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Technical Note

A SIMPLE METHOD FOR CALCULATING LIMING RATES FOR FISH PONDS*

V.K. PILLAI[1] and CLAUDE E. BOYD[2]

[1] *Central Marine Fisheries Research Institute, P.B. No. 1912, Cochin 682018 (India)*
[2] *Department of Fisheries and Allied Aquacultures, Alabama Agricultural Experiment Station, Auburn University, AL 36849 (U.S.A.)*

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ABSTRACT

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The pH change in 40 ml of buffer caused by 20 g dry soil may be multiplied by 5600 to provide the lime requirement of mud in a fish pond. The buffer contains 10 g p-nitrophenol, 7.5 g boric acid, 37 g potassium chloride, and 5.25 g potassium hydroxide dissolved and diluted to 1000 ml with distilled water; the buffer pH is adjusted to 8.00.

INTRODUCTION

For best response to fertilization, fish ponds should be limed when total alkalinity and total hardness are less than 20 mg/l as $CaCO_3$ (Thomaston and Zeller, 1961). Boyd (1974, 1976) altered a lime requirement procedure for agricultural soils (Adams and Evans, 1962) so that it could be used to estimate liming rates for fish ponds. Boyd (1974) found that total hardness and total alkalinity of pond waters exceeded 20 mg/l when the base unsaturation of muds was 0.2 or less. Furthermore, there was a strong correlation between the base unsaturation of pond muds and their pH values, and a mud pH of 6.0 corresponded to a base unsaturation of 0.2. Therefore, if the pH of a mud was known, the base unsaturation could be computed from the regression equation relating pH and base unsaturation of muds. The reduction of pH in a buffer solution caused by a known weight of dry mud provided an estimate of total exchange acidity. Neutralization of the total exchange acidity would give a base unsaturation of 0.0. Therefore, the amount of exchange acidity (in milliequivalents) which must be neutralized to lower the base unsaturation to 0.2 — this corresponds to 20 mg/l total hardness and alkalinity in pond water — was calculated as follows:

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$$\text{Acidity to be neutralized} = \frac{\text{exchange acidity}}{\text{initial base unsaturation}} \times \text{desired change in base unsaturation}$$

Boyd and Cuenco (1980) determined that agricultural limestone reacted to a depth of approximately 15 cm in pond muds over a 2-year period, and that air-dry weight of the upper 15-cm layer of mud in ponds averaged 1 400 000 kg/ha. The amount of acidity to be neutralized as estimated for the sample may be expanded to give the amount of acidity to be neutralized in the pond mud. The liming rate in kg/ha of $CaCO_3$ is calculated from the acidity. A liming factor of 1.5 is multiplied by the liming rate, because agricultural limestone is not 100% effective in neutralizing soil or mud acidity.

The method developed by Boyd (1974) has proven effective, and it has been widely used. However, the procedure was developed for ponds in Alabama, and relationships between pH and base unsaturation of muds differ geographically. For most accurate results, the relationship between pH and base unsaturation of muds should be determined for a region before the procedure is used. This is a difficult task which is often impractical. A simple method for determining the lime requirement of pond muds that does not require data on the relationship between pH and base unsaturation is presented. This method involves measuring the total exchange acidity with a buffer, and calculating the liming rate necessary to provide a base unsaturation of 0.0. Because this technique will always provide a higher liming rate than necessary, the liming factor of 1.5 is omitted.

MATERIAL AND METHODS

Pond muds were collected with an Ekman dredge from ponds in Lee and Russell Counties, Alabama. Samples were spread in thin layers on plastic sheets to air dry. Dry muds were pulverized and passed through a screen with 0.85-mm openings.

The buffer for the modified lime requirement procedure consisted of 10 g p-nitrophenol, 7.5 g boric acid, 37 g potassium chloride, and 5.25 g potassium hydroxide dissolved and diluted to 1000 ml with distilled water. The buffer was adjusted to pH 8.00 ± 0.01. Two methods for determining equilibrium pH in a mixture of 40 ml buffer and 20 g dry mud were evaluated. Mud—buffer mixtures in 125-ml Erlenmeyer flasks were agitated for 5, 10, 15, 30, 45, or 60 min at 200 rpm on a New Brunswick Model G-10 gyratory, platform shaker. The solution phase was then separated from the mud by vacuum filtration through Whatman No. 1 filter paper. The pH of the solution was measured with an Orion Model 701A pH meter. Alternatively, mud—buffer mixtures in 100-ml beakers were stirred intermittently with a glass rod, and the pH measured directly after 5, 10, 15, 30, 45, and 60 min by inserting the glass electrode directly into the mixtures.

The precision of the modified lime requirement procedure was estimated by making five replicate analyses on three mud samples. Fifteen mud samples were analyzed for lime requirement by the modified method and by the standard procedure described by Boyd (1976).

RESULTS AND DISCUSSION

Equilibrium pH is attained more quickly by mechanical agitation of the mud—buffer mixture, but equilibrium pH may also be reached by stirring intermittently for 1 h (Table I). Results shown in Fig. 1 also demonstrated that stirring for 1 h gives essentially the same equilibrium pH as attained following mechanical agitation and filtration. Although it is not necessary to remove the buffer (liquid phase) by filtration before measuring pH, it is much easier to measure pH in a solution than in the mud—buffer mixture. Stirring of the mixture with glass electrode inserted is tedious.

TABLE I

Effect of contact time on pH of buffer in mud—buffer mixtures. Samples were mechanically agitated at 200 rpm, the buffer was separated from the mud by filtration, and the pH was measured. Alternatively, the mud—buffer mixture was stirred intermittently with a glass rod and the glass electrode inserted into the mixture

Time (min)	pH	
	Mechanically agitated and filtered	Stirred
5	7.29	7.38
10	7.28	7.33
15	7.27	7.31
30	7.26	7.29
45	7.26	7.29
60	7.26	7.27

A 40-ml aliquot of the buffer was titrated with standard sulfuric acid, and the pH was measured after each addition of 0.32 milliequivalent of acid (Fig. 2). Each pH change of 0.1 unit in 40 ml of the buffer is equivalent to 0.16 milliequivalent of acidity over the pH range of 6.4 to 8.0. At lower pH values, buffering capacity is not constant.

The modified lime requirement procedure consisted of weighing 20 g of air-dry mud that passed a 0.85-mm screen into a 100-ml beaker and adding 40 ml of buffer. The mixture was stirred intermittently for 1 h and the pH was measured to the nearest 0.01 pH unit with a glass electrode. Alternatively, the mixture may be agitated mechanically, and the buffer may be filtered from the mud to make pH determination easier. If the equilibrium pH is less than 6.8, the procedure should be repeated using half as much dry mud. The

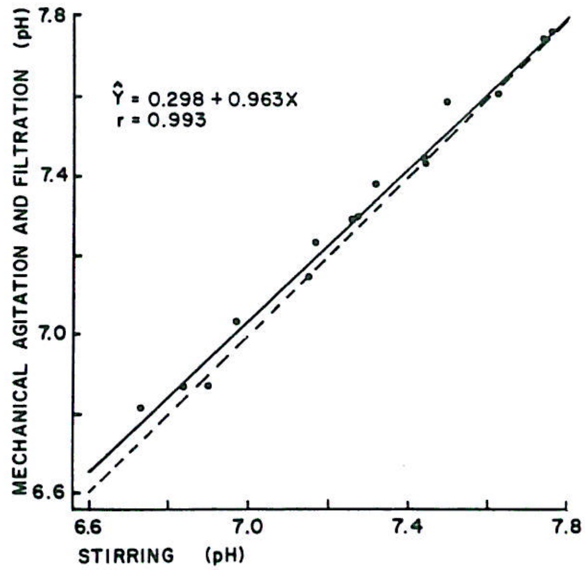

Fig. 1. Equilibrium pH of buffer in mud—buffer mixtures. Stirring: mixtures were stirred intermittently for 1 h with glass rod and glass electrode inserted into mixture. Mechanical agitation and filtration: mixtures were agitated at 200 rpm for 1 h on a mechanical shaker, buffer separated from mud by filtration, and buffer pH determined. Dashed line represents perfect agreement.

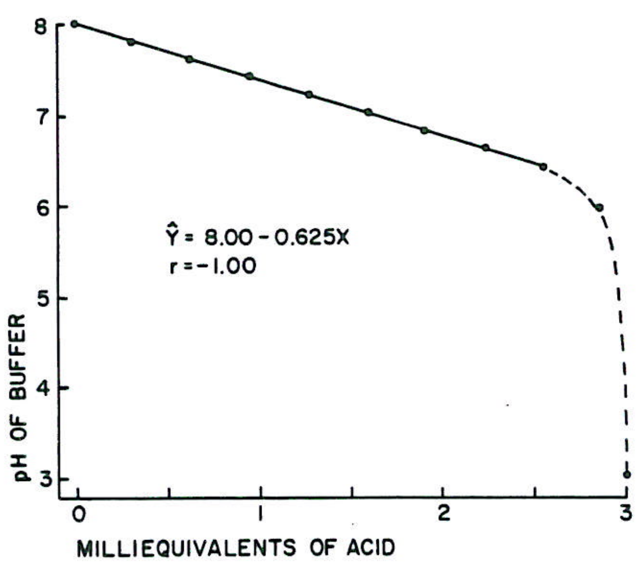

Fig. 2. Titration curve for buffer.

lime requirement was calculated as follows:

milliequivalent of acidity in sample = (pH change/0.1) × 0.16

$CaCO_3$ equivalent of sample = milliequivalent of acidity in sample × 50

kg $CaCO_3$ required for 1 kg mud = $CaCO_3$ equivalent of sample × (1000/sample weight)

liming rate (kg $CaCO_3$/ha) = kg $CaCO_3$ required for 1 kg mud × 1 400 000

If a 20-g sample of dry mud is used, the equations may be reduced to:

liming rate (kg $CaCO_3$/ha) = pH change × 5600.

Because the modified method gives the amount of $CaCO_3$ needed to lower base unsaturation of mud to 0.0, it will always provide a greater lime requirement than necessary — even when the liming factor of 1.5 is omitted. A comparison of the modified method with the standard method is presented (Fig. 3). The modified method gave values that were roughly 20% greater than the standard method for pond muds from Alabama. Because there is no assurance that the relationship depicted by the regression equation (Fig. 3) is general, its use is not recommended. Precision of the modified lime requirement method was high (Table II).

The modified lime requirement technique is simple, rapid, and applicable to all pond muds that are acidic because of exchange acidity. It is applicable to both mineral and organic muds; the reliability of the procedure is not influenced by the percentages of sand, silt, clay, and organic matter. It will not provide reliable liming rates for cat's clay (acid-sulfate soils), mine overburden, or other materials that are acidic because of pyrites. Application of

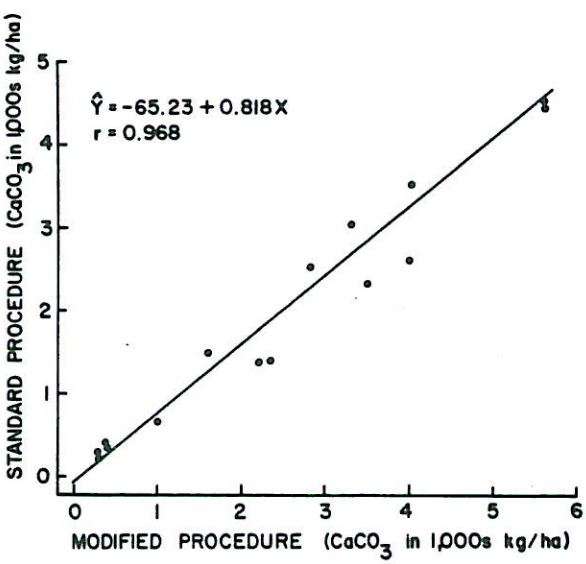

Fig. 3. Comparison of modified lime requirement procedure with the standard lime requirement procedure.

TABLE II

Precision estimates for the modified lime requirement method. Values based on five replicates

Sample no.	Mean (kg $CaCO_3$/ha)	Standard deviation (kg $CaCO_3$/ha)	Coefficient of variation (%)
1	920	15	1.6
2	2260	32	1.4
3	3820	23	0.6

20% or more agricultural limestone than necessary to raise total alkalinity and total hardness above 20 mg/l is not harmful to fish ponds. The lime application will merely have a longer residual effect.

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