Alkalinity and Hardness in Production Ponds

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Alkalinity and hardness are both important components of water quality. However, these two aspects of water chemistry are commonly confused. The confusion relates to the term used to report these measures, ppm $CaCO_3$ (same as mg/L). Total alkalinity indicates the quantity of base present in water -- bicarbonates, carbonates, phosphates, hydroxides, etc. Hardness represents the overall concentration of divalent salts (calcium, magnesium, iron, etc.) but does not identify which of these elements is/are the source of hardness. It is important to recognize the difference between hardness and total alkalinity when farming aquatic animals.

The determination of whether water is acid, neutral or base is defined by pH. However, alkalinity measures the total amount of base present and indicates a pond's ability to resist large pH changes, or the "buffering capacity." The most important components of alkalinity are carbonates and bicarbonates. The total alkalinity concentration should be no lower than 20 mg/L $CaCO_3$ in production ponds. Pond pH can swing widely during the day, measuring from 6 to 10, when alkalinity concentrations are below this level (Fig. 1). Large daily changes in pH can cause stress, poor growth and even death of the farmed animals. Most aquatic organisms can

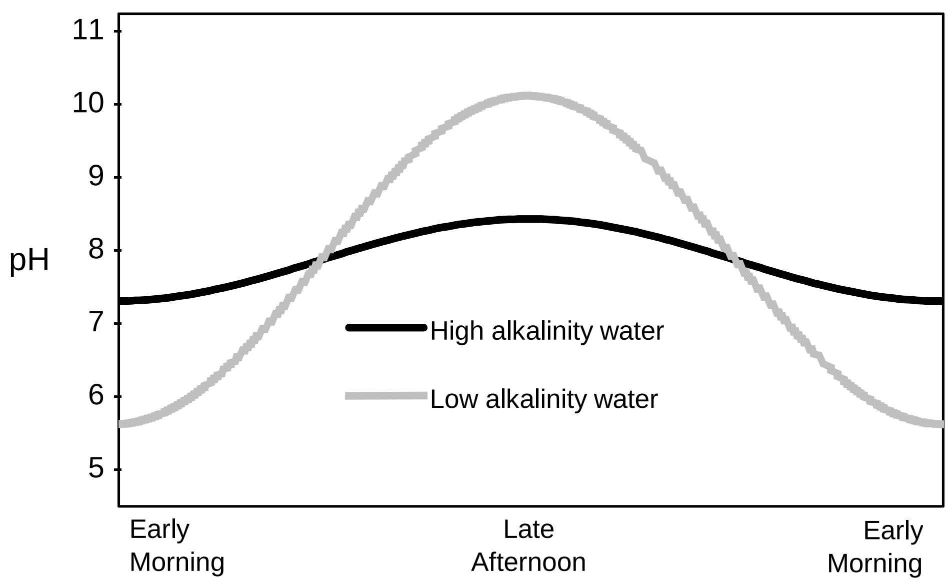

Fig. 1. Changes in pH during a 24-hour period in waters of high and low total alkalinities (Wurts and Durborow, 1992).

live in a broad range of alkalinity concentrations. The desired total alkalinity level for most aquaculture species lies between 50-150 mg/L $CaCO_3$, but no less than 20 mg/L.

Hardness is also important to aquaculture. Calcium and magnesium are the most common sources of water hardness. Calcium and magnesium are essential in the biological processes of aquatic animals, for example, bone and scale formation in fish. The critical component of total hardness is the calcium concentration, or “calcium hardness.” Environmental calcium is crucial for osmoregulation, that is, maintaining precise levels of internal salts for normal heart, muscle and nerve function. Calcium is also important in the molting process of shrimp and other crustaceans, and can affect the hardening of the newly formed shell. Aquatic animals can tolerate a broad range of calcium hardness concentrations. A desirable range would lie between 75 and 200 mg/L $CaCO_3$.

Increasing Alkalinity and Hardness

If alkalinity and hardness concentrations are below the suggested level, both can be increased by adding agricultural limestone [$CaCO_3$ and $CaMg(CO_3)_2$]. Agricultural limestone will not increase pH beyond a maximum of 8.3. The use of hydrated lime ($CaOH_2$) or quick lime (CaO) is not recommended because either of these compounds can cause the pH to rise very rapidly, to levels that are harmful to aquatic life. The most reliable way to determine the amount of agricultural limestone needed is to take several soil samples from the pond bottom. Collect the samples as you would for cropland and submit them to your county extension agent or a university soils lab for analysis. To get the correct recommendation, request the liming requirement suggested for “alfalfa production.” The amount of agricultural limestone needed to grow alfalfa should equal the minimum required for the production of most aquatic animals. The best (and easiest) time to lime your pond is before you fill it with water. Agricultural limestone should be distributed as evenly as possible over the entire pond.

When pond alkalinity concentrations are below 50 mg/L, agricultural limestone can be used to raise alkalinity and hardness. If total alkalinity is above 50 mg/L, adding agricultural limestone will not be effective. In this situation, or where hardness is not caused by calcium, adding agricultural gypsum (calcium sulfate) is an effective method of increasing calcium hardness to the desired concentrations. The addition of 5.0 lb of agricultural gypsum per acre-foot of water will raise calcium hardness, and total hardness, approximately 1.0 ppm $CaCO_3$. It is important to match calcium hardness with total alkalinity concentrations to help stabilize pond pH – this prevents pH from climbing too high.

Effects on Pond Productivity

Another benefit of using agricultural gypsum is that it can help to settle muddy water. By clearing the water, gypsum improves light penetration, which is critical to phytoplankton growth. Phytoplankton are microscopic aquatic plants that are responsible for most of the dissolved oxygen present in production ponds. In muddy or turbid water, light can not penetrate to any appreciable depth. This inhibits photosynthesis and aquatic plant growth, and can reduce daytime dissolved oxygen levels. These tiny plants absorb most of the toxic, nitrogen wastes produced by aquatic animals under intensive culture conditions. The effects of agricultural gypsum on water clarity can improve plant growth, primary productivity and water quality. It is important to note that adding phosphorus to ponds immediately after applying gypsum can result in phosphorus combining with calcium, causing both to drop out of solution as calcium phosphate. The addition of phosphorus based fertilizers should be delayed for several weeks following the application of agricultural gypsum.

Similarly, alkalinity has indirect effects on "primary productivity" or phytoplankton growth. In low alkalinity aquatic environments, certain nutrients are unavailable to aquatic plant life. Phosphorus fertilizers are relatively insoluble when alkalinity concentrations are below 20 mg/L $CaCO_3$. Liming with agricultural limestone increases total alkalinity, augmenting the availability of phosphorus for phytoplankton growth. Pond fertility is improved and primary productivity increases which, in turn, can lower toxic, nitrogen wastes and elevate daytime dissolved oxygen concentrations. Attentiveness to hardness and alkalinity concentrations, with periodic sampling and concentration adjustments, can profoundly affect water quality and overall pond productivity.

Reference

Wurts, W. A. and R. M. Durborow. 1992. Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds. *Southern Regional Aquaculture Center* Publication No. 464.