Definitions of Water Quality Parameters Important to Koi Ponds

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Total Ammonia Nitrogen (NH_3-N): This measurement is quite often referred to as just ammonia, but this is technically incorrect. This is actually a measurement of the concentration of the nitrogen atom, not the complete ammonia compound. However, the criteria commonly used are normally reported as TAN, even if referred to as ammonia. Two forms of ammonia can be found in aquatic systems and the concentration of each is dependent on pH. NH_3 is the most abundant form found at typical pond pH's of 7.0-8.0, and is also the less toxic form. NH_4^+ becomes more abundant at higher pH's (above 8.0) and is much more toxic. Fish excrete ammonia into the water as they break down the food that they eat. Nitrification, or the biological process of breaking down nitrogen-based compounds, will convert ammonia into nitrite (Nitrosomonas).

Total Nitrite Nitrogen (NO_2^--N): Similar to TAN, this measurement is often referred to as nitrite, but again is technically incorrect. This is a measurement of the concentration of the nitrogen atom, not the complete nitrite compound. However, the criteria commonly used are normally reported as TNN, even if referred to as nitrite. TNN is more toxic than ammonia to fishes. It is the secondary product in the biological filtration process. Further nitrification will convert the nitrite to nitrate (Nitrobacter).

Total Nitrate Nitrogen (NO_3^{2-}-N): This is the final product of the nitrification process, and is generally considered harmless unless unreasonably high levels are achieved (>100 mg/l). This is not common in koi ponds because there is usually sufficient water exchange to remove the excess nitrate.

pH: This is a measure of the concentration (represented by brackets) of hydrogen (H^+) atoms free floating in the water (scale is 0 to 14). pH is the inverse logarithm of the concentration:

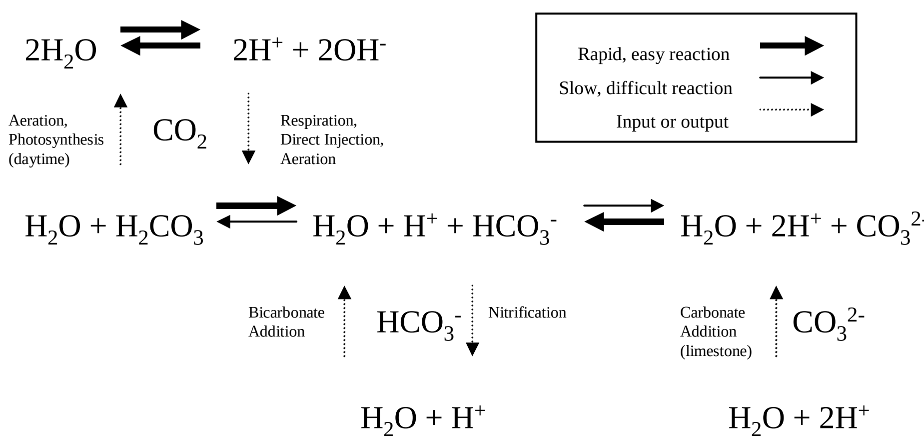
$$pH = -\log[H^+]$$

A high concentration of H^+ ions means a low pH (acidic), and conversely a low concentration of H^+ ions means a high pH (basic). Because pH is logarithmic, a change of 1 pH unit means a change of 10 times the number of H^+ ions. A pH of 7.0 to 8.0 is recommended. Below 6.5, nitrification can become hindered. Above 8.0, the toxic form of ammonia begins to predominate. The natural tendency in koi ponds is for the pH to slowly shift down. This is the result of a reduction in alkalinity, and also an increase in carbon dioxide (CO_2). If high pH's are observed, it is likely the alkalinity is high also, probably from the inflow water. The best option in this case is to just let the pond go and the pH will slowly shift down. If a quicker change becomes necessary, addition of muriatic acid (diluted hydrochloric acid) will accomplish this, but caution must be observed so as not to change the pH too quickly. If the pH is too low, either the alkalinity has become too low or the CO_2 level has become too high. Addition of baking soda will correct low alkalinity, or, as a slower alternative, a few pieces of limestone can be added to the pond. Reduction of CO_2 can be accomplished by additional aeration.

Alkalinity (as $CaCO_3$): This is a measurement of the buffering capacity of the water (tendency to resist shifts in pH). Alkalinity can be affected by a number of factors, but the primary factors involved are represented by the following equation:

$$\text{Total Alkalinity (as } CaCO_3) = [HCO_3^-] + 2[CO_3^{2-}] + [OH^-] - [H^+]$$

The primary factors in the alkalinity equation are affected by the carbonate cycle, which is represented by the following diagram:



The bacteria involved in the nitrification process (Nitrosomonas and Nitrobacter) will consume HCO_3^- (bicarbonate). HCO_3^- will not be replaced naturally. This must be added by the pond keeper in the form of baking soda (sodium bicarbonate). As stated earlier under pH, the addition of limestone (carbonate, CO_3^{2-}) will also work, but must go through one additional step in the equation before becoming usable. Thus limestone addition is slower, but can work in lightly loaded systems. Also, be aware that the addition of limestone in high quantity will affect water hardness, and possibly fish behavior or color, but should not affect health.

Dissolved Carbon Dioxide (CO_2): As stated above, carbon dioxide is involved in the alkalinity process. Fish produce it during respiration. As the concentration of carbon dioxide increases, the pH will decrease. Sufficient aeration should remove carbon dioxide and subsequently raise the pH back to normal levels.

Dissolved Oxygen (O_2): Oxygen is required not only by the fish in the pond, but also by bacteria involved in the nitrification process. Aeration is usually sufficient to provide the necessary oxygen. However, additional bacteria known as heterotrophic bacteria will also consume oxygen during the breakdown of organic compounds. Most organics are in the form of suspended solids (free floating, but not dissolved) and can be removed by some type of mechanical filtration. Dead spots in ponds, or a lack of removing the suspended solids may consume significant levels of oxygen, thus it is best to quickly remove any suspended particles in the water with sufficient mechanical filtration and sufficient removal of the solids from the pond by washing the mechanical filtration. Algae, during sunlight hours, will produce oxygen. However, at night, algae will actually begin to respire and will also consume oxygen.

Total Suspended Solids/Total Dissolved Solids: Total suspended solids (TSS) are any solid particles that are not dissolved in the water. The separation between suspended solids and dissolved solids is 0.45 μm (~1/200th the diameter of a human hair). Any particles trapped by a 0.45 μm filter are considered suspended solids, and any particles that pass through that same filter are considered dissolved. Suspended solids can enter a pond through many routes. Fish excrete solid waste which can contribute to TSS, leaves may fall into a pond and degrade, mud may get washed into a pond, and so on. A properly designed and maintained filter should remove solids quickly, thus minimizing any problems. If a filter is not operating properly, suspended solids may build up, which can reduce visibility and may cause bacterial build-up. Also, many suspended solids are made up of organic matter. Heterotrophic bacteria will degrade organic matter, but will consume oxygen in the process. This oxygen consumption can be greater than that of the fish, thus filters should be appropriately designed to remove suspended solids quickly. Total dissolved solids (TDS) are mostly made up of salts (primarily sodium chloride, NaCl, a.k.a. table salt). These are not usually of concern in koi ponds, unless salts have been intentionally added to the pond, or some type of well water is used that contains salts. Koi can generally tolerate up to 8-10 g/L of dissolved solids, or possibly more, but this is not recommended on a regular basis. Dissolved solids should be maintained at less than 1 g/L unless there is a need to treat the fish (such as for parasites). When treating, a salt level of 5 g/L should be sufficient to treat most problems and reduce stress on the fish. Do not ever use iodized salt to treat fish! If salt treatment is required, make sure the salt is pure NaCl, or some appropriate mixture recommended by a professional.