USES OF HYDRATED LIME IN FISH PONDS

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Abstract: Hydrated lime is not as suitable as agricultural limestone for increasing pH and total alkalinity in soft water ponds. However, small amounts of hydrated lime may be applied during dry summer months to increase alkalinity for several weeks in ponds that have such high water exchange rates during wetter months that conventional applications of agricultural limestone are ineffective. Hydrated lime is an effective sterilant for damp pond bottoms. It will also remove carbon dioxide from water. Hydrated lime is not an oxidizing agent, so it will not destroy organic matter in mud or water. The biochemical oxygen demand (BOD) of water may be reduced by large applications of hydrated lime because the lime increases pH to levels toxic to microorganisms. The concentration of hydrated lime necessary to reduce BOD will retard photosynthesis and will harm fish. Although hydrated lime can be used to raise pH and kill fish, its potential as a fish eradicant needs further study. Hydrated lime is not as effective as alum in coagulating clay turbidity. There is no evidence that hydrated lime will reduce problems with off-flavor in fish.

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Hydrated lime {$Ca(OH)_2$} is widely used in fish ponds. Applications of hydrated lime are effective in some usages, but not in others. Most of the uses of hydrated lime originated through practical experience rather than research. Therefore, it is not surprising that fish farmers and fisheries biologists have so many misconceptions about the value of hydrated lime applications.

The present report discusses most of the uses of hydrated lime in fish ponds. A portion of the discussion is based on literature, but in other instances, the results of some simple experiments conducted by the authors are the basis for supporting or denying alleged benefits of hydrated lime.

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Pond Liming

Liming materials are frequently added to ponds to increase the pH of waters and bottom muds and to raise the total alkalinity of waters (Boyd 1979a). Hydrated lime is a liming material and may be used for pond liming. However, large amounts of liming materials (2,000 to 10,000 kg/ha) must be applied to ponds to satisfy the lime requirements of bottom muds (Boyd 1974). Such large applications of hydrated lime will raise the pH of pond waters to levels toxic to fish. Hydrated lime may be used to lime ponds that do not contain fish and fish may be stocked as soon as pH values fall to safe levels—usually within 1 to 3 weeks during warm months. Nevertheless, the use of hydrated lime as a liming material for ponds should be discouraged because agricultural limestone is a better, safer, and more readily available liming material (Boyd 1979a).

There is one potential application of hydrated lime as a liming material for ponds. Some ponds have such high water exchange rates during winter and spring that the traditional procedure of adding agricultural limestone at 3-to 5-year intervals (Boyd 1974) is ineffective. Furthermore, it is too expensive to make large annual applications of agricultural limestone to such ponds. Small applications of hydrated lime will increase the total alkalinity of such ponds at a small cost during summer months. For example, 5 ponds at the Auburn University Fisheries Research Unit, Auburn, Alabama, were each treated with an amount of hydrated lime calculated to raise the total alkalinity to 25 mg/liter:

Hydrated lime in mg/liter = (Desired alkalinity–initial alkalinity) (0.74)

where the desired alkalinity is 25 mg/liter and 0.74 = mg/liter hydrated lime per mg/liter total alkalinity. Hydrated lime was broadcast evenly over pond surfaces on 28 June 1979. Three other ponds served as controls.

The small applications of hydrated lime (7-15 mg/liter) raised average total alkalinity values above 20 mg/liter for at least 8 weeks (Fig. 1). An alkalinity of 20 mg/liter or above is considered desirable in fertilized fish ponds (Boyd 1979a). The pH of waters did not rise above 9.5 in any of the limed ponds.

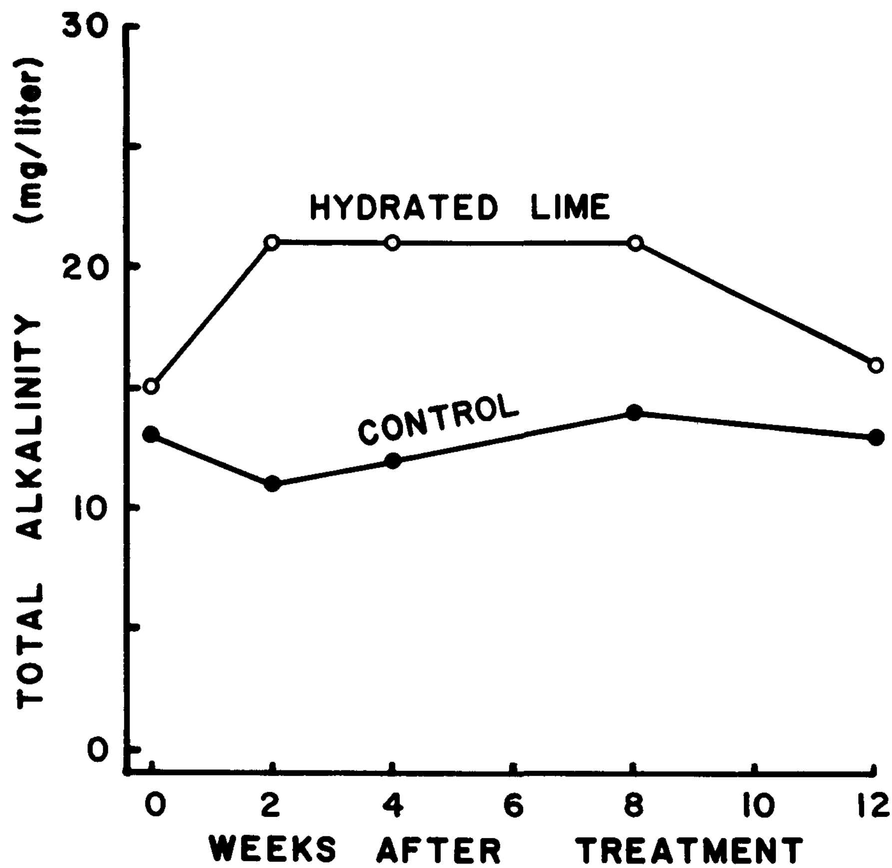

Fig. 1. Total alkalinity in 3 control ponds and in 5 ponds treated with enough hydrated lime to theoretically raise the total alkalinity to 25 mg/liter.

Sterilization of Pond Muds

Hydrated lime and quick lime (CaO) have been used to destroy parasites and other undesirable organisms in damp pond muds before ponds were refilled for stocking (Sills 1974). Usually, treatment of damp muds with 1,000 to 2,000 kg/ha of hydrated or quick lime will raise pH to toxic levels (Snow and Jones 1974, Sills 1974). A period of 10 to 14 days should pass before ponds are refilled and stocked with fish.

Decomposition Of Organic Matter In Muds

It is commonly believed that treatment with hydrated lime rapidly oxidizes accumulated organic matter in damp muds. This is obviously an erronous belief because hydrated lime is not an oxidizing agent. True, elevation of mud pH to 6.5 or 7 will increase microbial activity (Alexander 1961), but a relatively small percentage of the organic matter in damp muds will decay during a few days or weeks.

Muds from 3 ponds (A, B, and C) were air dried and passed through a 2-mm mesh screen. Soil organic matter was determined by the Walkley-Black procedure (Allison 1965). Dry muds (45 g) were placed in respiration chambers prepared from 0.95-liter Mason jars. The dry mud filled each jar to a depth of 2.5 cm and provided a surface area of 65 cm^2. Hydrated lime was applied over mud surfaces at rates equivalent to 0, 1,120, 2,240, and 4,480 kg/ha and mixed thoroughly. Two replicates of each soil were used at each treatment rate. The mixtures of hydrated lime and dry mud were then saturated with water (surfaces moist but not flooded) and pH values measured. Respiration chambers were attached to an apparatus for measuring microbial respiration (Bartholomew and Broadbent 1949). In the apparatus, carbon dioxide-free air passed through the respiration chambers and carbon dioxide from microbial respiration was swept from the chambers into Pettenkoffer tubes where it was absorbed by standard sodium hydroxide. The amounts of carbon dioxide evolved in the respiration chambers during 38 days were determined by back-titration of the alkali solutions from the Pettenkoffer tubes with standard sulfuric acid. Muds were removed from respiration chambers and pH values determined.

Muds A, B, and C contained relatively large amounts of organic matter, 4.7, 12.8, 6.1 percent, respectively. Total amounts of carbon evolved from these muds during 38 days are presented in Table 1. The highest hydrated lime rate sterilized muds A and C by elevating pH and no carbon was evolved. The greatest evolution of carbon was measured in muds with a final pH of 6.5 to 7.2 (Tables 1 and 2). Application of hydrated lime at 1,120 kg/ha raised the pH of muds A and B into the optimum pH range while mud C had an initial pH that favored rapid decomposition. Further additions of hydrated lime to the muds reduced carbon evolution.

Calculations based on the carbon content of organic matter (Jackson 1958), organic matter concentrations in muds, and amounts of carbon evolved revealed that the greatest carbon loss from any mud was 1.4 percent of the total carbon initially present. Clearly, hydrated lime treatment of muds does not result in large losses of organic matter as commonly believed. In fact, treatment with enough agricultural limestone to raise the mud pH between 6.5 and 7.2 would be just as effective as hydrated lime treatment in stimulating decomposition.

Carbon Dioxide Removal

Carbon dioxide can be removed from water by hydrated lime according to the following reactions:

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$
$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2.$$

Boyd (1979a) used the stoichiometric relationships shown above as a basis for suggesting the application of 0.84 mg/liter of hydrated lime to remove 1 mg/liter of carbon dioxide. To

Table 1. Mean amounts (± standard error) of carbon evolved in 38 days from 3 muds as affected by 4 hydrated lime concentrations. Each value represents the average for 2 replicate samples.

Mud	Hydrated lime (kg/hectare)	Carbon evolved (mg)	Carbon lost from mud[1]/ (percent of initial carbon)
A	0	7.3 ± 0.1	0.65
	1,120	9.7 ± 0.1	0.79
	2,240	5.7 ± 1.2	0.46
	4,480	0.0 ± 0.0	0.00
B	0	33.3 ± 1.1	0.99
	1,120	45.8 ± 0.8	1.37
	2,240	43.8 ± 2.8	1.31
	4,480	22.0 ± 1.1	0.65
C	0	18.8 ± 0.2	1.18
	1,120	12.7 ± 0.7	0.79
	2,240	12.5 ± 2.1	0.78
	4,480	0.0 ± 0.0	0.00

[1]/Calculations based on the carbon content of organic matter (Jackson 1958), organic matter concentrations in muds, and amounts of carbon evolved.

Table 2. Effects of 4 concentrations of hydrated lime of the pH of 3 muds.

Mud	Hydrated lime (kg/hectare)	pH	
		Immediately after treatment	38 days after treatment
A	0	4.7	5.0
	1,120	9.3	7.2
	2,240	11.2	8.2
	4,480	12.3	10.0
B	0	5.4	5.4
	1,120	9.1	7.2
	2,240	10.8	7.8
	4,480	12.1	7.9
C	0	5.6	5.6
	1,120	9.4	7.5
	2,240	11.1	8.0
	4,480	12.1	8.7

test this suggestion, 14-liter water samples containing high concentrations of carbon dioxide were treated with 0, 100, 150, and 200 percent of the amounts of hydrated lime calculated to remove all of the carbon dioxide. Hydrated lime was sprinkled over water surfaces and waters were gently stirred for a few seconds. The concentrations of carbon dioxide remaining were determined after 20 minutes.

Hydrated lime was effective in removing carbon dioxide from water (Table 3). Complete carbon dioxide removal required about twice the amount of hydrated lime calculated to theoretically effect full removal. Apparently, the hydrated lime did not dissolve completely since a residue was visible on the bottoms of the containers. Dissolution of hydrated lime would also be incomplete in ponds, so for practical purposes the amount of hydrated lime needed to remove all the carbon dioxide from water may be calculated as:

Hydrated lime in mg/liter = (1.68) (mg/liter of Co_2).

Removal of carbon dioxide is beneficial in ponds with low dissolved oxygen because carbon dioxide is antagonistic to oxygen uptake by fish (Boyd 1979a). Application of hydrated lime to remove carbon dioxide would not harm fish or other organisms because the pH would not exceed 8.3 unless excess lime was added.

Table 3. Percentages of carbon dioxide removed from water by 4 concentrations of hydrated lime. Each value represents the average for 3 replicates.

Hydrated lime[1]/ (percent of amount theoretically needed to remove all CO^2)	percent of CO_2 actually removed
0	0
100	39.7
150	78.0
200	100.0

[1]/Theoretically, 0.84 mg/liter of hydrated lime will remove 1 mg/liter of carbon dioxide.

Effect on BOD and COD

Some fish farmers apply hydrated lime to waters with low dissolved oxygen concentrations with the rationale that it will reduce the chemical and biological oxygen demands (COD and BOD), thereby alleviating dissolved oxygen crises. The influence of 0, 50, and 100 mg/liter additions of hydrated lime on BOD and COD was determined on water samples from 4 ponds with heavy plankton blooms. The appropriate amounts of hydrated lime were added to 1-liter samples in settling columns, mixed with a plunger (Boyd 1979b) and allowed to stand. The BOD, COD, and pH were measured after 24 hours.

There was a slight reduction in COD of waters in settling columns with increasing hydrated lime concentration (Fig. 2). Treatment of samples with 50 or 100 mg/liter of hydrated lime reduced COD by averages of 8.5 and 9.1 percent, respectively. The reduction in COD did not result because hydrated lime oxidized organic matter. Rather, hydrated lime caused coagulation and precipitation of some of the phytoplankton, thereby reducing the amount of particulate organic matter in the water. Application of 100 mg/liter of hydrated lime to water samples reduced BOD if the initial pH of the water was greater than 9 (Figs. 3 and 4). This reduction in BOD was apparently related to high pH after lime treatment (Fig. 4) and subsequent death of microorganisms. Calabrese (1969)

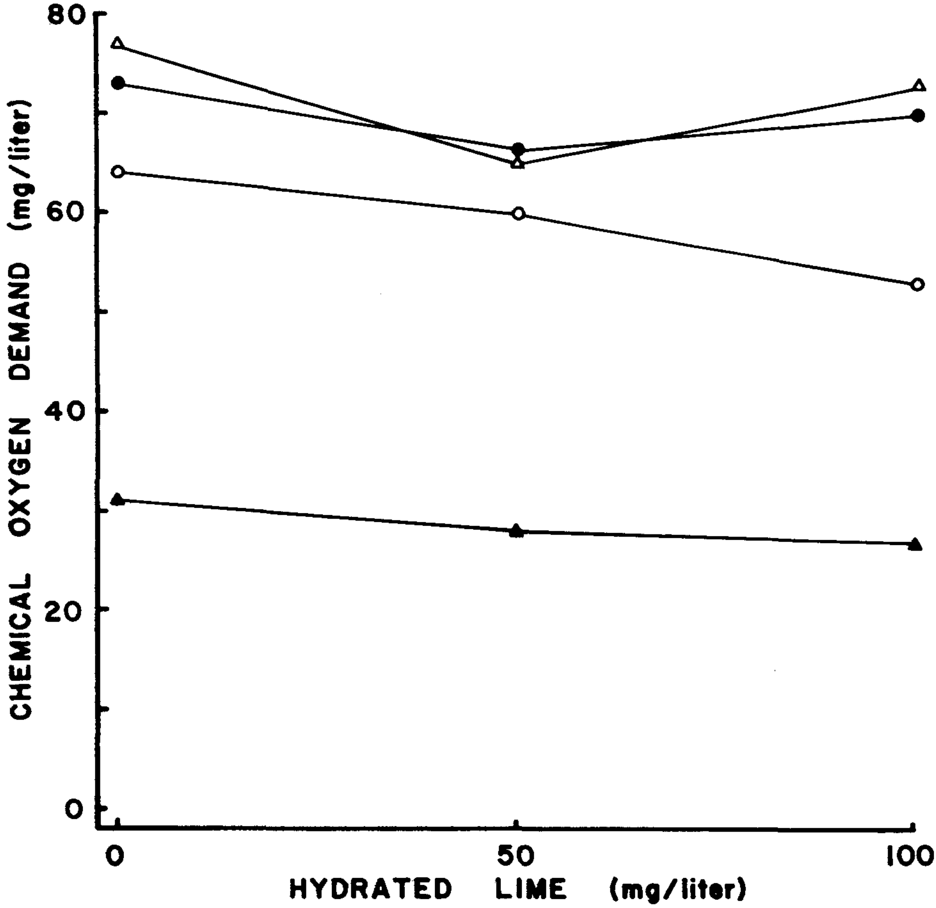

Fig. 2. Chemical oxygen demand (COD) of 4 pond water samples as affected by 3 hydrated lime concentrations. The COD was measured 24 hours after lime treatment. Each data point represents the average of 3 replicates.

indicated that pH values of 11 are lethal to fish, so the application of enough hydrated lime to reduce BOD would likely be harmful to fish.

When oxygen concentrations are low in fish ponds, any treatment that reduces oxygen production by photosynthesis is undesirable (Boyd 1979a). Therefore, an experiment was conducted to determine the effect of hydrated lime treatment on photosynthesis. Samples that had been treated with 0, 50, and 100 mg/liter of hydrated lime 24 hours previously were transferred to BOD bottles. Initial dissolved oxygen concentrations were determined and dissolved oxygen was measured again after the samples had been exposed to sunlight for 4 hours. Application of 100 mg/liter of hydrated lime essentially halted oxygen production and 50 mg/liter of hydrated lime greatly reduced oxygen production in a sample that had an initial pH above 9 (Fig. 5). Reduction in oxygen production resulted from carbon dioxide removal and from adverse effects of high pH on phytoplankton.

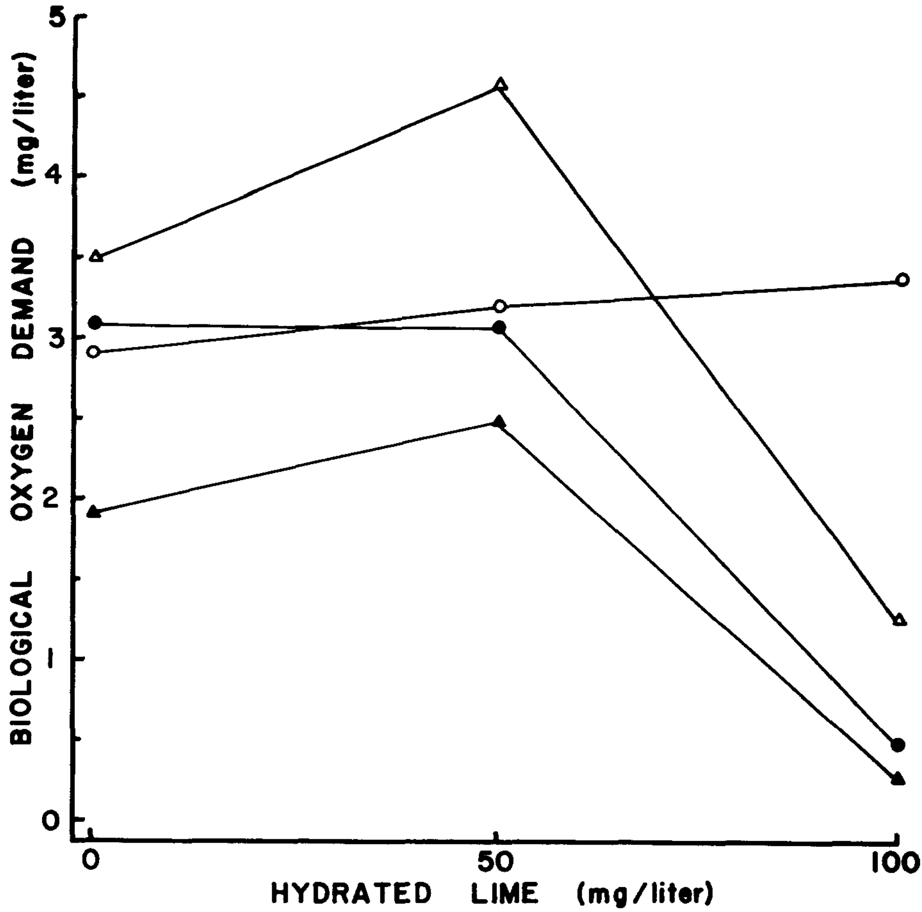

Fig. 3. Biological oxygen demand (BOD) of 4 pond water samples as affected by 3 hydrated lime concentrations. The BOD was measured 24 hours after lime treatment. Each data point represents the average of 3 replicates.

Turbidity Removal

Hydrated lime can be used as a coagulating agent to remove clay turbidity from water. However, Boyd (1979b) showed that aluminum sulfate (alum) was much more effective than hydrated lime in removing clay turbidity. In laboratory trials, 20 to 30 mg/liter of alum caused a greater reduction in clay turbidity than 100 to 1,000 mg/liter of hydrated lime. Alum concentrations of 15 to 25 mg/liter were highly effective in clearing clay turbidity from ponds, so hydrated lime was not considered a suitable coagulating agent for pond waters. Alum treatment causes a reduction in total alkalinity and pH, so in soft waters hydrated lime may be applied to counteract the influence of alum on alkalinity and pH. The application rate for neutralization is 0.40 mg/liter hydrated lime per 1.0 mg/liter of alum (Boyd 1979b).

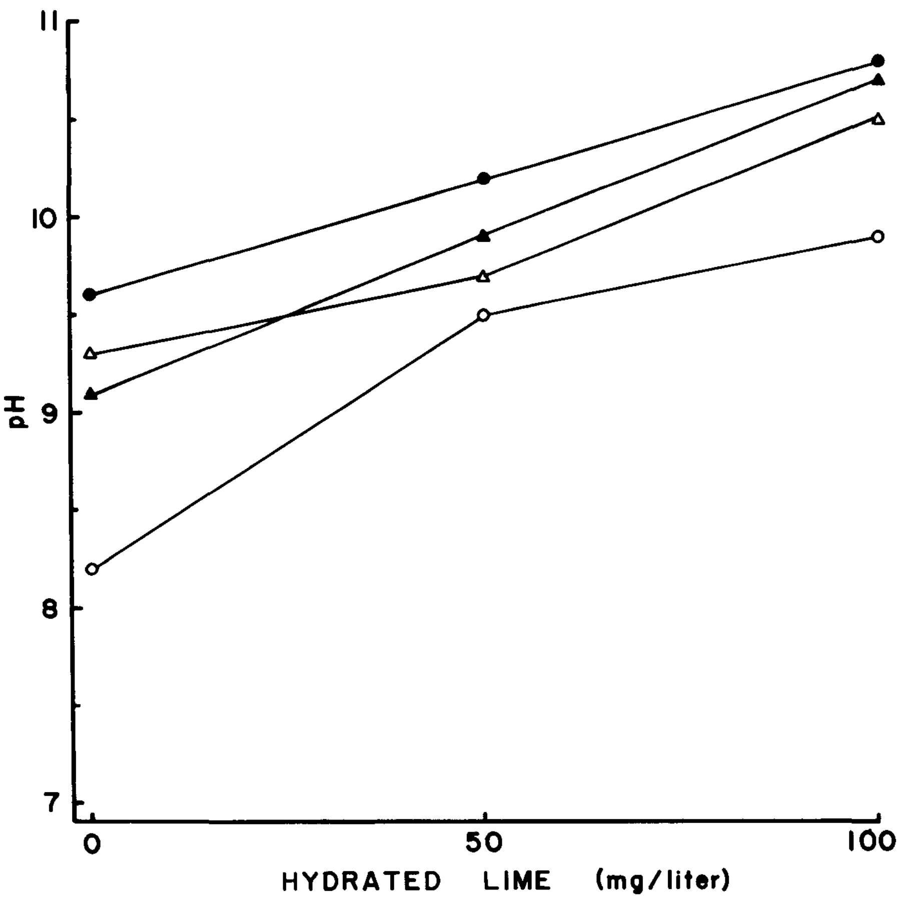

Fig. 4. The pH of 4 pond water samples as affected by 3 hydrated lime concentrations. The pH was measured 24 hours after lime treatment. Each data point represents the average of 3 replicates.

Off-Flavor

Off-flavor in fish flesh results from the absorption by fish of geosmin and related compounds that are produced by blue-green algae and actinomycetes (Lovell 1979). The only reliable means of purging off-flavor from fish is to transfer the fish to clear water or to delay harvest until the conditions responsible for off-flavor disappear through natural changes in ponds. Of course, fish farmers desire a rapid way of purging off-flavor compounds from fish before harvest. Fish farmers in Alabama and Mississippi often apply hydrated lime to ponds in attempts to combat off-flavor. Unfortunately, there is no research to verify that hydrated lime will alleviate off-flavor problems and no reason to suspect that it will.

Eradication of Wild Fish

Some biologists recommend hydrated lime for eradication of wild fish from ponds before stocking. A pH of about 11 is generally considered toxic to fish within a few hours

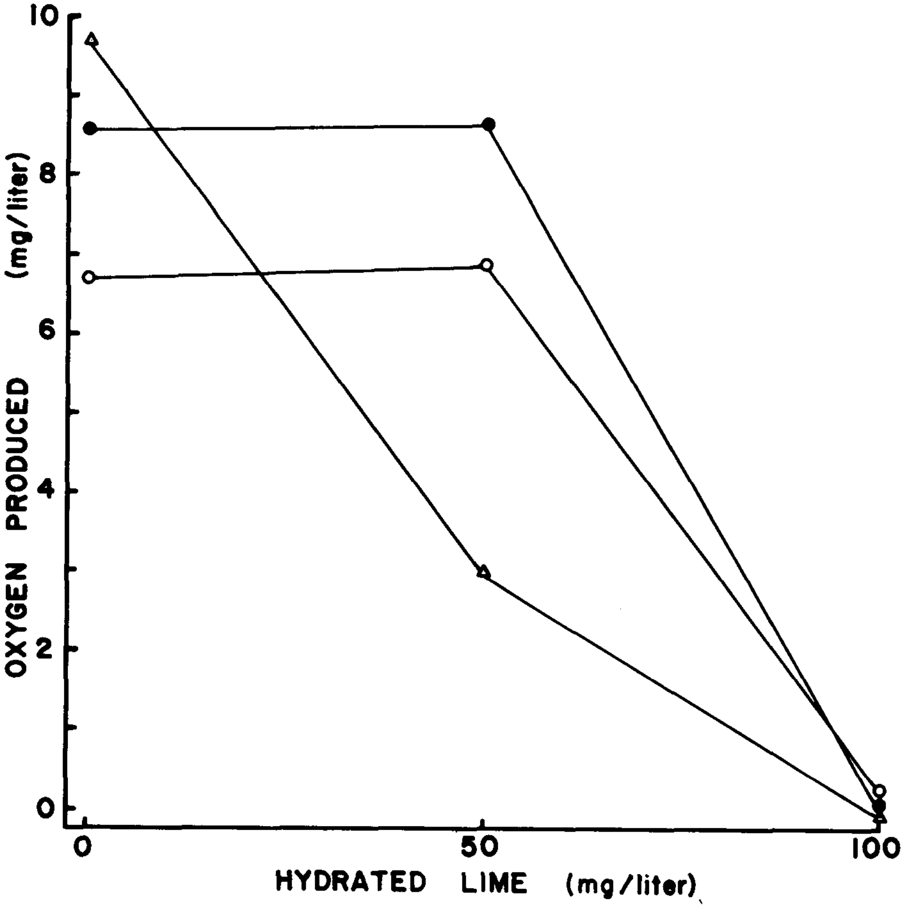

Fig. 5. Oxygen produced in 4 hours in samples of 3 pond waters that had been treated 24 hours previously with 3 concentrations of hydrated lime. Each data point represents the average of 3 replicates.

(Calabrese 1969). Therefore, water samples were treated with 0, 25, 50, 100, 150, 200, 300, 400, and 500 mg/liter of hydrated lime and pH was measured after 24 hours (Table 4). In one water, 150 mg/liter of hydrated lime raised the pH above 11, while in another water, 500 mg/liter of hydrated lime was required. The initial pH values of the samples ranged from 7.1 to 7.8. In general, the higher the initial pH, the less hydrated lime required to raise the pH to 11. In a pond, more hydrated lime would probably be required to increase pH because it would not be possible to mix the hydrated lime as thoroughly as in the laboratory systems. Because of the high treatment rates necessary to raise pH to lethal levels, hydrated lime does not appear useful as a fish eradicant unless the volume to be treated is small or a large application of hydrated lime would later be beneficial by increasing alkalinity. Pond studies should be conducted to determine the actual effectiveness of hydrated lime as a fish eradicant.

Table 4. Minimum, maximum, and mean (± standard error) pH after 24 hours for 6 water samples treated with hydrated lime.

Hydrated lime (mg/liter)	pH		
	Minimum	Maximum	Mean
0	7.4	7.9	7.5 ± 0.28
25	8.4	10.0	8.7 ± 0.25
50	8.6	10.5	9.0 ± 0.43
100	9.2	10.8	9.6 ± 1.00
150	9.8	11.1	10.2 ± 0.32
200	10.3	11.3	10.6 ± 0.18
300	10.7	11.4	10.9 ± 0.61
400	10.9	11.6	11.1 ± 0.23
500	11.1	11.6	11.3 ± 0.02

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