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LIMING YOUR POND TO IMPROVE THE FISHERY

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INTRODUCTION

Adding crushed agricultural limestone (calcium carbonate), or “liming,” is a relatively inexpensive, well-known, and highly discussed management practice to enhance crop productivity in both acidic soil and water. Similar to vegetable crops, fish crops may also need to have their water fertilized to improve primary food production from the pond and stabilize water chemistry.

The soil type and associated soil chemistry within a pond system and surrounding ecosystem strongly influence the overall water chemistry found in an established pond. Most ponds on the eastern side of Texas are located in regions containing acidic soils. In this region, common soil types are various combinations of loam containing sand, silt, and clay particles, with added clay to seal the pond when necessary. This composition, combined with the acidic soils in the watershed, leaves ponds slightly acidic and typically needing a liming product on a regular basis—generally, every 2 to 5 years, depending on soil type and pH. Central and western areas of Texas commonly have limestone bedrock, which is basic on the pH scale, and ponds in these regions less commonly need to be limed.

Liming directly increases alkalinity, and the total concentration of bases is usually made up of bicarbonate and carbonate. Alkalinity concentrations are important in any fishery because they indicate the water’s ability to neutralize acid and stabilize pH. Primary productivity, which is a measure of planktonic algae production that forms the basis of a pond’s food chain, becomes limited when the total alkalinity falls below 30 parts per million (ppm; Fig. 1). Not only is alkalinity important as a carbon source for phytoplankton (microscopic, unicellular algae) during photosynthesis, it also affects nutrient availability during fertilization programs, so it is highly correlated with food and subsequent fish production in ponds.

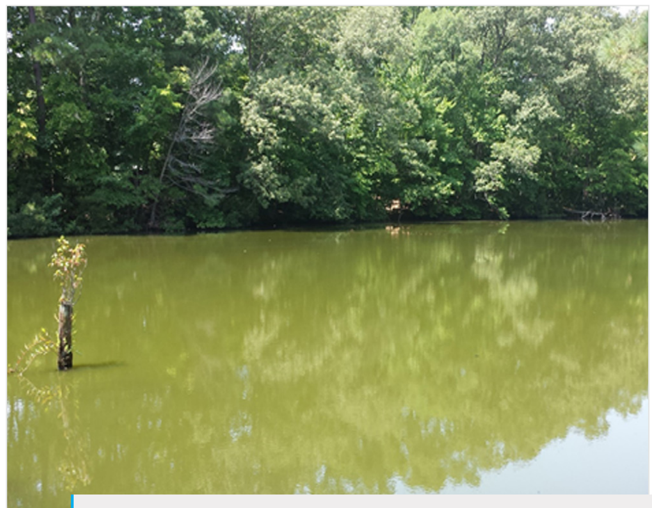

Figure 1. The green color of this pond indicates high primary productivity, which is a measure of planktonic algae production that forms the basis of a pond’s food chain. Adequate alkalinity of greater than 30 ppm is required to maintain good primary productivity.
Photo courtesy of Bob Lusk, www.pondboss.com.

The desired alkalinity range in a fishery is 50 to 150 ppm and a pH of 6.5 to 9.0. Alkalinity below 20 ppm can affect food production in the pond, fish growth, and fish health, and leads to poor recruitment as eggs are especially sensitive and larval survival is reduced. While alkalinity concentrations above 20 ppm are acceptable for fish survival in most cases, the lower the alkalinity, the more susceptible the pond becomes to drastic pH shifts caused by photosynthesis and respiration throughout each day.

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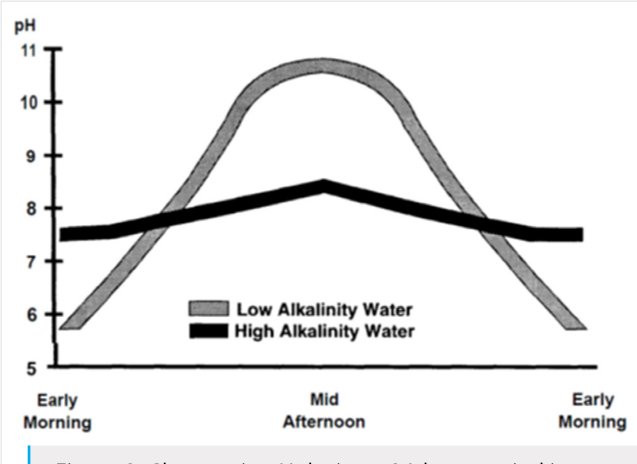

Figure 2. Changes in pH during a 24-hour period in waters of high and low total alkalinities.
Photo courtesy of Wurts, W.A. and R.M. Durborow. 1992. Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds. Southern Regional Aquaculture Center Publication No. 464.

Under sunny conditions during daylight hours, aquatic vegetation consumes carbon dioxide through photosynthesis, which can raise the pH significantly within a short period of time if alkalinity is not sufficient. On the other hand, during periods of minimal light—seen under cloudy conditions or at night—carbon dioxide is produced through respiration, which creates a more acidic environment when alkalinity is not sufficient. When this is observed throughout a 24-hour cycle, this creates a bell-shaped effect (Fig. 2), with typically the highest pH observed during midafternoon.

Aquatic Health

Some fish species are more tolerant of daily pH swings, but constant or frequent stress can increase the chances of infection, stunt growth, and limit reproduction. Rapid shifts across several pH units or reaching levels below 4.0 and above 11.0 usually result in a fish die-off across multiple species and fish age classes. In a low-pH (≤ 4.0) situation, the primary organ affected is the gill tissue because of increased mucus production limiting gas and ion exchanges. Fish fry are especially sensitive to even minimal shifts in pH. Liming to keep alkalinity within optimal ranges can safeguard a pond owner by increasing the number of carbonates that are available to bind when carbon dioxide is released through the respiration process mentioned earlier. Not only does this increase and stabilize the pH, but liming also increases calcium and magnesium concentrations, which aids in egg and fry development for fish and exoskeleton development in crustaceans.

Quick Fact:

Increasing and stabilizing pH by increasing alkalinity to acceptable ranges (≥ 20 ppm) can reduce the chances of copper toxicity to fish. Alkalinity should always be checked before applying an algaecide containing copper. Ponds with low pH have increased chances of fish kills at lower copper concentrations, and low alkalinity prolongs copper toxicity to fish and invertebrates.

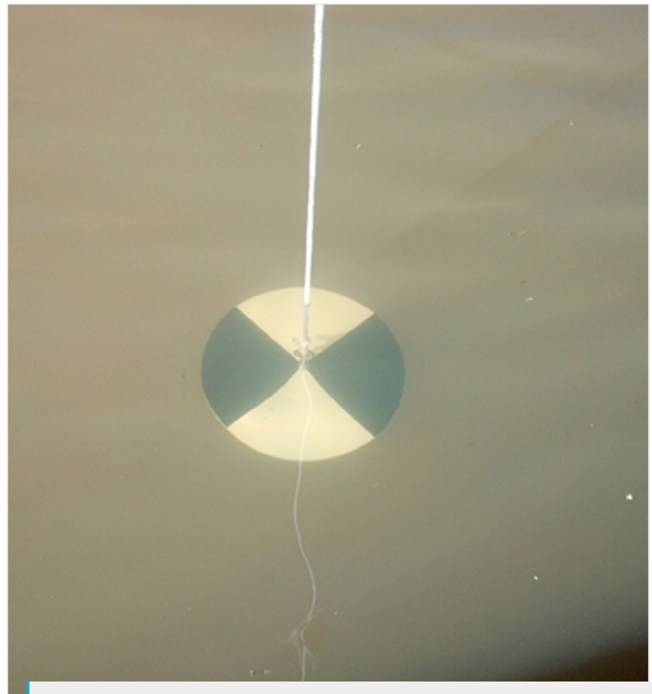

Figure 3. Ponds with high clarity, as indicated by the Secchi disk above, are generally low in alkalinity and primary productivity and could benefit from the application of lime.
Photo courtesy of Bob Lusk, www.pondboss.com.

Overall Productivity

Ponds in need of lime applications due to low alkalinity are usually very clear (Fig. 3). In general, ponds with low alkalinity are not very productive in terms of fish growth due to a reduction in nutrients resulting in little to no phytoplankton production. Phytoplankton are the basis of the pond food chain, produce a significant portion of a pond's dissolved oxygen through photosynthesis, and help shade out nuisance aquatic vegetation. Phytoplankton become limited once the alkalinity concentration drops below 30 ppm. This is due to a lack of bicarbonate and carbonate, the major components that make up alkalinity. As noted above, phytoplankton utilize carbon from bicarbonate and carbonate during photosynthesis, and when these compounds are limited, photosynthesis is reduced. Liming can increase nutrient availability—primarily phosphorus—which would otherwise be locked in acidic soils.

Figure 4. Crushed, calcitic, agricultural limestone being loaded onto a barge to apply to a pond.
Photo courtesy of Dave Beasley, www.pondboss.com.

APPLICATION

Type of limestone

Not all types of limestone (Fig. 4) have the same impacts on water chemistry and overall pond health. There are several compounds to choose from, each differing in particle size and neutralizing power. To complicate the issue further, there are multiple names for products with the same formula. Liming products include calcium carbonate (calcitic or agricultural lime), calcium carbonate + magnesium carbonate (dolomitic lime), calcium hydroxide (slaked or hydrated lime), calcium oxide (burnt or quick lime), calcium carbonate + calcium hydroxide in aqueous solution (liquid lime), etc. In most cases, pond owners will want the smallest particle size available to dissolve quickly.

Note that of the products listed, only calcium carbonate, magnesium carbonate, and liquid lime are considered safe to add to ponds containing fish (Table 1). Calcium hydroxide and calcium oxide are strong bases that can result in rapid pH increases and can cause fish kills. So, when fish are present, they should be used only sparingly in small quantities and slowly added over time. They are very useful for quickly and efficiently correcting alkalinity and pH issues in new ponds before stocking fish. Fish should not be stocked within the first week after adding quick or hydrated lime, and pH should be checked regularly. If fish have already been stocked in a pond, it is recommended to use the safer forms of lime such as calcium carbonate, calcium carbonate + magnesium carbonate, or liquid lime (Table 1).

Quick Fact:

If the alkalinity concentration is too high in a pond (>400 ppm), but the hardness is acceptable or low (<150 ppm), gypsum (calcium sulfate) can be added to precipitate excess bicarbonate as calcium carbonate (limestone) and thus lower alkalinity.

TABLE 1. COMMON NAMES, CHEMICAL COMPOSITION, FORMS AND RECOMMENDED USES FOR VARIOUS TYPES OF LIME USED TO ADJUST ALKALINITY IN PONDS.

LIME TYPE			
COMMON NAME	CHEMICAL COMPOSITION	FORM	SAFETY & USE
Calcitic lime or agricultural limestone	calcium carbonate; $CaCO_3$	powdered, crushed, pelletized	Recommended for use in ponds containing fish
Dolomitic lime	calcium carbonate + magnesium carbonate; $CaMg(CO_3)_2$	powdered, crushed, pelletized	Recommended for use in ponds containing fish
Liquid lime	calcium carbonate + calcium hydroxide in aqueous solution; $CaCO_3$ + $Ca(OH)_2$ + H_2O	liquid	Recommended for use in ponds containing fish; large applications may be slplit into two applications, 5 days apart to improve safety for fish
Slaked or hydrated lime	calcium hydroxide; $Ca(OH)_2$	powdered, pelletized	Not recommended for use in ponds containing fish; may be used to adjust alkalinity and pH in new ponds before stocking fish
Burnt or quick lime	Calcium oxide; CaO	powdered, granular	Not recommended for use in ponds containing fish; ma be used to adjust alkalinit and pH in ponds before stocking fish

Filled ponds

For ponds already filled with water, determination of whether lime is needed and approximate application rates can be made by having a water chemistry analysis performed. The Texas A&M Aquatic Diagnostic Laboratory (ADL) performs basic water chemistry testing to determine if liming may be needed based on the water chemistry. In addition, these tests will determine how much lime is required to bring the alkalinity into the desired range to support a fishery. More information on the ADL, the tests it performs, and directions on how to take and submit a sample can be found at *https://fisheries.tamu.edu/aquatic-diagnostics-lab/.*

Figure 5. Pelletized lime is applied to a small pond from the bank using a mechanical spreader. Lime should be applied to several different points around the pond to maximize the effectiveness of the treatment.
Photo courtesy of Bob Lusk, www.pondboss.com.

Adding lime during warmer months or during a fertilization program should be avoided and will decrease overall pond productivity. As a calcium product, adding lime will precipitate phosphorus from the water, negatively impacting a fishery by reducing phytoplankton blooms. Applying during cooler months will give the lime more time to dissolve and mix throughout the pond area before upcoming spring pond management practices like fertilization, stocking, and herbicide applications. Liming should take place at least 1 month before starting any fertilization programs.

In small ponds, lime can be spread from the banks around the edge of the pond (Fig. 5), or bagged lime can be poured out of a small boat from multiple points. A common application technique is to lay a sheet of plywood, or a large tarp for larger applications like truckloads, on the bank right next to the edge of the water. The lime is then placed onto the plywood or tarp, and a 2-inch, gas-powered water pump is used to wash the lime into the pond, ensuring mixing with the water.

Figure 6. Crushed lime is loaded onto a barge to be applied to larger ponds. Since lime application may be more than a ton per acre and require the application of large quantities of material, many landowners choose to hire one of the numerous pond and lake management companies in Texas to apply lime to their ponds.
Photo courtesy of Dave Beasley, www.pondboss.com.

Place the pump intake hose into the pond, start the pump, and with the discharge hose, spray the lime in a side-to-side motion, washing it into the pond and mixing it with the water.

In larger ponds, a barge or a boat with a platform (Fig. 6) will be needed to either shovel lime into the water or to wash the lime into the water via a high-pressure hose (Fig. 7). Regardless, the key to liming is to have a uniform application, and dumping large amounts of lime in one area will result in very slow changes. Since lime application may be anywhere from 250 pounds to 2 tons per acre and require the application of large quantities of material, many landowners choose to hire one of the numerous pond and lake management companies in Texas to apply lime to their ponds. These companies have the proper equipment and experience to effectively apply lime to ponds.

Figure 7. Lime is washed from a barge using a high-pressure hose and is thoroughly mixed throughout the pond.
Photo courtesy of Dave Beasley, www.pondboss.com.

Empty ponds

The best time to apply lime is before a pond has been filled with water. This is the easiest way to bring in large equipment, like a spreader truck, and ensure the lime is evenly distributed throughout the pond area (Fig. 8). To determine if lime is needed and proper application rates, soil chemistry analysis can be performed. If the source of the water that will fill the majority of the pond is already determined (e.g., well water versus filled by natural runoff), testing the water may add some additional insight. However, exposure to the atmosphere and interactions with the pond's soil can cause water chemistry to vary, and another test should be performed 3 to 4 weeks after the pond has been completely filled.

Figure 8. Pelletized lawn lime like those shown above can be easily applied to the soil of dry ponds after construction and before filling to ensure proper alkalinity when filled. To determine the correct amount for application, soil testing must be conducted.
Photo courtesy of Bob Lusk, www.pondboss.com.

Application Rates

The amount of lime required to raise the alkalinity of a pond 1 ppm is difficult to determine because there are other water chemistry as well as biological factors present in a pond that affect alkalinity. For example, if a pond has high calcium hardness, but low alkalinity, much of the lime added will be precipitated out of the water column in the form of limestone due to the high calcium content of the water. After liming, a rapid increase in phytoplankton populations can result in a decrease in alkalinity. The calcium and magnesium content of the lime source can also affect alkalinity. So bearing this in mind, in general terms, it takes approximately 4.5 pounds of calcitic lime (calcium carbonate) to increase the alkalinity of 1-acre-foot of water 1 ppm. One-acre foot of water is 1 acre of water, 1 foot deep, or 325,851 gallons.

Example:

In this case, a pond is 3 acres with a mean depth of 8 feet, which results in 24 acre-feet of water. An alkalinity test was processed on the water sample and came back with a 19 ppm reading. So, the pond is 24 acre-feet, and alkalinity should be increased by 31 ppm to reach the minimum desirable concentration of 50 ppm.

4.5 lbs calcium carbonate/acre-ft × 24 acre-ft × 31 ppm increase = 3,348 lbs of calcium carbonate

It is important to account for other biological and chemical interactions that will take place among the soil and phytoplankton once the lime is added.

Typically, 15 to 20 percent more should be added to account for various chemical and biological reactions that will consume alkalinity, so:

3,348 lbs × 1.15 = 3,850 lbs of calcium carbonate total to treat the entire pond, or 1,283 lbs per acre.

CONCLUSION

Generally, over time, a pond will become more acidic through sequestration by plants and phytoplankton, and dilution from groundwater or surface water, including rain events. Ponds with low productivity or minimal flow or turnover rates may not need to be limed for 5 or more years. However, smaller applications can be made more frequently to maintain optimal concentrations consistently and without the large expense of larger lime applications years apart. Regardless, alkalinity and other water quality parameters should be monitored at least yearly. As rainwater moves through the atmosphere, it becomes slightly acidic with an average pH of 5.6 due to carbon dioxide being absorbed and creating carbonic acid. In more urbanized areas, rainwater becomes even more acidic due to larger concentrations of other pollutants in the immediate atmosphere forming stronger acids like sulfur and nitric acid. Liming a pond to maintain consistent and optimal alkalinity concentrations will improve ecosystem health and maximize fish growth.

SUGGESTED READINGS

Lazar, A.M., C.E. Cichra, and C. Watson. (2013). The Use of Lime in Fish Ponds. University of Florida, IFAS Extension. Retrieved from *http://agrilife.org/fisheries2/files/2013/09/The-Use-of-Lime-in-Fish-Ponds2.pdf*

Wurts, W. A., and M. P., Masser. (2013). Liming Ponds for Aquaculture. Southern Regional Aquaculture Center Pub. No. 4100. Mississippi State University, Starkville, MS. Retrieved from *http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-4100-Liming-Ponds-for-Aquaculture.pdf*