pH in Fish Farming

Application Note

Introduction

Importance of Water Quality in Aquaculture

Fish perform all their bodily functions in water. Because fish are totally dependent upon water to breathe, feed and grow, excrete wastes, maintain a salt balance, and reproduce, understanding the physical and chemical qualities of water is critical to successful aquaculture. To a great extent water determines the success or failure of an aquaculture operation.

Very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic organisms. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may die at these low pH values.

High pH levels (9-14) can harm fish by denaturing cellular membranes. Changes in pH can also affect aquatic life indirectly by altering other aspects of water chemistry. Low pH levels accelerate the release of metals from rocks or sediments in the stream. These metals can affect a fish's metabolism and the fish's ability to take water in.

High pH Levels Effect

At high pH (>9) most ammonium in water is converted to toxic ammonia (NH3) which can kill fish. Moreover, cyanobacterial toxins can also significantly influence fish populations.

NOTE: One critical parameter is pH: Not only for the health of the fish, but for the bacteria have that cleaned up the water as well as nitrifiers that remove excess nutrients.

pH is important in aquaculture as a measure of the acidity of the water or soil. Fish cannot survive in waters below pH 4 and above pH 11 for long periods. The optimum pH for fish is between 6.5 and 9. Fish will grow poorly and reproduction will be affected at consistently higher or lower pH levels

The Effects of pH on Warm-Water Pond Fish	
pH	**Effects on fish**
4	Acid death point
4 to 5	No reproduction
4 to 6.5	Slow growth
6.5 to 9	Desireable ranges for fish reproduction
9 to 10	Slow growth
≥11	Alkaline death point

Ammonia

Fish excrete ammonia and lesser amounts of urea into the water as wastes. Two forms of ammonia occur in aquaculture systems, ionized and un-ionized. The un- ionized form of ammonia (NH_3) is extremely toxic while the ionized form (NH_4^+) is not. Both forms are grouped together as "total ammonia." Through biological processes, toxic ammonia can be degraded to harmless nitrates.

In natural waters, such as lakes, ammonia may never reach dangerous high levels because of the low densities of fish, But the fish farmer must maintain high densities of fish and, therefore, runs the risk of ammonia toxicity. Un- ionized ammonia levels rise as temperature and pH increase (Table 1).

Table 1 - Percentage of total ammonia that is unionized at various temperatures and pH.

pH	**12.2 degC**	**16.7 degC**	**20 degC**	**23.9 degC**	**27.8 degC**	**32.2 degC**
7.0	0.2	0.3	0.4	0.5	0.7	1.0
7.4	0.5	0.7	1.0	1.3	1.7	2.4
7.8	1.4	1.8	2.5	3.2	4.2	5.7
8.2	3.3	4.5	5.9	7.7	11.0	13.2
8.6	7.9	10.6	13.7	17.3	21.8	27.7
9.0	17.8	22.9	28.5	34.4	41.2	49.0
9.2	35.2	42.7	50.0	56.9	63.8	70.8
9.6	57.7	65.2	71.5	76.8	81.6	85.9
10.0	68.4	74.8	79.9	84.0	87.5	90.6

To determine un-ionized ammonia concentration, multiply total ammonia concentration by the percentage which is closest to the observed temperature and pH of the water sample. For example, a total ammonia concentration of 5 ppm at pH 9 and 20 deg C would be: 5 ppm total ammonia X 28.5% = 1.43 ppm.

Toxicity levels for un-ionized ammonia depend on the individual species; however, levels below 0.02 ppm are considered safe. Dangerously high ammonia concentrations are usually limited to water recirculation system or hauling tanks where water is continually recycled and in pond culture after phytoplankton die-offs. However, the intermediate form of ammonia--nitrite--has been known to occur at toxic levels (brown-blood disease) in fish ponds.

Buffering Systems

A buffering system to avoid wide swings in pH is essential in aquaculture. Without some means of storing carbon dioxide released from plant and animal respiration, pH levels may fluctuate in ponds from approximately 4-5 to over 10 during the day. In recirculating systems constant fish respiration can raise carbon dioxide levels high enough to interfere with oxygen intake by fish, in addition to lowering the pH of the water.

pH

The quantity of hydrogen ions (H+) in water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. A value of 7 is considered neutral, neither acidic or basic; values below 7 are considered acidic; above 7, basic. The acceptable range for fish culture is normally between pH 6.5- 9.0.

Alkalinity

Alkalinity is the capacity of water to neutralize acids without an increase in pH. This parameter is a measure of the bases, bicarbonates (HCO_3^-), carbonates (CO_3^{2-}) and, in rare instances, hydroxide (OH^-). Total alkalinity is the sum of the carbonate and bicarbonate alkalinities. Some waters may contain only bicarbonate alkalinity and no carbonate alkalinity. The carbonate buffering system is important to the fish farmer regardless of the production method used. In pond production, where photosynthesis is the primary natural source of oxygen, carbonates and bicarbonates are storage area for surplus carbon dioxide. By storing carbon dioxide in the buffering system, it is never a limiting factor that could reduce photosynthesis, and in turn, reduce oxygen production. Also, by storing carbon dioxide, the buffering system prevents wide daily pH fluctuations. Without a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night-time pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and, as a result, drive the pH levels above 10. As discussed, fish grow within a narrow range of pH values and either of the above extremes will be lethal to them.

In recirculating systems where photosynthesis is practically non-existent, a good buffering capacity can prevent excessive buildups of carbon dioxide and lethal decreases in pH. It is recommended that the fish farmer maintain total alkalinity values of at least 20 ppm for catfish production. Higher alkalinities of at least 80-100 ppm are suggested for hybrid striped bass. For water supplies that have naturally low alkalinities, agriculture lime can be added to increase the buffering capacity of the water.

Why Lime?

Several factors contribute to lowering the pH in ponds. Rain is acidic, usually with a pH of 5.2 to 5.6, and industrial pollution can lower it to 2.5. In areas with coniferous forests, rain percolates through the pine needles, making it even more acidic. Over time, this leaches all the minerals out of the soil. Also, the clay bottom necessary to keep a pond from leaking is acidic, and decaying plants can release additional acids. Agricultural lime is crushed limestone (calcium carbonate), which will neutralize these acids and act as a buffer to keep the pH from changing rapidly. Fish can live in water with a wide range of pH, from about 4 to 10. However, rapid changes in pH can kill fish, even within this range. While fish can adjust their body chemistry to different environmental pH values, this takes energy which could otherwise be used for growth and reproduction. Maintaining a constant internal pH in an extreme environment causes fish stress, making them susceptible to disease and parasites. In a limed pond, the fertilizer element phosphorus is in the soluble, orthophosphate form that is available to plankton; otherwise, it will be mostly tied up in bottom sediments. Finally, liming can increase the amount of carbon dioxide in water, which is used in photosynthesis. For these reasons, liming ponds has been shown to double bluegill production in ponds, without adding any fertilizer.

Summary

Measurement points: In tank

Typical problems: Installation of pH sensor at right measuring point

Remedies: Using immersion fitting with 2" pipe mounting accessories support This crucial levels of pH can be measured by using Yokogawa's 4-wire/2-wire pH Analyser with suitable immersion fitting and sensor. For cleaning one has to take out pH sensor and then put back the cleaned sensor. The pH sensor will be a combination electrode having double junction electrodes, which provide long time stability and a prolonged lifetime.

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