Influence of Particle Size of Agricultural Limestone on Pond Liming

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Abstract: A finely-pulverized agricultural limestone was much more effective than a coarse agricultural limestone in elevating the total alkalinity of ponds and of laboratory mud-water systems. The relative abilities of different particle-size classes of agricultural limestone to raise total alkalinity were determined. A method for correcting pond lime requirements for the neutralizing value and fineness of agricultural limestone was proposed.

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Agricultural limestone is often applied to sportfish ponds to increase the alkalinity and hardness of waters and to reduce the acidity of waters and muds (Boyd 1982). Agricultural limestone is prepared by pulverizing calcium carbonate or dolomite. Agronomists discovered long ago that soil acidity was neutralized faster by fine than by coarse particles of agricultural limestone; they developed a system for evaluating the fineness of agricultural limestone (Tisdale and Nelson 1956). Experience suggests that fine limestone is also better than coarse limestone for use in fish ponds. Therefore, an evaluation was conducted on the influence of particle size on the effectiveness of limestone for liming ponds.

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Methods

Agricultural limestone was obtained from 2 sources: Southern Stone Company Quarry near Auburn, Alabama, and Dolcito Quarry near Montevallo, Alabama. The neutralizing value—the amount of acid that a liming material will neutralize expressed as a percentage of acid neutralized by an equal weight of pure calcium carbonate ($CaCO_3$)—and the particle-size distribution (fineness) of each material were determined by standard procedures (Jackson 1958).

A 2-ha pond with an average depth of 2 m was treated with 4,000 kg/ha of limestone from the Dolcito Quarry, and a 1.5-ha pond with an average depth of 1.8 m received 4,000 kg/ha of limestone from the Southern Stone Quarry. The application rates were determined by the lime requirement test for pond muds (Boyd 1974). In February 1980, limestone was loaded onto a platform at the front of a boat and spread with a shovel as the boat moved over the pond surface. Water samples for total alkalinity analysis were collected at monthly intervals (February, 1980 through February, 1981).

In another trial, 11 g of agricultural limestone from each quarry were applied to mud-water systems in aquaria. Treatments and controls were replicated 3 times; alkalinity analyses were made after 8, 22, 37, and 49 days.

Limestone particles of different size classes for use in efficacy tests were prepared by sieving the coarser of the 2 limestone samples (Southern Stone Company). The particle-size classes were: <270 mesh (<0.053 mm), 100–270 mesh (0.053–0.15 mm), 60–100 mesh (0.15–0.25 mm), 20–60 mesh (0.25–0.85 mm), 10–20 mesh (0.85–2.0 mm), and >10 mesh (>2.0 mm).

In practice, the benefit of limestone applications to ponds can best be judged by the increase in total alkalinity (Boyd 1974). Hence, the effectiveness of the different size classes was determined by comparing the influences of equal amounts of each size class on total alkalinity in mud-water systems. Acidic mud (pH = 5.1) was spread in a 3-cm layer over the bottoms of aquaria, and the aquaria were filled with acidic water (pH = 5.5; total alkalinity = 1.5 mg/l as $CaCO_3$).

After 2 weeks of equilibration, the total alkalinity of water from each aquarium was determined, and 11 g of a particular size class of limestone—this amount of limestone equalled the lime requirement of the pond muds—were sprinkled over the water surface of each system. Each size class was applied to 3 aquaria; 3 aquaria served as controls. Water samples for alkalinity analysis were removed after 2, 7, 14, 28, 41, and 56 days.

Results and Discussion

The limestone from the Dolcito Quarry was much more effective than that from the Southern Stone Company Quarry in raising total alkalinity in ponds (Fig. 1) and in laboratory mud-water systems (Fig. 2). The neutralizing value of the agricultural limestone from both quarries was 102%, and limestone from both quarries had almost identical percentages of calcium and magnesium. However, the limestone from the Dolcito Quarry was much

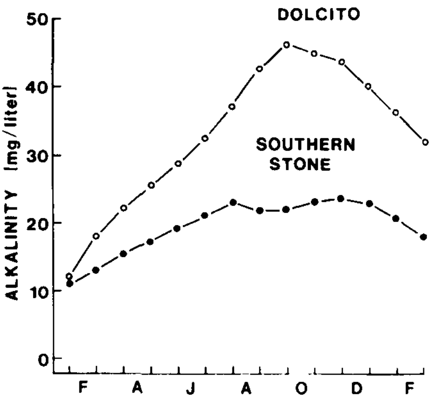

Figure 1. Total alkalinity (mg/liter as $CaCO_3$) in waters of 2 ponds following applications in late February, 1980, of agricultural limestone. Both ponds had lime requirements of 4,000 kg/ha as $CaCO_3$ and 4,000 kg/ha of limestone were applied to each. The limestone for one pond came from the Dolcito Quarry, Montevallo, Alabama, while that for the other pond came from the Southern Stone Company Quarry, Auburn, Alabama.

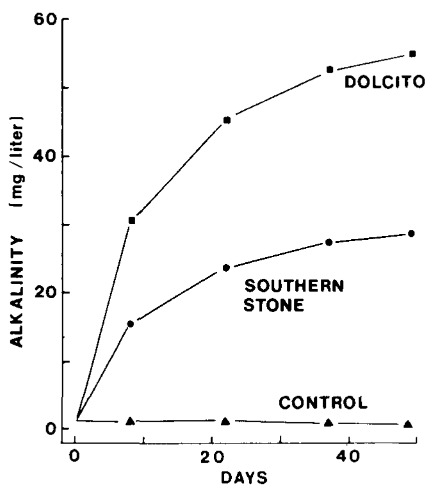

Figure 2. Effects of equal application rates of agricultural limestone on total alkalinity (mg/liter as $CaCO_3$) in laboratory mud-water systems. Waters and muds in all systems (3 replicates per treatment) had essentially identical properties before liming.

finer than the material from the Southern Stone Company Quarry (Table 1). Hence, the difference in effectiveness of the 2 agricultural limestones was related to particle size.

The different size classes (Table 1) of Southern Stone Company limestone all had neutralizing values of 102%. The increases in total alkalinity following treatment of laboratory mud-water systems with these different size classes of Southern Stone Company limestone were closely related to particle size (Fig. 3). The larger particles (>10 mesh and 10–20 mesh) were only slightly effective in increasing total alkalinity; the intermediate-sized particles

Table 1. Particle-Size Distribution of 2 Agricultural Limestones

Classification of Material by Tyler Screen Scale	Particle Size (mm)	Particle Distribution %	
		Dolcito	Southern Stone
Retained on 10 mesh	> 1.70	0.0	7.82
Retained on 20 mesh	1.69–0.85	0.04	14.03
Retained on 60 mesh	0.84–0.25	5.29	24.57
Retained on 100 mesh	0.24–0.15	44.36	16.25
Retained on 270 mesh	0.14–0.053	9.31	16.32
Passed 270 mesh	< 0.052	41.00	21.01

(20–60 mesh) had a moderate effect on alkalinity; the smaller particles (60–100 mesh, 100–270 mesh, and <270 mesh) were highly effective. Because all 3 of the smaller particle size fractions (material passing the 60-mesh screen) were highly effective in increasing alkalinity, they were grouped and the average alkalinity increase over the control after 56 days was calculated. The alkalinity increases over the control for the 3 larger particle-size fractions were also calculated. The alkalinity increases resulting from the different particle-size fractions were then expressed as percentages of the alkalinity increase caused by the particles which passed the 60-mesh screen (Table 2). The percentages were termed efficiency values (Tisdale and Nelson 1956); they may be used to compare the fineness of agricultural limestone.

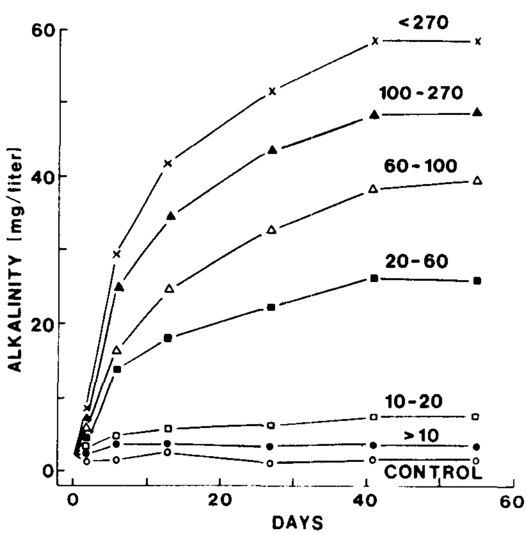

Figure 3. Effects of equal application rates of different particle-size classes of agricultural limestone on total alkalinity in laboratory mud-water systems. Waters and muds in all systems (3 replicates per treatment) had essentially identical properties before liming. All particle-size classes had the same neutralizing value (102%). The numbers above each line refer to mesh size as determined with a Tyler sieve mesh series.

Table 2. Efficiency Ratings for Different Particle-Sizes of Agricultural Limestone.

Classification of Material by Tyler Screen Scale	Particle Size (mm)	Increase in Alkalinity (mg/liter)	Efficiency[2] Rating (%)
Retained on 10 mesh	> 1.70	1.7	3.6
Retained on 20 mesh	1.69–0.85	6.0	12.7
Retained on 60 mesh	0.84–0.25	24.7	52.2
Passed 60 mesh[1]	< 0.24	47.3	100.0

[1] The average of the three smallest particle-size classes.
[2] Ratings were computed by expressing as a percentage the effectiveness of each particle-size class in raising total alkalinity of laboratory mud-water systems. The finest particles (those passing a 60-mesh screen) were the most effective and were taken as 100%.

For agricultural purposes, the influence of different particle sizes (fineness) of limestone on soil acidity is used to calculate efficiency values (Tisdale and Nelson 1956). Efficiency values and neutralizing values for a particular agricultural limestone are helpful in establishing liming rates for agricultural soils. The lime requirement of a soil is determined by a soil test and reported in kilograms per hectare of equivalent $CaCO_3$ (100% efficient in neutralizing acidity). The neutralizing value of the available limestone is used to compute the amount of limestone necessary to provide the required $CaCO_3$. The fineness data are then used to adjust the liming rate so that enough small particles will be applied to assure the neutralization of soil acidity.

The approach used for agricultural soils is also applicable in liming fish ponds. To illustrate, suppose that the lime requirement of a pond mud is 2,000 kg/ha as $CaCO_3$. The agricultural limestone available has a neutralizing value of 90% and a particle size distribution as follows: >10 mesh, 8%; 10 to 20 mesh, 14%; 20–60 mesh, 24%; <60 mesh, 54%. The total efficiency rating for the limestone may be calculated by multiplying the fraction of the sample represented by a particular size class by the efficiency rating for that size class (Table 2):

54% passes a 60-mesh	0.54 x 100 = 54.0
24% passes a 20 but not a 60 mesh	0.24 x 52.2 = 12.5
14% passes a 10 but not a 20 mesh	0.14 x 12.7 = 1.8
8% retained on a 10-mesh	0.08 x 3.6 = 0.3
Total efficiency rating	68.6

The liming rate is calculated by the following equation:

$$\text{Application rate} = \frac{\text{Liming rate as } CaCO_3 \text{ (in kg/ha)}}{\dfrac{\text{Percent neutralizing value}}{100} \times \dfrac{\text{Total efficiency rating}}{100}}$$

For the example, the rate is:

$$\text{Application rate} = \frac{2{,}000 \text{ kg/ha}}{\frac{90}{100} \quad \frac{68.6}{100}}$$

$$\text{Application rate} = 3{,}240 \text{ kg/ha}$$

In practice, the pond owner or biologist can usually obtain data on the neutralizing value of a limestone from the vendor. In some cases, it will not be possible to get particle-size data. However, a coarse limestone can be identified visually. In case particle-size data are not available, for a coarse agricultural limestone an efficiency rating of 70% may be assumed, because few commercial agricultural limestones will have efficiency ratings less than 70%.

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