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Pond bottom soil analyses



1 September 2008 Claude E. Boyd, Ph.D.



The best soil for pond construction has a loam or clay texture



Soil pH for aquaculture ponds should be measured using a slurry of distilled water and pulverized soil with a pH meter and glass electrode. Soil pH testers provide less accuracy.

Aquaculturists sometimes send samples of pond bottom soil to laboratories for physical and chemical analyses. Many variables can be measured easily in the laboratory, but the interpretation of results for use in aquaculture is more difficult.

Soil pH

There are many ways of measuring soil pH, but for aquaculture ponds, it should be measured in a 1:1 slurry of distilled water and dry pulverized soil using a pH meter and glass electrode. Soil pH testers are not as accurate as pH meters.

The ideal pH is 7.5 to 8.5. Pond soils with pH below 7.5 should be limed with the amount of liming material applied based on either the results of a lime requirement test or soil pH. Most laboratories do not measure lime requirement, but liming rates can be estimated from soil pH (Table 1). There is no effective way of reducing pH in pond soils.

Boyd, Approximate liming rates of bottom soils, Table 1

Soil pH	Liming Rate (Calcium carbonate equivalent, kg/ha)
5.0-5.5	2,500
5.6-6.0	2,000
6.1-6.5	1,500

Soil pH	Liming Rate (Calcium carbonate equivalent, kg/ha)
6.6-7.0	1,000
7.1-7.5	500
Over 7.5	0

Table 1. Approximate liming rates of bottom soils in aquaculture ponds based on soil pH. Values do not apply to acid-sulfate soils.

Pond aquaculture can be conducted in soils of a wide texture range. The best soil for pond construction has a loam or clay texture. However, clay soils dry slowly between crops, and tilling of such soils is more difficult than for lighter-textured soils. Ponds built in sandy soils usually seep badly.

Organic matter

The organic matter concentration in pond soil often is measured by the Walkley-Black sulfuric acid-potassium dichromate method. Results usually are given as percentage organic carbon. Suggestions for interpreting soil organic carbon concentrations are provided in Table 2.

Boyd, Interpretation of soil organic carbon concentration data, Table 2

Organic Carbon (%)	Comment
0-0.50	Very low, will not support good growth of benthos
0.51-1.00	Low for fertilized ponds, but excellent for ponds with feeding
1.01-2.50	Optimum for fertilized ponds and acceptable for ponds with feeding
Over 2.50	Excessive, prone to anaerobic zones in bottom

Table 2. Interpretation of soil organic carbon concentration data from aquaculture ponds.

Fresh organic matter that settles to the bottom during a crop decomposes much faster than older, partially decomposed soil organic matter from previous crops. However, overfeeding and improper feed distribution can result in the accumulation of uneaten feed, causing zones of impaired soil quality.

Ponds with low or moderate soil organic matter concentrations, high feeding rates and dense phytoplankton blooms can develop poor conditions at the soil-water interface because of sedimentation of dead plankton. Maintaining desirable organic carbon concentrations in pond bottoms is beneficial, but it does not avoid zones with anaerobic conditions in the bottoms of ponds with bad feed management.

Phosphorus

Soil phosphorus can be extracted with several extractants, but dilute or moderate-strength sulfuric acid and hydrochloric acid are common extractants. Acid-extractable phosphorus can range 1 to 1,000 ppm.

Phosphorus is tightly bound in soil, and fertilization generally is necessary to promote phytoplankton growth regardless of acid-extractable phosphorus concentration. In ponds with feeding, phosphorus continually enters the water from uneaten feed and excrement. The difficulty in accurately predicting phytoplankton productivity or the production of culture species from pond soil phosphorus concentrations makes it difficult to justify bottom soil phosphorus analyses.

Nitrogen

Most of the nitrogen in bottom soils is contained in organic matter. Bacteria mineralize organic matter to ammonia that can be used by phytoplankton. In fertilized ponds, nitrogen mineralization may lessen the need for nitrogen fertilization. Soil nitrogen concentration, however, does not need to be measured, for bottom soils with 1 percent soil organic carbon or more (Table 1) do not require as much nitrogen fertilization as ponds with less organic carbon.

In ponds with feeding, input of feed nitrogen overshadows the input of this nutrient from microbial degradation of soil organic matter. The most compelling reason for determining total nitrogen concentration in ponds with feeding is for the calculation of carbon:nitrogen (C:N) ratio.

The ideal C:N ratio is probably 8.1 to 12:1. Ponds with high concentrations of fresh organic matter have lower ratios and tend to develop anaerobic zones at the sediment-water interface. Higher C:N ratios suggest that pond bottoms are accumulating stable organic matter that decomposes at a slow rate. This phenomenon usually is found in ponds with low natural productivity.

Sulphur

A high concentration of total sulfur indicates that pond soil contains iron pyrite, which oxidizes to create excessive acidity. Soils with more than 0.75 percent sulfur are considered potential acid-sulfate (PAS) soils.

Pond soils should be initially analyzed for total sulfur to determine if they are PAS soils. No further sulfur analyses are needed in ponds without PAS soils.

The liming rates in Table 1 are not suitable for PAS soils. The pH usually is below 5 in PAS soil, and much higher liming rates are necessary.



The black sulfur deposits in some pond soil can contribute to excessive acidity. Liming of potential acid-sulfate soils requires increased application rates.

Major cations

Major exchangeable cations include sodium, potassium, calcium and magnesium. These ions are adsorbed on negative charges in clay particles and finely divided organic matter in soils. They can exchange with other cations in the surrounding water and are potentially available to plants.

Current knowledge of the relationships among pond soil chemistry, water quality and aquacultural production is inadequate to permit interpretation of routine analyses of exchangeable cations.

Cation exchange capacity

Cation exchange capacity (CEC) is a measure of the quantity of cations that soil can attract. It was traditionally reported in milliequivalents (meq)/100 grams of dry soil, but today many laboratories report CEC in centimoles of charge (cmolc)/kg, which gives the same value as the older unit.

Soils range in CEC from less than 1 meq/100 grams to more than 50 meq/100 grams. Factors that influence CEC are the type of clay minerals present and amount of organic matter.

CEC cannot be interpreted usefully in pond aquaculture. However, it should be noted that 2:1-layered clays such as smectite clays can fix potassium in much greater quantities than the CEC value suggests by sequestering potassium in space between the clay layers. Potassium fixed in this manner has a very low availability.

This process is important in inland culture of marine shrimp in ponds filled with saline well water. Saline well water usually has a low potassium concentration, so potassium chloride is applied to ponds to increase potassium concentration. These applications must be repeated even after cation exchange sites on soils are saturated with potassium because the potassium continues to be fixed within the layers of the clay.

Trace elements

Tests for trace elements – iron, manganese, copper, zinc, boron, cobalt, molybdenum, barium, chromium, lead and others – are routinely made by soil-testing laboratories. Some of these elements are nutrients, but all can be toxic at sufficiently high concentration.

A study conducted at Auburn University in the early 1990s on hundreds of samples from marine and freshwater aquaculture ponds revealed that concentrations of individual trace elements varied by two to three orders of magnitude. In spite of this, ponds from which the samples were taken were successfully producing fish or shrimp. Of course, concentrations greater than those found in the study could be cause for concern.

The greatest concentrations found in the study were iron, 1,200 ppm; manganese, 350 ppm; copper, 11 ppm; zinc, 14 ppm; boron, 24 ppm; cobalt, 3.5 ppm; molybdenum, 1.2 ppm; barium, 4 ppm; chromium, 7 ppm; and lead, 9 ppm.

Obviously, interpretation of trace element data is fraught with difficulty, for no data relates trace element concentrations in bottom soil to aquaculture production variables. Measurement of trace elements in pond soils probably results in more confusion than beneficial information.

(Editor's Note: This article was originally published in the September/October 2008 print edition of the Global Aquaculture Advocate.)

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The reliability of trace element analyses reported by custom laboratories cannot be checked by simple techniques, and results may not always be accurate. One should check the reliability of major ion analyses by determining the charge balance and comparing the measured total ion concentration with the total ion concentration estimated from conductivity.

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