Water Chemistry Basics: pH, Temperature, Water Hardness, Waste Breakdown, Minerals, and Chemicals

Drs. Foster & Smith Educational Staff

Learning about water chemistry is often avoided by most aquarium owners, but by knowing just the basics of water chemistry, you can greatly improve your success in rearing healthy fish.

Most aquarium owners are aware that the quality of water has a direct impact on the health of their fish. But many aquarium owners do not understand the basic internal chemistry of their fish's water, nor do they understand how to correctly or safely adjust it. Until the basics of water chemistry are mastered and some common water maintenance techniques are learned, it will be difficult to maintain a healthy and safe environment for the fish in your tank.

There are entire books written on the specifics of water chemistry and it's encouraged that all aquarium owners learn as much as possible about this subject. Water quality is by far the single most important factor in the health of your fish, and the more you know the better job you will do. This article provides a brief overview that is just the bare minimum that aquarium owners should know and understand.

pH

Every aquarium owner has heard of pH, but many do not understand the importance of controlling it. pH is the measure of acidity or alkalinity in the water. The pH scale is from 1 to 14. A pH of 7 is neutral which basically means the water is not acid or alkaline. As the scale goes down, for example 6, the water becomes more acidic. As the pH goes up, for example 8, the water gets more alkaline. One very important part of the pH scale that most people do not understand is that it is a logarithmic scale. What this means is that the pH changes at a tenfold level between each number. For example a pH of 5 is 10 times more acidic than a pH of 6 and a ph of 4 is 100 times more acidic than a ph of 6. So if your fish are supposed to be at a pH of 7 and the water level is 8, they are in water that is 10 times more alkaline than what they should be. If the pH is 9, then they are in water that is 100 times more alkaline than what they need. So it is easy to see why even a small change in required pH is stressful and potentially fatal to fish.

These examples really emphasize the importance in matching your fish closely to the expected pH level of your water, and then closely monitoring the pH. Putting a fish that requires a pH of 8 with a fish that requires a pH of 6 is just not a good idea because one or both will be at a very unacceptable level of pH and will be under a great deal of stress.

There are several different ways to influence your water's pH. There are chemical additives that can be added directly to the water that will either raise or lower the pH. More natural agents can be used to alter water pH as well. Peat in the tank or filter will acidify the water. Mineral salts like calcium that are found in limestone or in some shells will cause an increase in alkalinity and pH. There is one important consideration in altering the pH of water and that relates to the mineral content (hardness) of the water. See the section below for a complete description. Remember that fish are very sensitive to changes in pH, and rapid changes in pH can cause extreme stress and death. Fish should not be exposed to a change in pH greater than 0.3 in a 24-hour period.

Temperature

While not considered chemistry, water temperature needs to be mentioned. Fish are cold blooded, which means they cannot raise or lower their body temperature and their body temperature will be the same as the water around them. If a fish is kept outside of their normal temperature range, they will become stressed and become diseased or die. The majority of fish are tropical, which means they come from temperate climates with water temperatures around 75ºF. Even cold water species such as goldfish cannot handle very cold water or sudden changes in temperature. Know your species of fish and their temperature requirements.

Water hardness

Water hardness is often confusing and therefore overlooked by many aquarium owners. Water hardness is important because it is closely related to pH and, just like pH, fish have certain levels of water hardness that they thrive in and if the hardness is too far off it can cause stress and death. Water hardness can be most simply described as the level of mineral in the water. Hard water has a lot of dissolved mineral and soft water has very little dissolved mineral in the water. The most common mineral in water is calcium, however, other minerals can also be present. Most people's tap water is either slightly hard or soft depending on where it comes from. Well water from areas that have a lot of limestone (calcium) is often hard. Water that comes from lakes (rainwater) is often devoid of mineral and is soft. It is important that you know the hardness of the water that you use in your fish tank. Some species of fish require hard water and others require soft water.

The other reason that hardness is important is that it affects pH. Hard water (high mineral content) is usually high in pH. Soft water (low mineral) is usually low in pH. The mineral in hard water will act as a buffer which will reduce the amount of acid in the water. The resulting water will be more alkaline and higher in pH. The problem arises when we try to lower the pH in hard water. If we add a commercial pH decreaser to an aquarium that is filled with hard water, the mineral in the hard water will buffer the water and make it difficult to successfully lower the pH. We would first have to remove the mineral from the water before we could effectively lower the pH. The same is true for trying to raise the pH in acidic water that is soft and does not contain much mineral. Until we add mineral to the water, it will be difficult to successfully alter and maintain a high pH

level. So what do we do? Well it is not too hard to add mineral in the form of calcium based rock, so making soft water hard and more alkaline (higher in pH) should not be too difficult. To soften hard water, you need to take the mineral out with a water softener, reverse osmosis, or a specialized chemical that irreversibly binds up the mineral. Another option is to find a source of demineralized water for your fish tank.

Of course the alternative to all of this may be to tailor your fish and plant species around your existing water source. For beginning aquarists this may be the best solution. There are a wide variety tropical fish available and it is not difficult to find at least a dozen different species for every different type of water. Any decent book on aquariums and tropical fish will list the individual pH and hardness requirements of the different fish species.

Ammonia, nitrites, and nitrates

Ammonia, nitrites, and nitrates are all part of the breakdown of waste in an aquarium. A significant amount of fish and plant waste can accumulate in any aquarium. Uneaten food, algae, and bacteria can also contribute to the waste load in an aquarium. As in all environments, this waste needs to be broken down and either eliminated or turned into something that can be utilized by another organism. In an aquarium, there is a population of bacteria that is responsible for this process. The breakdown of waste is a four-part process.

1. First, the waste from fish, plants, and food breaks down and releases ammonia.
2. This ammonia is very toxic to fish and must be converted by bacteria to nitrite.
3. The nitrite is also toxic to fish and must then be converted to nitrate.
4. The nitrate is not nearly as toxic and is taken up by plants or algae and used to help them grow.

Nitrate, nitrite, and ammonia are also removed through the weekly water changes. Because high levels of ammonia and nitrite are lethal for fish, it is critical that these products be efficiently removed or converted to nitrate.

Maintaining a population of bacteria that can convert ammonia and nitrite is an important part of the water chemistry, and the process is known as biological filtration. Biological filtration will occur naturally in most tanks that have been up and running for a couple of months. The better filters often contain a special area or wheel that is made specifically for providing an optimal habitat for growing these bacteria. While the bacteria will live in a traditional filter and on rocks etc. in the aquarium, the new filters harbor a much higher number and can therefore do a better job of removing ammonia and nitrites.

If a fish tank is over crowded, or the waste level gets too high through overfeeding or dead fish etc., even a properly functioning biological filter can be overwhelmed and toxic conditions can result. Periodically checking the ammonia and nitrite levels in your tank with a test kit will ensure that your biological filter is working correctly. Tanks that have a healthy plant population will also aid in the removal of nitrates. Because it takes weeks to months for a tank to grow a healthy population of bacteria, it is important that a tank be allowed to age before fish are added. After the tank ages several weeks with only a few hardy fish, more fish can be slowly added over a couple of months to make sure the biological filter is not overloaded.

Copper

Copper is not found in any significant levels in most water supplies, but it can be toxic to fish if it is present in larger amounts. In homes that have uncoated copper plumbing and soft water, a small amount of copper may leach into the water supply. In addition, some parts of the country will also have a small percentage of copper in their water source. There are commercial test kits available for copper if you feel that your water may contain copper. Polyfilters, chemical copper removers (e.g., CuprisorbTM by Seachem), or an alternate water source are the current recommendations for eliminating copper.

Nitrate

High levels of nitrate can be present in the water of wells contaminated from fertilizer, agricultural run off, or sewage. These nitrates are dangerous to humans as well as livestock. Nitrates can be removed by reverse osmosis or specialized nitrate removing chemicals.

Chlorine

Chlorine is commonly added to water supplies to disinfect the water and can be harmful to fish. It can be removed with chemical chlorine eliminators or by aerating the water in a bucket over night.

Chloramine

Some municipal water treatment companies use chloramine in place of chlorine. It is a combination of chlorine and ammonia and is harmful to fish and must be removed. Standard dechlorinating agents will not remove chloramine. A chloramine remover must be used to treat this water.

Understanding water chemistry does not have to be difficult, and because of the completely enclosed environment of a fish tank, it is very important. Even small changes in water hardness, pH, and ammonia can be stressful or harmful to your fish. By knowing exactly what type of water your fish require, and then maintaining that water quality, you can greatly enhance the health and longevity of your fish.