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Erosion, sedimentation in earthen aquaculture ponds

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By Claude E. Boyd, Ph.D. and Puttitorn Saengrungruang

Practices to lessen impacts should begin at the design phase

Sediment in earthen ponds originates primarily from two sources: a high concentration of suspended solids in the water supply and erosion of pond bottoms and embankments. Because erosion and sedimentation are common, aquaculturists tend to consider them the norm and devote little attention to ways of lowering the rates at which embankments erode and sediment accumulates in deeper areas of ponds.

Erosion degrades embankments, and excessive sediment in ponds reduces depth, creates a soft bottom, makes harvesting more difficult and damages benthic plant and animal communities. Suspended soil particles in ponds increase turbidity and thereby reduce light penetration for phytoplankton photosynthesis. High levels of suspended solids in effluents are pollutants.

Embankments made of heavy clay soils must have adequate side slopes or they will slip.

Pond construction

The implementation of practices to lessen external inputs of suspended soil particles to ponds and minimize internal erosion should begin at the design and construction stages. Embankments should have sufficient side slopes to resist erosion. Table 1 gives recommended side slopes for different types of soil.

Boyd, Recommended side slopes, Table 1

Soil Type	Side Slope (horizontal: vertical)
Clay, clay sand, sandy clay, silty sand	3:1 wet side
Clay, clay sand, sandy clay, silty sand	2:1 dry side
Silty clay	3.1 wet side
Silty clay	3.1 dry side
Well-graded soil	1:1, 2:1 wet side

Well-graded soil	1:1, 2:1 wet side

Table 1. Recommended side slopes for preventing erosion of earthen pond embankments.

Although most references on pond construction suggest that a high percentage of clay in fill for pond embankments is desirable, heavy clay soil material does not bear loads well and is difficult to compact. Steeply sloped embankments with high clay content may slip, encouraging severe erosion. A well-graded soil with less clay and a wide range in particle size distribution is best suited for embankments.

Fill material should be thoroughly compacted, which requires that fill be near the optimum moisture content for compaction. A laboratory procedure known as the standard Proctor test can measure the optimum moisture content of a soil for compaction to 95 percent of maximum density. It often is not possible to use this procedure for pond construction, but the following guidelines can be helpful.

Typical optimum moisture contents for good compaction of common types of soil are: sandy materials, 6 to 10 percent; silty sand, 8 to 12 percent; silt, 11 to 15 percent; clay materials, 13 to 21 percent. Fill material should be installed in 15- to 20-cm layers and compacted before the next layer is applied. Water should be added to dry soil to increase moisture and enhance compaction.

Stone, riprap rock or gabion can be installed below the water line to control erosion. Grass cover should be used above the water line on the wet side and on the dry side to control erosion. If the top of the embankment is not covered with gravel, it also should be covered with grass.

Canals constructed to convey water to ponds also should be designed with consideration for erosion control. The minimum side slopes (horizontal to vertical) and maximum allowable water velocities for avoiding erosion in canals of different depths are provided in Table 2.

Boyd, Allowable side slopes, Table 2

Soil Type	Side Slope (horizontal: vertical)	Maximum Water Velocity (m/second 1.0 m deep	Maximum Water Velocity (m/second 1.5 m deep	Maximum Water Velocity (m/second 2.0 m deep
Sandy loam	3.0	0.77	0.84	0.89
Silty clay	3.0	0.97	1.05	1.11
Silty sand	2.0	0.97	1.05	1.l1
Stiff clay	1.5	1.35	1.47	1.55

Table 2. Allowable side slopes and maximum water velocities for preventing erosion in earthen channels.

Water supply, embankments

The water supply for ponds should be examined to determine if it is a significant source of suspended solids. Erosion on small catchments for “watershed” ponds can be a major source of suspended solids. Denuded areas on catchments should be covered with grass or other vegetation. Sometimes it is possible to construct ditches or terraces in critical areas to divert turbid runoff from ponds.

The embankment ponds most commonly used in aquaculture are filled with water from streams, canals, estuaries or other water bodies that can be high in suspended solids concentrations. Turbid water should be held in a settling basin before being transferred to farm canals and ponds. Failure to do so can lead to excessive sedimentation. A settling time of four to eight hours will remove most of the coarse solids, but fine silt and clay particles often remain in suspension.

Erosion on the dry side of embankments and above the waterline on the wet side as a result of wind and rain can be minimized in ponds that were constructed with inadequate side slopes by installation of grass cover or other erosion-resistant cover.

Mechanical aeration

Mechanical aeration generates water currents that can erode pond embankments and bottoms. Sediments sometimes mound in the center of heavily aerated ponds.

The mechanical aeration used in many ponds generates water currents that can cause severe erosion of pond embankments and bottoms, and sediment accumulation on pond bottoms. Aerator-related erosion becomes more severe as the amount of aeration increases, but at moderate levels of aeration up to about 20 hp/ha, improved practices can minimize erosion.

These practices include placing aerators in water over 1 meter deep, installation of aerators beyond the inside toes of embankments – usually about 6 meters from the water's edge, and prevention of aerator-generated water currents from impinging on embankments.

Sediment can be removed from ponds to restore pond bottoms to near-original condition. This sediment should be used to repair erosion on insides of embankments when possible. It is particularly important to thoroughly compact the repaired areas and reinforce them against erosion.

Liners

At higher aeration rates, some type of liner should be installed to protect earthwork from aerator-generated currents. Lining also protects pond bottoms from erosion caused by culture species that stir up the bottoms of ponds in search of food or for building nesting sites.

The most effective approach is to completely line ponds with plastic membranes, but this method is very expensive and causes aberrations in water quality. In particular, the adsorption of phosphorus from water by soil is prevented by the liner, and dense phytoplankton blooms occur. These blooms tend to "bloom and crash," making the pond environment unfavorable for aquaculture. Of course, completely lined ponds can be used for heterotrophic, biofloc-based aquaculture, but most producers have not adopted this super-intensive culture method.

Partial lining of erosion-vulnerable areas in ponds with plastic or geofabric is a cheaper alternative than complete lining of ponds. There is evidence from recent research at Auburn University that relatively inexpensive, permeable geofabric liners allow exchange of phosphorus and other dissolved and gaseous substances between bottom soil and water. Such liners can prevent erosion in ponds without interfering with water quality. However, several issues – expected service life, a tendency for the fabric to float and optimum fabric opening size – remain to be resolved before this material can be recommended for general use.

Erosion prevention in ponds has the added benefit of reducing concentrations of suspended solids in water and therefore in pond effluents. Aquaculturists participating in eco-label certifications such as the Best Aquaculture Practices program may find that an investment in erosion control can avoid the necessity for constructing an effluent settling basin for compliance with a limit on total suspended solids concentration.

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Authors

CLAUDE E. BOYD, PH.D.
Department of Fisheries and Allied Aquacultures
Auburn University
Auburn, Alabama 36849 USA
boydce1@auburn.edu (mailto:boydce1@auburn.edu)

PUTTITORN SAENGRUNGRUANG
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama, USA