WATER ALKALINITY IN THE CULTIVATION OF MARINE SHRIMP
Litopenaeus vannamei

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Definition
Total alkalinity is a measure of the capacity of water to neutralize acids. It also indicates the total amount of titratable bases in the water, mostly bicarbonates (HCO$_3^-$), carbonates (CO$_3^{2-}$) and hydroxides (OH$^-$). Bicarbonate is the main form of alkalinity. Carbonate and hydroxide can be significant in the face of high algal activity, certain water types, or certain water residues.

In a *L. vannamei* culture pond, water alkalinity should not be less than 80 mg/L CaCO$_3$ if good growth/survival rates are to be obtained (Limsuwan, 2005). When water alkalinity is low, broad pH variations occur (Figure 1) resulting in shrimp stress, reduced growth, and even mortality.

Figure 1. pH changes during a 24-h period in waters with total high or low alkalinity levels (Wurts & Durbrow, 1992.)
**High alkalinity**

During periods of rapid photosynthesis resulting from dense phytoplankton populations, alkalinity is dramatically increased (pH > 9.0) due to excess carbonate release from bicarbonates:

\[ 2\text{HCO}_3^- + \text{phytoplankton} = \text{CO}_2 \text{(photosynthesis)} + \text{CO}_3^{2-} + \text{H}_2\text{O} \]

\[ \text{CO}_3^{2-} + \text{H}_2\text{O} = \text{HCO}_3^- + \text{OH}^- \]

High alkalinity levels (200 - 300 mg/L CaCO₃) with pH levels >8.5 halt shrimp molting process due to excess salt losses.

Reducing phytoplankton populations by major water exchange or applying algicidal products can result in lower alkalinity levels, even though the latter is not recommended, due to dissolved oxygen losses which can be too stressful for shrimp.

The application of calcium carbonate can also aid to decrease alkalinity since it is a source of calcium. This treatment will tend to decrease potentially high pH levels during photosynthesis, since increased calcium ion concentrations will result in the precipitation of both calcium carbonate and inorganic phosphorus. Both events cause decreased pH.

**Low alkalinity**

Low alkalinity can result from the inflow of low alkalinity fresh water and/or from the presence of mollusks such as mussels that absorb carbonated salts and filter the phytoplankton in the water column as a feed source, resulting in crystal clear, low alkalinity water.

Sodium bicarbonate and slaked (hydrated) lime are the most appropriate chemicals for the control of low alkalinity. Even though slaked lime is most popular, we should also remember that the use of balanced feeds results in increased alkalinity due to the production of carbonate ions.

**Water alkalinity and hardness**

The concepts of water alkalinity and water hardness are frequently confused. The origin of this confusion is that both parameters are expressed in terms of mg/L carbonate. Nevertheless, alkalinity measures the amount of bases (such as carbonates, bicarbonates, phosphates, hydroxides, etc.) present in the water, while water hardness represents the total concentration of bivalent salts (calcium, magnesium, iron, etc.), but it does not explain which of these elements is the source of hardness. Both calcium and magnesium are the most common sources of water hardness, but calcium is most important for shrimp because of its involvement in the molting process. The desirable hardness level for shrimp aquaculture is 80-200 mg/L CaCO₃.
The effects of alkalinity on pond's primary productivity

Alkalinity has indirect effects on the primary productivity in the pond. At low alkalinity levels, some elements are no longer available for microalgae. Phosphorus fertilizers become insoluble when CaCO$_3$ concentrations drop below 20 mg/L. In such case, the application of lime is required aiming to increase total alkalinity thus improving phosphorus availability for phytoplankton bloom.

Conclusion

In shrimp aquaculture, alkalinity has shown to be a major factor to attain good production. Measuring this parameter weekly is important for shrimp farming, but in the face of mollusk (i.e., mussel) fouling or low salinity/low alkalinity water inflow, alkalinity should be measured more frequently. It is also important to master the management practices needed for a pond with high or low alkalinity levels. The appropriate monitoring of water alkalinity and its effect on the health of *L. vannamei* will make the difference in terms of production bottom line.

References


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