

De-Nitrifying Bacteria

Some Heterotrophic bacteria, of which there are several species, utilize nitrate by consuming the oxygen within nitrate and releasing nitrogen gas. These are the good guys among heterotrophs, since de-nitrification is important in a healthy aquarium.

Waste Control Bacteria

Like all bacteria, they colonize surfaces, and these are most prevalent in the substrate and the filter media. Many species can survive complete drying, allowing them to remain potent even when filter

media that has been previously used is completely dry. They compete with autotrophic bacteria for both oxygen and surface area, studies show that even in relatively clean environments, they occupy more than 50% of the available surface area. In a filter, if sludge is allowed to increase, heterotrophic bacteria will multiply so fast they actually smother and kill the autotrophic nitrifying bacteria. The best control is limiting organic carbon which comes from dead organic matter. In non-planted tanks this is more crucial, and here is where carbon filtration helps, since it absorbs organic carbon which is essential for these not so good heterotrophic bacteria, Purigen and Chemipure do this with far more efficiency than standard activated carbon

Bacterial blooms, Referred to as New tank Syndrome

These are most common in new tanks, but with very little if any obvious organic waste, how does the bloom happen? When water is dechlorinated, it can suddenly support bacteria, and the "organic waste" in the water itself feeds the heterotroph bacteria and it very rapidly reproduces and clouds the tank a milky white. It is usually less likely, or will be minimal by comparison, with live plants because they assimilate nutrients from organics. When heterotrophs bloom in the water they switch from anaerobic to aerobic and consume vast amounts of oxygen. This is the real danger of a bacteria bloom, as it can starve the fish of oxygen. What to do? Increasing aeration is helpful as heterotrophs consume a lot of oxygen. Add carbon / purigen to the filtration to ease the load, adding a true nitrifying bacteria such as ATM's Colony, DR tims or Tetra safestart will help convert the resulting ammonia. Test for Ammonia regardless. Quick note about ammonia, Heterotrophs convert organic carbons into ammonia for autotrophs to consume, without the needed autotrophs ammonia spikes can happen quickly, in which case a water change is advised) (A water change is not recommended normally to clear a bacterial bloom unless ammonia is above 1-2ppm). When the free-floating heterotrophs are removed however, the others will reproduce even faster to compensate, thus worsening the bloom. If left alone, they usually dissipate in a few days, keep in mind most tap water sources contain phosphates, both heterotrophs and cyano bacteria consume this as food, so water changes may just feed these bacterias.

Established tank

a bacterial bloom is caused by something that upsets the biological balance by increasing the organic matter too quickly, such as overfeeding, excessive decaying plant and animal matter, excess waste from overcrowding, addition of numerous fish, etc. The heterotrophs quickly reproduce by feeding on this organic matter. This produces ammonia as a by-product, and the sudden surge in ammonia overtakes the nitrifying bacteria that need time to "catch up." Live plants again help here, as they can assimilate and/or take up considerable quantities of ammonia faster. Note that the bacterial bloom causes the rise in ammonia, not the opposite as some may think. In an established tank, the source of the problem should be removed. Clean the gravel, remove decaying matter, don't overfeed, reduce overstocking, etc. And be aware of the oxygen shortage issue.