Experimental Evaluation of Lime Requirement Estimators for Global Sites

Work Plan 7, Africa Study B

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Introduction

Aquaculture ponds with acid bottom muds and soft waters are commonly treated with lime to raise soil pH and base saturation levels and to increase the alkalinity of the pond water to an acceptable level. Pond mud pH readings of less than about 6.0 or pond water alkalinities of 20 mg $CaCO_3$/L or less are usually taken as indications that a given pond needs to be limed (Boyd 1979). Aquaculturists have used a number of methods (both agricultural and aquacultural) to estimate the amount of lime that should be added to ponds. Agricultural methods generally estimate the lime requirement (LR) for raising soil pH to a particular level, whereas aquacultural methods go a step further by estimating the LR for raising pond water alkalinity to a desired level.

Boyd (1974) showed that particular relationships exist between soil pH and soil base saturation and between soil base saturation and water hardness in fish pond muds in Alabama, and that these relationships can be used to estimate the LRs of ponds in that region. Boyd warned, however, that the relationships found for Alabama ponds may not hold for ponds in other areas. Work on agricultural soils by a number of workers, notably Mehlich (1942, 1943), has suggested that the relationship between soil pH and soil base saturation may in fact be dependent on the type of soil, that is on the amount of clay and organic matter present and on the mineralogy of the clay fraction. The work of Bowman and Lannan (1995) supports the hypothesis that this relationship does indeed vary with soil type. If different soil types have different relationships between soil pH and soil base saturation, then a logical question is whether different methods for estimating pond lime requirements should be used for different soil types. This study was designed to evaluate the suitability of several different LR estimators for a wide variety of soils.

Materials and Methods

Soil samples from aquaculture ponds or other wetland areas in Thailand, Kenya, and Rwanda were collected, characterized, and treated in laboratory microcosms to evaluate the suitability of several LR estimators for them. Prior to treatment each soil sample was air-dried and crushed to pass a 2mm sieve. Baseline analyses were done to determine pH, particle size distribution, exchangeable bases (calcium, magnesium, potassium, and sodium), CEC, and acidity. The LR of each soil was estimated by the following methods: SMP-1 (single-buffer method of Shoemaker et al., 1962), SMP-2 (double-buffer modification of SMP method described by McLean, 1982), SMP kit ("lime requirement module" from HACH), Boyd (1979), Pillay and Boyd (1985), and POND (Bolte et al., 1994).

The experiments were conducted in a constant temperature room at the Oak Creek Laboratory of Biology, Oregon State University, Corvallis, Oregon. Glass beakers with a capacity of 800 mL were used to test the LR estimates obtained using the methods noted above. Each beaker was filled with 750 mL of soft water (alkalinity of approximately 10 mg $CaCO_3$/L). The appropriate amount of agricultural limestone was thoroughly mixed with twenty-five grams of soil and then added to the solution. The soil-lime-water mixture was stirred vigorously with a glass rod for ten seconds to begin the experiment. An unlimed treatment was also prepared for each soil. For some soils an additional, high lime treatment was included. Each treatment was applied in triplicate. Water temperatures in the beakers were maintained at between 23 and 26°C. Samples of approximately 12.5 mL were removed after 1, 3, 7, 14, 21, and 28 days for determination of total alkalinity. Alkalinity was determined according to the methods described in Standard Methods (APHA et al., 1989). Three runs of the experiment were conducted between November 1994 and July 1995.

FOOTNOTE: 1 The lime requirement module is part of the HACH Soil and Irrigation Water Kit, Model SIW-1, Cat. No. 24960-00. HACH Company, Loveland, Colorado.

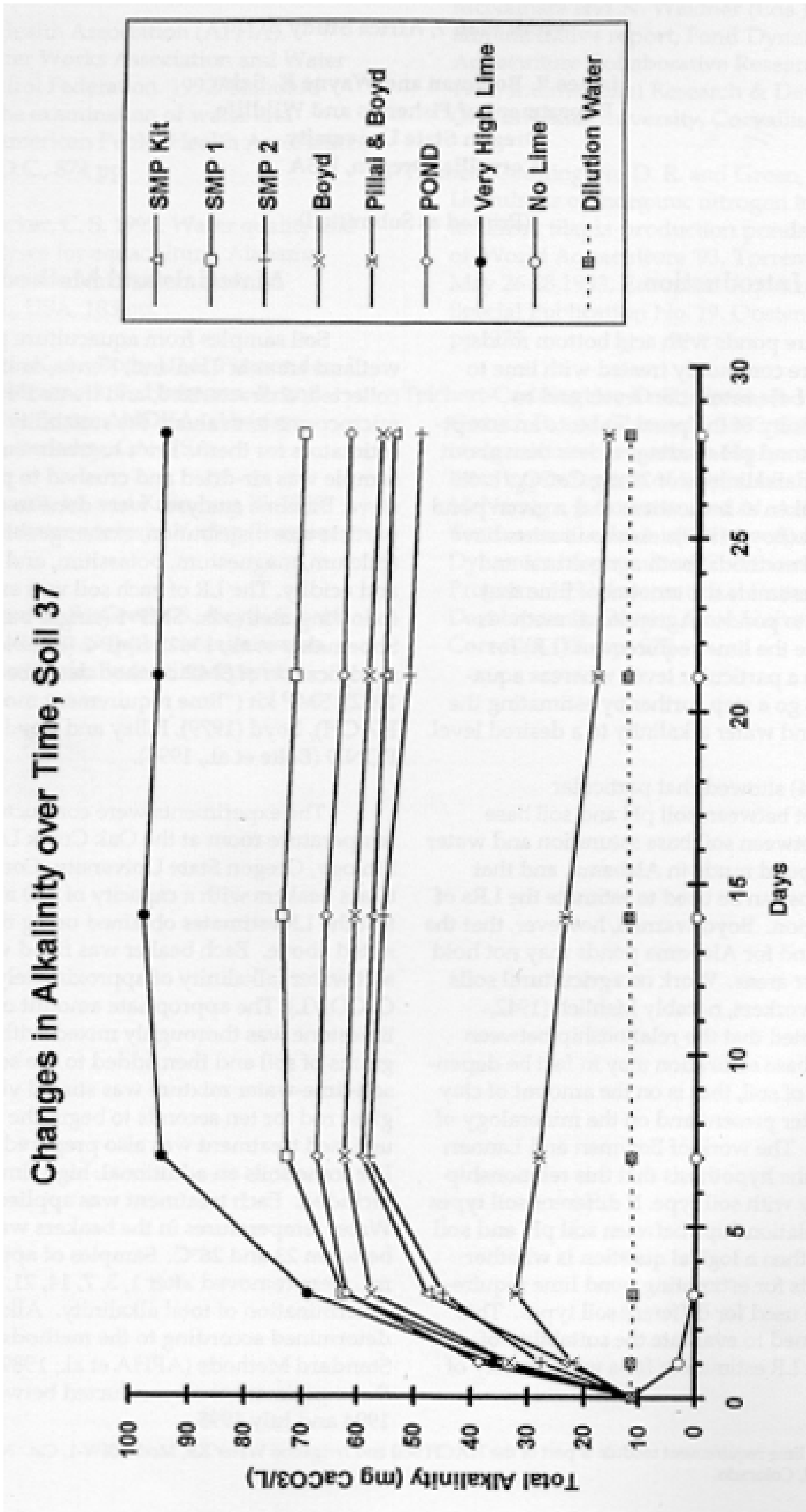

Figure 1. Changes in alkalinity over time for microcosms containing Soil 37. All lime requirement estimators provided adequate initial levels of alkalinity in the microcosms, but alkalinity in the Pillai and Boyd treatment fell to unsatisfactory levels by about 15 days after treatment.

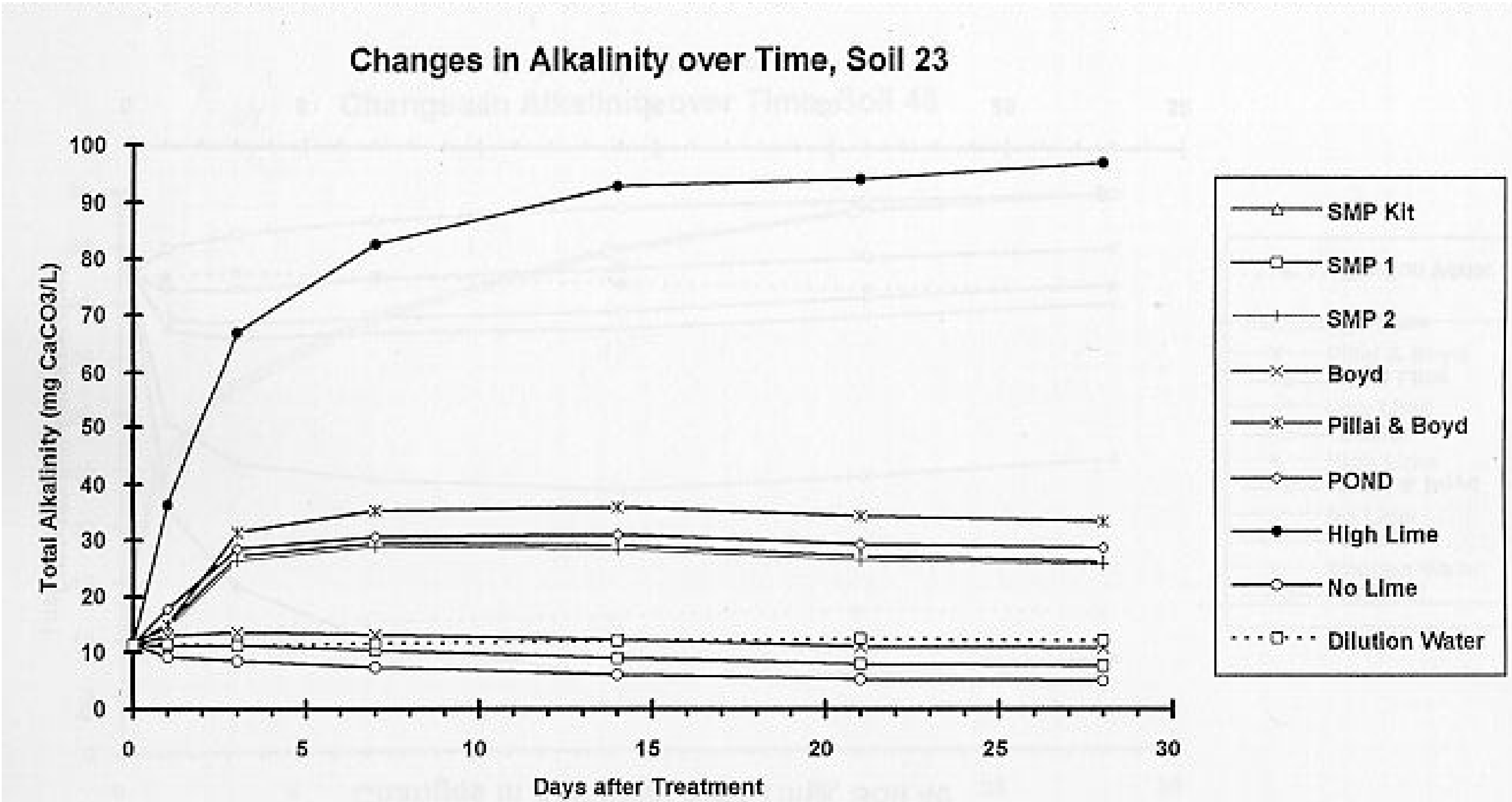

Figure 2. Changes in alkalinity over time for microcosms containing Soil 23. All lime requirement estimators except SMP-1 and Boyd provided adequate levels of alkalinity in this soil throughout the experimental period. In microcosms where no lime was applied alkalinity decreased steadily throughout the course of the experiment.

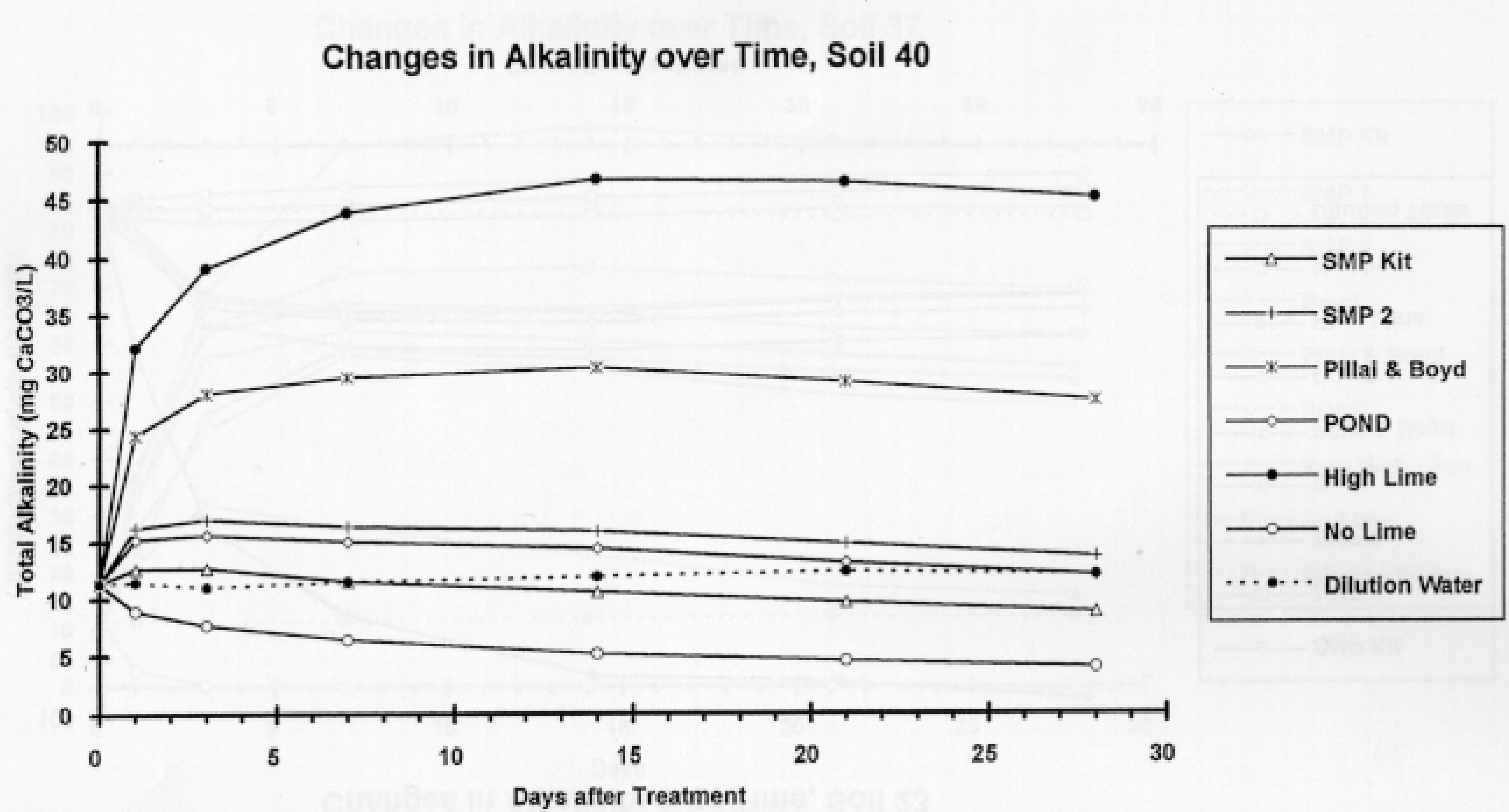

Figure 3. Changes in alkalinity over time for microcosms containing Soil 40. Only the Pillay and Boyd lime requirement estimator provided adequate levels of alkalinity in microcosms containing this soil.

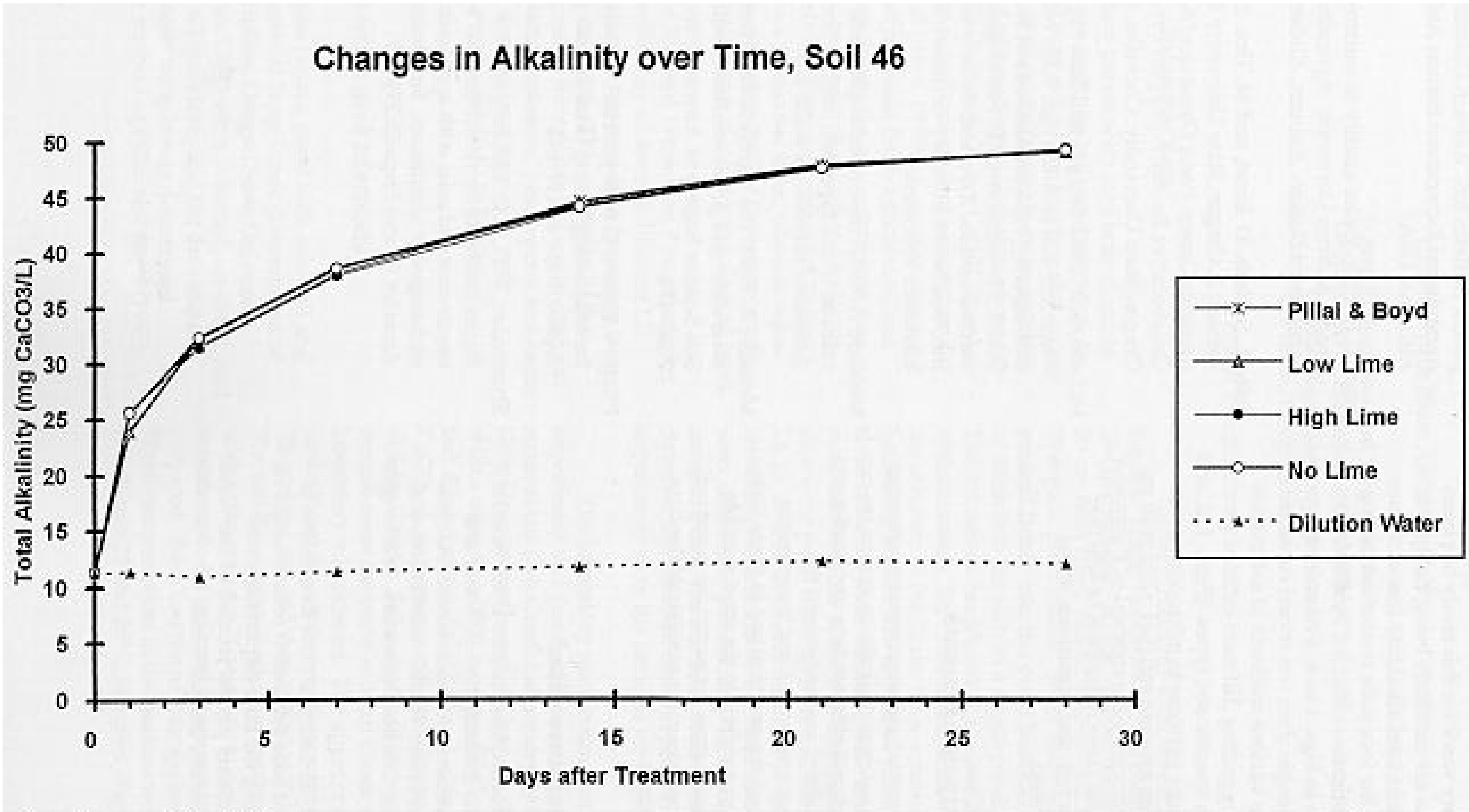

Figure 4. Changes in alkalinity over time for microcosms containing Soil 46. The total akalinity in all microcosms containing this soil rose throughout the experiment, apparently approaching an asymptotic level of about 50mg/L as $CaCO_3$. This pattern was the same regardless of whether lime was applied or not, and regardless of how much lime was applied.

Results and Discussion

The laboratory work for this study has been completed, and data are currently being analyzed. Plots of the changes in total alkalinity (mean values for each treatment) for four soils treated according to lime requirement estimates obtained by different methods are shown in Figs. 1 to 4. Preliminary analysis of these changes does not reveal consistent performances of the various methods of estimation across soil types, suggesting different estimators perform better with specific soil types. (Figs. 1, 2, and 3). The total alkalinity patterns in microcosms containing Soil 46, an alkaline soil (pH >7.8) with no lime requirement, except by the method of Pillay and Boyd (1985), were the same regardless of whether lime was applied or not, and regardless of the amount of lime applied.

Anticipated Benefits

The most suitable lime requirement estimator in terms of producing correct alkalinity responses can ensure effective and cost efficient lime applications to users. Where estimations are equivalent, the opportunity to select convenient and inexpensive estimators can extend the practical use of these tests. Efforts are underway to identify the most suitable lime requirement estimators for particular pond soil types through a more complete analysis of the data from these experiments.

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