UNDERSTANDING WATER HARDNESS

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Water hardness is important to fish culture and is a commonly reported aspect of water quality. It is a measure of the quantity of divalent ions (for this discussion, salts with two positive charges) such as calcium, magnesium and/or iron in water. There are many different divalent salts; however, calcium and magnesium are the most common sources of water hardness.

Hardness is traditionally measured by chemical titration. The hardness of a water sample is reported in milligrams per liter (same as parts per million, ppm) as calcium carbonate (mg/l $CaCO_3$). Calcium carbonate hardness is a general term that indicates the total quantity of divalent salts present and does not specifically identify whether calcium, magnesium and/or some other divalent salt is causing water hardness. Hardness can be a mixture of divalent salts. In theory, it is possible to have water with high hardness that contains no calcium. Calcium is the most important divalent salt in fish culture water.

Calcium has an important role in the biological processes of fish. It is necessary for bone formation, blood clotting and other metabolic reactions. Fish can absorb calcium for these needs directly from the water or food. The presence of free (ionic) calcium at relatively high concentrations in culture water helps reduce the loss of other salts (e.g. sodium and potassium) from fish body fluids (i.e. blood). Sodium and potassium are the most important salts in fish blood and are critical for normal heart, nerve and muscle function. In low calcium water, fish can lose (leak) substantial quantities of these salts into the water. Fish must then use energy supplied by their feed to re-absorb lost salts. That can reduce the energy available for growth and may extend the time necessary to grow fish to market size. For some species (e.g. red drum and striped bass), environmental calcium is required for good survival.

It is easy to see that the presence of calcium in water for fish culture is important. A low $CaCO_3$ hardness value is a reliable indication that the calcium concentration is low. However, high hardness does not necessarily reflect a high calcium concentration. A high hardness reading could result from high magnesium concentrations with little or no calcium present. Since limestone commonly occurs in the soil and bedrock of Kentucky, it would be reasonably safe to assume that high hardness readings reflect high calcium levels.

A $CaCO_3$ value of 100 mg/l would represent a free calcium concentration of 40 mg/l (divide $CaCO_3$ value by 2.5) if hardness is caused by the presence of calcium only. Similarly, a $CaCO_3$ value of 100 mg/l would represent a free magnesium value of 24 mg/l (divide $CaCO_3$ value by 4.12) if hardness is caused by magnesium only. Where hardness is caused by limestone, the $CaCO_3$ value usually reflects a mixture of free calcium and magnesium with calcium being the predominant divalent salt.

Hardness is commonly confused with alkalinity. Alkalinity is a measure of the amount of acid (hydrogen ion) water can absorb (buffer) before achieving a designated pH. The problem relates to the term used to report both measures, $CaCO_3$ in mg/l. Just as with hardness, mg/l $CaCO_3$ alkalinity is a general term used to express the total quantity of base (hydrogen ion acceptors) present. If limestone is responsible for both hardness and alkalinity, these values will be similar if not identical. However, where sodium bicarbonate ($NaHCO_3$) is responsible for high alkalinity it is possible to have low hardness and low calcium. Acid ground or well water has little or no alkalinity and can have low or high hardness.

An acceptable range for free calcium in culture waters is 25-100 mg/l (63-250 mg/l $CaCO_3$ hardness). Channel catfish can tolerate low calcium concentrations as long as their feed contains a minimum level of mineral calcium. However, they may grow more slowly under these conditions. If striped bass, trout, salmon or red drum culture is being considered, free calcium concentrations in the 40-100 mg/l range (100-250 mg/l as $CaCO_3$ hardness) are more desirable. Tests specific for calcium should be performed on samples of the water source being considered for these fishes.

Agricultural limestone can be used to increase calcium concentrations in areas with acid waters or soils. Agricultural gypsum or food grade calcium chloride could be used to raise calcium levels in soft, alkaline waters. Expense may be prohibitive when large volumes of water need treatment. At a pH of 8.3 or greater, calcium will come out of solution as an insoluble carbonate (limestone). Likewise, agricultural lime will be insoluble in waters with that pH range. Identifying a suitable water source may be more practical.