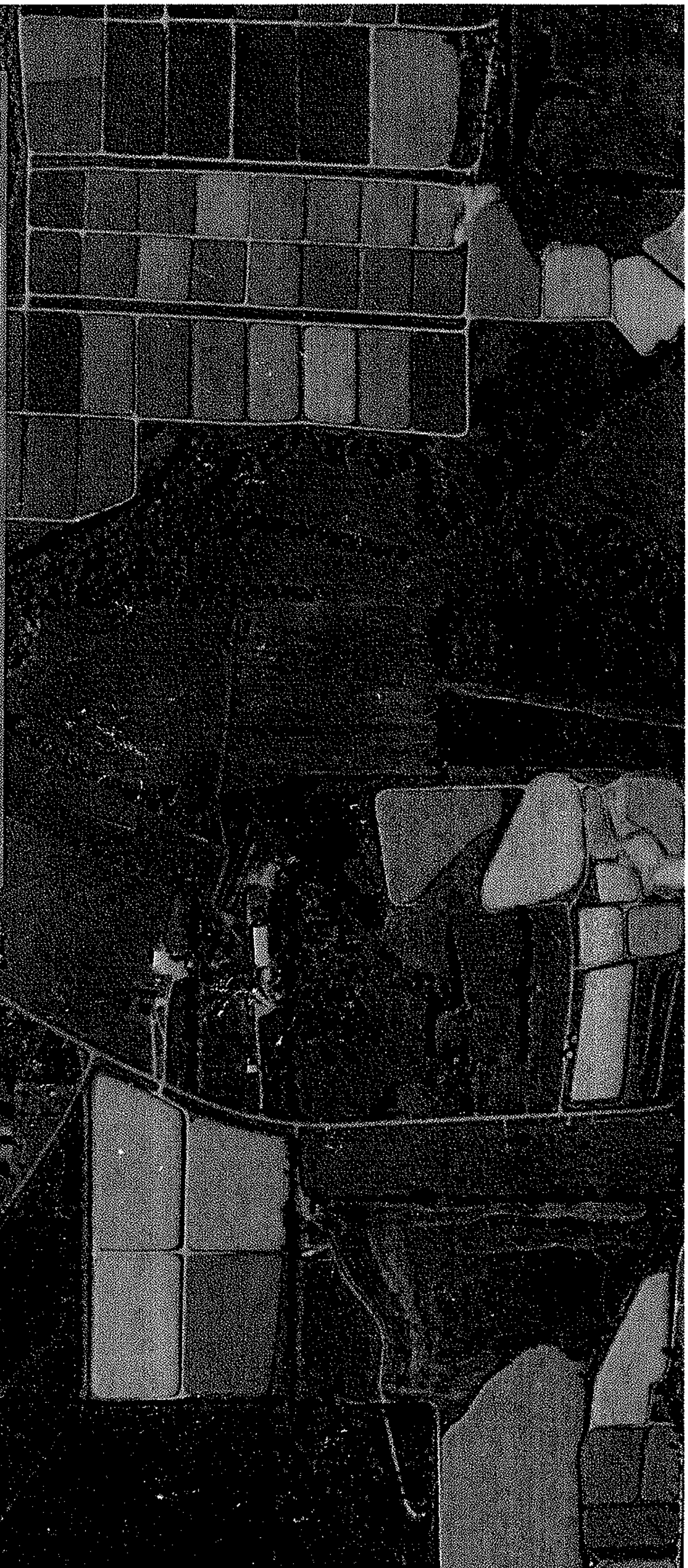

Best Management Practices for Channel Catfish Farming in Alabama

Special Report No. 1
For Alabama Catfish Producers
March 2003

Alabama Agricultural Experiment Station
Alabama Catfish Producers
Alabama Department of Environmental Management
Auburn University
U.S. Department of Agriculture–Natural Resources Conservation Service

This publication is the result of collaboration among the following:

Alabama Agricultural Experiment Station

Alabama Catfish Producers

Alabama Department of Environmental Management

Auburn University
The College of Agriculture
Department of Fisheries and Allied Aquacultures
Alabama Fish Farming Center

U.S. Department of Agriculture–Natural Resources Conservation Service

On the cover: Aerial photo of catfish ponds in Hale County, Alabama.
Top insert: severe embankment erosion;
bottom insert: embankment erosion controlled by grass.

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Authors

Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama 36849

Julio F. Queiroz
Embrapa Meio Ambiente
Rodovia SP 340 km 127.5
Jaguariuna, SP 12820-00
Brazil

Gregory N. Whitis
Alabama Cooperative Extension System
Alabama Fish Farming Center
529 Centreville Street
Greensboro, Alabama 36744

Richard Hulcher
Chief, Mining & Nonpoint Source Section
Field Operations Division
Alabama Department of Environmental Management
PO Box 301463
Montgomery, Alabama 36130

Perry Oakes, PE
State Conservation Engineer
USDA, Natural Resources Conservation Service
3381 Skyway Drive
Auburn, Alabama 36830

Jimmy Carlisle
Alabama Catfish Producers,
A division of Alabama Farmers Federation
P.O. Box 11000
Montgomery, Alabama 36191

Dickie Odom, Jr.
Route 1, Box 41
Boligee, Alabama 35443

Marshall M. Nelson, PE
State Design Engineer
USDA, Natural Resources Conservation Service
3381 Skyway Drive
Auburn, Alabama 36830

William G. Hemstreet
Alabama Fish Farming Center
529 Centreville Street
Greensboro, Alabama 36744

Best Management Practices for Channel Catfish Farming in Alabama

Claude E. Boyd[1], Julio F. Queiroz[2], Gregory N. Whitis[3], Richard Hulcher[4], Perry Oakes[5], Jimmy Carlisle[6], Dickie Odom, Jr.[7], Marshall M. Nelson[8], William G. Hemstreet[9]

Introduction

Aquaculture grew rapidly during the past 50 years, and it is continuing to expand. This growth is possible because of an increasing demand for fisheries products and failure of capture fisheries to keep pace with demand. It is doubtful that aquacultural production can continue to increase fast enough to meet the rising demand for fisheries products *(1)*. Channel catfish farming in the United States has followed the global trend with expansion from about 2,500 acres in the early 1960s to around 190,000 acres at present *(2)*. In Alabama, catfish farming has increased from a few farms in the early 1960s to about 28,000 acres in 2002.

Recent environmental concerns could greatly complicate the future of aquaculture. Although these concerns have been directed primarily at marine shrimp farming and cage culture of salmon in marine environments, there has been at least one report critical of channel catfish farming *(3)*. Concerns about aquaculture include wetland destruction, conversion of agricultural land to ponds, water pollution, loss of biodiversity, competition for water use, use of toxic or bioaccumulative chemicals, inadvertent fuel or other chemical spills, and negative social impacts *(4)*. The main environmental concern about channel catfish farming is water pollution by pond effluents. Other environmental issues raised about aquaculture in general appear less problematic in catfish farming

According to federal regulations, effluents from aquaculture farms in the United States are subject to permitting under the National Pollution Discharge Elimination System pursuant to the requirements of the Clean Water Act *(5)*, but in some states, aquaculture effluents have not been subject to permitting. The United States Environmental Protection Agency (USEPA) has recently initiated rule-making related to aquaculture effluents nationwide, and the channel catfish industry will have to comply with effluent regulations that were published by EPA in draft form in early September 2002, and are expected to be finalized by June 2004 *(6)*.

The Alabama Catfish Producers (ACP), in a proactive effort to minimize the impact of pending effluent regulations, contracted with Auburn University to make an environmental assessment of catfish farming in the state *(7)*. This study suggested that pollution of natural waters by catfish farming could be prevented or minimized through application of reasonable practices to reduce the volume and improve the quality of effluents. Application of specific management practices to prevent or lessen water pollution or other adverse environmental impacts is commonly used in terrestrial agriculture and other endeavors. Such practices are known as best management practices or BMPs. Many of the BMPs for catfish farming represent the most efficient way of conducting production activities and may actually reduce production costs in the long run.

[1] Professor and Butler/Cunningham Eminent Scholar, Department of Fisheries and Allied Aquacultures. [2] Research scientist, Embrapa Meio Ambiente. [3] Extension aquaculturist, Alabama Fish Farming Center. [4]Chief, Mining & Nonpoint Source Section, Alabama Department of Environmental Management. [5] State Conservation Engineer, USDA, Natural Resources Conservation Service. [6] Director, Alabama Catfish Producers. [7] Past Chairman, Alabama Catfish Producers. [8] State Design Engineer, USDA, Natural Resources Conservation Service. [9] Research Associate IV, Alabama Fish Farming Center.

The ACP contracted again with Auburn University to conduct an environmental audit of selected catfish farms to determine the practicality of installing BMPs. This effort further supported the use of BMPs for lessening pollution loads in pond effluents. The ACP has cooperatively provided assistance in support of the Alabama Department of Environmental Management's (ADEM) efforts to rely on effective BMPs to the extent possible, and ADEM recognizes ACP stewardship in supporting development of practical, reasonable, and effective aquaculture BMPs to ensure the protection of water quality in Alabama. Auburn University, ACP, ADEM, and the United States Department of Agriculture Natural Resources Conservation Service (NRCS) collaborated in preparing a formal list of BMPs.

The activities leading up to formalization of the BMPs are provided in the table.

To the extent allowed by EPA rules, ADEM intends to rely on these EPA recognized BMPs in implementing any mandated regulatory or water quality requirements, including inspections and any potential compliance action, if needed (*8*). ADEM anticipates that catfish producers who implement and maintain BMPs will meet or exceed any ADEM effluent standard. ADEM has committed to work in cooperation with the ACP to update the BMPs, if needed in the future.. The BMPs may be obtained from the NRCS website (http://www.al.nrcs.usda.gov/SOsections/Engineering/BMP/index.html). Since some farmers may not find it convenient to use the website, the BMPs are presented in this manual.

Activites Leading up to Formalization of BMPs

Activity	Date
Environmental assessment	1997-1999
Farmer meeting to discuss environmental assessment	October 1999
Environmental audit	1999-2000
First draft of BMPs	March-May 2000
Review of draft BMPs by selected farmers, extension agents, and researchers	May-July 2000
Revision to prepare second draft of BMPs	August-Sept. 2000
Farmers meeting to review draft BMPs	October 2000
Revision to prepare third draft of BMPs	Nov.-Dec. 2000
Review of draft BMPs by employees of ADEM, NRCS, and USEPA	Jan.-April 2001
EPA/ADEM aquaculture site visit in Alabama	March 2001
Revision to prepare fourth draft of BMPs	April-August 2001
Farmers meeting to review draft BMPs	October 2001
Revision to prepare fifth draft of BMPs	Nov.-Dec. 2001
Final editing of BMPs and installation on NRCS website	Jan.-Feb. 2002
EPA recognition of ACP BMPs for Alabama	Sept. 2002
Publication of manual	2003

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(1) Boyd, C. E. 1999. Aquaculture Sustainability and Environmental Issues. World Aquaculture 30:10-13.

(2) Annonymous. 2000. Status Of World Aquaculture 2000. Aquaculture Magazine Buyer's Guide And Industry Directory 2000, 29:6-42.

(3) Goldberg, R. and T. Triplett. 1997. Murky Waters: Environmental Effects Of Aquaculture In The United States. Environmental Defense Fund, Washington, D.C. 196 pp.

(4) Boyd, C. E. and J. W. Clay. 1998. Shrimp Aquaculture And The Environment. Scientific American 278:58-65.

(5) Boyd, C. E. 2000. Water Quality – An Introduction. Kluwer Academic Publishers, Boston, Massachusetts. 330 pp.

(6) Federal Register. 2000. Environmental Protection Agency, Effluents Guidelines Panel. Federal Register: June 16, 2000 (Volume 75, Number 117, Pages 37783-37788). Office Of The Federal Register, National Archives And Records Administration, Washington, D.C.

(7) Boyd, C. E., J. Queiroz, J. Lee, M. Rowan, G. N. Whitis, and A. Gross. 2000. Environmental Assessment Of Channel Catfish, *Ictalurus Punctatus*, Farming In Alabama. Journal Of The World Aquaculture Society 31(4):511-544.

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Reducing Storm Runoff into Ponds

BMP No. 1

Definition

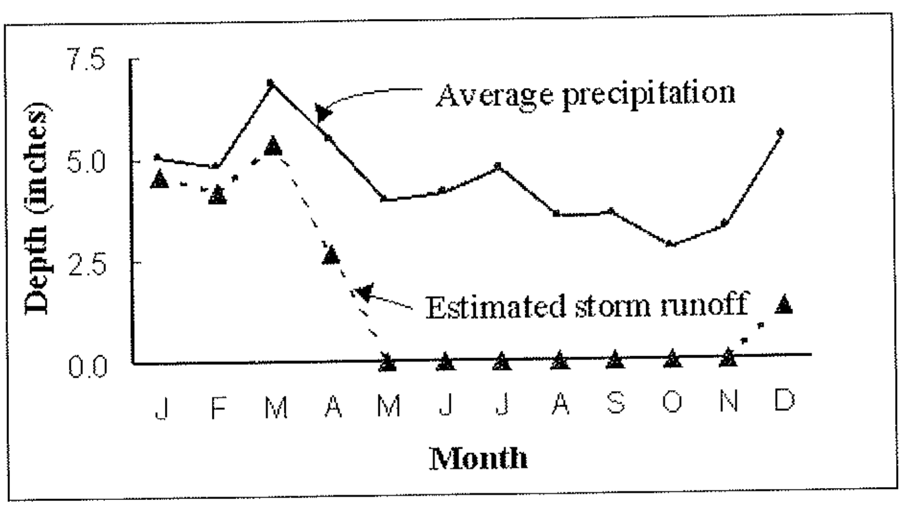
Storm runoff or overland flow is the water that flows over the land surface following rainfall events. Storm runoff enters watershed ponds, and sometimes small streams or springs may flow into them. The amount of runoff entering ponds depends upon the size and characteristics of their watersheds. The volume of effluent from ponds in response to heavy rains depends largely upon the watershed-area-to-pond-surface ratio (WP ratio).

Explanation

Catfish farming in Alabama is conducted primarily in watershed ponds located in the Blackland Prairie region of Alabama. Soils in this region are high in clay content, and this results in high runoff volumes after storm events. Watershed ponds are filled by runoff that occurs mostly in the winter and spring as illustrated in Figure 1.

The recommended maximum WP ratio for watershed ponds in the Blackland Prairie region of Alabama usually is 10:1, but some ponds may have a much larger ratio. Ponds located in the Coastal Plain region of Alabama may need 30 acres or more of land to contribute runoff for each surface acre of ponded water. Watersheds also may have small ephemeral or permanent streams or springs that also contribute inflow to ponds. Enough watershed area to supply water to fill ponds during the winter and spring is desirable. However, if WP ratios are larger than necessary, excessive flow through ponds could cause erosion of pond outlet structures, which increases total suspended solids concentration in effluents. Water flowing through ponds lowers alkalinity and flushes out products, such as fertilizer, lime, and salt, which are added to ponds to enhance water quality and fish production. If phytoplankton abundance and nutrient concentrations are high in ponds at time of overflow, pollutant loads to

Figure 1. Distribution by month of normal precipitation at Demopolis, Alabama, and estimates of monthly runoff.



streams may increase. Alabama Department of Environmental Management (ADEM) rules require that discharges of pollutants be prevented or reduced to the maximum extent practical to ensure instream water quality. Thus, excessive overflow from watershed ponds should be avoided.

There are several ways to minimize the overflow from watershed ponds. If possible during pond design, the water area should be adjusted for watershed area so that the WP ratio does not result in excessive runoff. Where existing ponds have an excessively large watershed area, a part of the stream, spring, or overland flow may be routed around ponds or another pond may be constructed on the watershed to increase storage volume. Changes in vegetative cover may be implemented to intercept more water and lessen overland flow.

Reduction in Storm Overflow

Practices

The following practices are suggested to reduce storm runoff into ponds:

• Design new watershed ponds in the Blackland Prairie region of Alabama to have a WP ratio of 10:1 or less.

• Use diversions and grade stabilization structures to divert excess runoff around ponds, or build an additional pond to increase storage on the watershed.

• Maintain good vegetative cover on all parts of watersheds, and replace short or sparse vegetation with taller and denser vegetation where feasible.

Implementation Notes

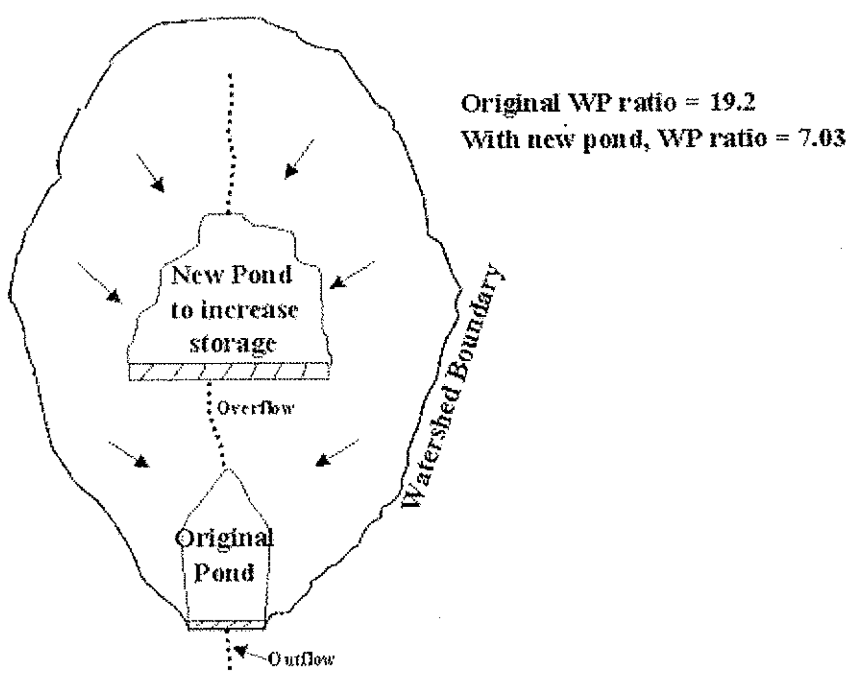
The watershed drainage area is a vital element in new pond design. In Blackland Prairie locations, the pond area usually should be about 10% of watershed area. If enough pond area to provide a WP ratio of 10:1 is not feasible, then methods for routing runoff around ponds should be considered.

In the case of existing ponds with excessive watershed area, construction of another pond or wetland on the watershed may be possible. This will lessen the WP ratio and increase water storage on the watershed (See Figure 2).

Diversions also are useful for controlling water on watersheds. A diversion is a channel constructed across the slope with a supporting ridge on the lower side.

A drawing illustrating the use of a diversion to divert overland flow around ponds is shown in Figure 3. A grade stabilization structure will be necessary to control the runoff water safely to the drainage way below the pond. USDA-NRCS can provide information on proper diversion and grade stabilization structure design and construction. In some cases, extending pipes through embankment type diversions to allow a portion of the runoff to enter ponds may be necessary.

Figure 2. Illustration of the installation of another pond to increase storage on a watershed.



Small streams or drainage from upstream dams may be partially or completely diverted from ponds by ditches. Pipes or other structures also may be installed in ditches to allow a portion of the flow to enter ponds.

Storm runoff from watersheds is greater where the land is bare or covered with short grass. Bare soil is highly undesirable on watersheds for catfish ponds because it erodes and results in highly turbid runoff (See BMP No. 3). Many watersheds of catfish ponds in Alabama are covered by short grass. Converting short or sparse vegetation to taller and denser vegetation can reduce the runoff volume from these watersheds. Of course, this application usually would require that the pond owner own most or all of the watershed.

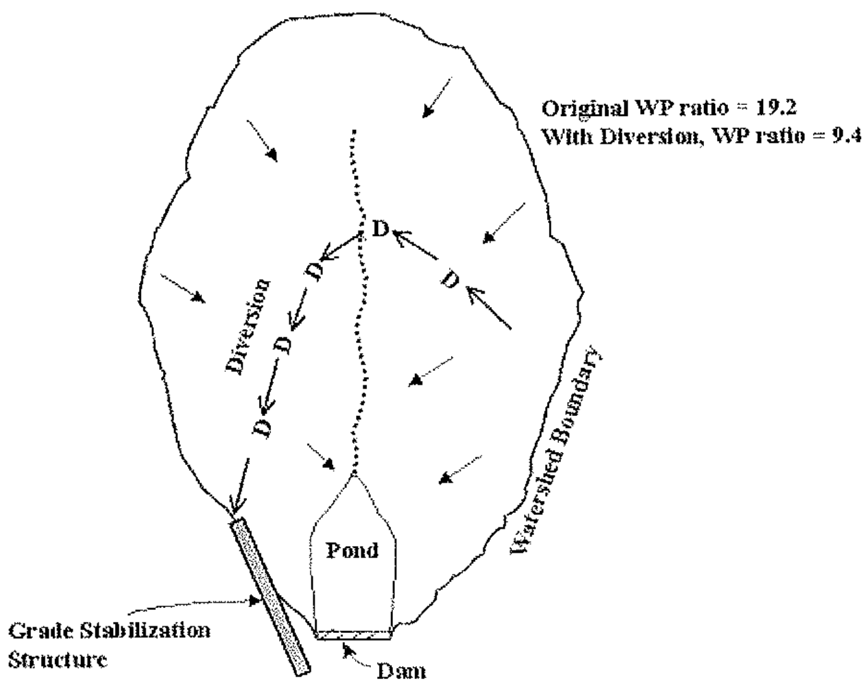
References

USDA-NRCS Alabama Conservation Practice Standards:
Code 362 – Diversion,
Code 410 – Grade Stabilization Structures.

Yoo, K. H. and C. E. Boyd. 1994. Hydrology and Water Supply for Pond Aquaculture. Chapman and Hall, New York, New York.

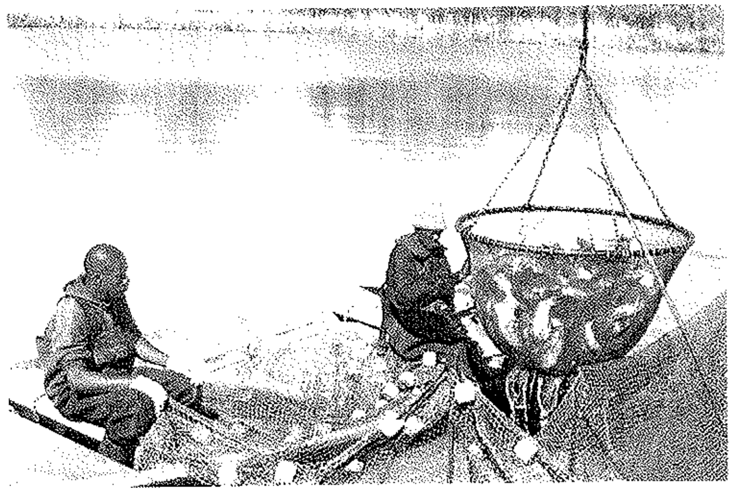
Evans, J. O. and J. H. Patric. 1983. Harvest trees, reap water. J. Soil and Water Conservation 38:390-392.

Figure 3. Illustration of the use of a diversion to reduce the amount of overland flow entering a pond from its watershed.



Managing Ponds to Reduce Effluent Volume

BMP No. 2



Definition

Catfish ponds can release effluents following rainfall events and during intentional drainage. Effluent volume can be reduced by operating ponds to maximize storage capacity and by draining them only when necessary.

Explanation

Discharge from ponds occurs when the amount of water entering ponds exceeds the capacity of ponds to store water. During periods of heavy rainfall and runoff, ponds fill to capacity and overflow cannot be avoided. Storm overflow from catfish ponds in Alabama occurs mostly in winter and spring because rainfall normally is abundant and conditions are optimum for producing runoff on watersheds. During summer and fall there is little runoff and ponds filled to the top of the overflow pipe can have discharge due to rainfall directly into the pond. This overflow can be largely avoided if ponds are not full to the tops of overflow pipes when rain occurs.

Water also is intentionally discharged from ponds. Water from wells or streams is sometimes pumped into ponds for the purpose of improving water quality and conditions for fish production by flushing water of reduced quality from ponds. This practice is called water exchange. Ponds also may be partially drained to facilitate fish harvest, or they may be completely drained to harvest fish or to renovate pond earthwork. Alabama Department of Environmental Management (ADEM) rules require that discharge of pollutants be prevented or minimized to the maximum extent practical to ensure in-stream water quality.

Prevention of Discharge

Practices

The following statements summarize the practices that should be used to reduce the volume of draining effluent and storm runoff from ponds:

- Construct seine-through ponds when possible.
- Harvest fish by seining and without partially or completely draining ponds unless it is necessary to permit harvest in deep ponds, to renovate fish stocks, or to repair pond earthwork.
- Maintain adequate storage capacity to capture rain falling into ponds during summer and early fall.
- Do not flush well or stream water through ponds.

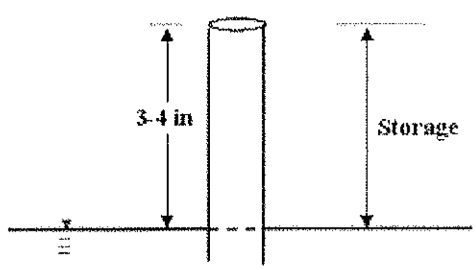
Implementation Notes

There is no reason to drain most catfish ponds frequently because fish can be harvested by seining. A recent study indicated that catfish ponds are partially drained about once every 6 years to renovate fish stocks. Large fish must be removed from ponds because they compete with small fish for feed, and large fish do not convert feed to fish flesh as efficiently as smaller ones. After about 15 to 20 years, ponds must be completely drained to repair earthwork. Thus, the usual industry practice does not require ponds to be drained often. Of course, not all producers will be able to implement this practice because some ponds cannot be seined.

By not draining ponds on an annual basis, the volume of draining effluent entering streams can be greatly reduced. Considering an average pond depth of 5.5 feet, annual pond draining would yield 82.5 acre-feet of effluent per acre of pond surface in 15 years, while the seine- harvest method would yield about 11 acre-feet of effluent per acre of pond surface in 15 years. Moreover, studies at Auburn University revealed that water quality problems did not increase in catfish ponds that were not drained each year.

Ponds normally are full of water at the end of April, and water levels then decline until the end of November. During this period there usually is little runoff into ponds and pond evaporation exceeds rain falling directly into ponds. The 24-hour rainfall rarely exceeds 3 or 4 inches in water depth. Pond water levels usually begin to decline in late spring. Make-up water should be added, but the water level should be kept 3 to 4 inches below tops of overflow pipes. Storm overflow should not occur during summer and fall if this practice is followed. This practice is illustrated in the figure. If this

Illustration of practice of maintaining the water's level below the top of standing drain pipe to provide storage volume for summer and fall rainfall.



Standing Overflow Pipe

practice creates shallow water around the edges of the pond, the edges should be deepened during the next pond renovation.

Water exchange is sometimes used to flush plankton, ammonia, and nitrite from ponds or to improve dissolved oxygen concentration. Research has shown that water exchange normally is not effective. Application of sufficient mechanical aeration will prevent low dissolved oxygen and increase the capacity of nitrifying bacteria to oxidize ammonia and nitrite to non-toxic nitrate. Thus, farmers should not use water exchange.

References

Boyd, C. E. 1982. Hydrology of small experimental fish ponds at Auburn, Alabama. Transactions of the American Fisheries Society 111:638-641.

Hollerman, W. D. and C. E. Boyd. 1985. Effects of annual draining on water quality and production of channel catfish in ponds. Aquaculture 46:45-54

McGee, M. V. and C. E. Boyd. 1983. Evaluation of the influence of water exchange in channel catfish ponds. Transactions of the American Fisheries Society 112:557-560.

Erosion Control on Watersheds and Pond Embankments

BMP No. 3

Definition

Erosion in the pond watershed, sides and tops of pond embankments, emergency spillways, farm roads around the pond, access roads to the farm, and stream crossings increase suspended solids concentrations and turbidity in pond waters. Control of erosion on watersheds and embankments can reduce the input of solids to ponds, minimize turbidity, and lessen concentrations of suspended solids in effluents. This will protect in-stream water quality.

Explanation

Erosion from soil surfaces results from the kinetic energy of raindrops and flowing water. Raindrops dislodge soil particles, and runoff flowing downslope can suspend and transport the loose particles. A high concentration of suspended clay particles in runoff will increase turbidity, and clay particles require an extended period to settle out of water.

Runoff collects into progressively larger channels as it moves downslope. The energy of flowing water can cause downcutting of the land resulting in gullies. Bare soil erodes easily, and loose soil has a greater potential for erosion than tight soil. Erosion potential also increases with steeper slope.

Areas of bare soil may occur on catfish pond watersheds, and some watersheds may exhibit gully erosion. Farm roads often are subject to erosion. Tops of embankments and dams may be used as roads, and heavy traffic encourages erosion.

Livestock make paths on watersheds, and grass does not grow in these areas. Paths are highly erodible, and they serve as small channels that may eventually grow into gullies. Livestock traffic also can expose bare soil at pond edges, on dams and embankments, and at ditch crossings. If cattle wade in ponds, they will suspend sediment and increase turbidity. Pond dams and embankments are steep and heavy rains can cause severe erosion on both dry and wet sides.

Erosion control on watersheds, roads, dams, and embankments involves protecting the land surface from raindrops and flowing water. Protecting all soil surfaces with vegetation, stone, or other structural practices can do this. Plant cover lessens erosion in several ways. Foliage intercepts raindrops and prevents them from impacting the soil directly. Vegetation on the land surface offers some resistance to water flow and reduces the velocity of runoff. Vegetation also protects the soil from direct contact with the flowing water. Plant roots bind soil to strengthen it against the impact of falling or flowing water. Moreover, vegetation and ground cover reduce uncontrolled transport of nutrients from fertilizer and other sources.

For counties to participate in the flood insurance program of the Federal Emergency Management Agency (FEMA), flood plain blockage must not cause an additional rise of over 1 foot in flood water levels. Encroachment of structures such as ponds on flood plains causes depth and velocity of flood water to increase, resulting in increased erosion in the stream channel and floodway. Therefore, it is important to limit flood plain blockage by aquaculture ponds. NRCS recommends that 40 to 50% of the owner's 100-year flood plain area around the stream channel be left open.

Prevention of Erosion

Practices

The following practices should be used to prevent erosion:

- Control erosion on watersheds by providing vegetative cover, eliminating gully erosion, and using diversions to route water from areas of high erosion potential.
- Avoid the practice of rearing livestock near ponds and allowing livestock to walk on embankments and enter ponds.
- Eliminate steep slopes on farm roads and cover these roads with gravel—especially those roads built of soil of high clay content.
- Use 3:1 (horizontal:vertical) or flatter side slopes for pond embankments in new construction.
- Provide grass cover on sides of pond dams or embankments and grass or gravel on tops of dams or embankments.
- Construct new ponds or extensions of existing ponds to maintain 40 to 50% of the owner's 100-year flood plain area near the channel.

Implementation Notes

Watersheds should be examined and gullies, places with bare soil, soil with high clay content, or sparse vegetation, and other potential sites for erosion identified. Gullies should be stopped by shaping the sides, filling them with soil, and constructing a grade control structure if necessary. Grass or other vegetative cover should be established on all areas of bare soil. Diversions may be used on some watersheds to route water away from steep slopes or other areas of high erosion potential (See USDA-NRCS Alabama Conservation Practice Standard, Code 362 – Diversion).

Livestock are not recommended in watersheds of catfish ponds. Nevertheless, eliminating cattle from pond watersheds is not realistic, for many farmers consider the cattle essential. However, if exclusion from watersheds is not feasible, electric fences should be installed to restrict livestock from ponds.

Grades greater than 10% should be avoided on farm roads, and roads should follow contours (See USDA-NRCS Alabama Guide Sheet No. AL 655). A 2- to 3-inch layer of gravel should be applied on farm roads (See USDA-NRCS Alabama Guide Sheet No. AL 561).

Grass cover should be established on the entire dry side of embankments and above the water level on the wet side. Common pasture grass can be used on the dry side to control erosion. Halifax maiden cane and canary reed grass are suitable plants for preventing erosion on wet sides.

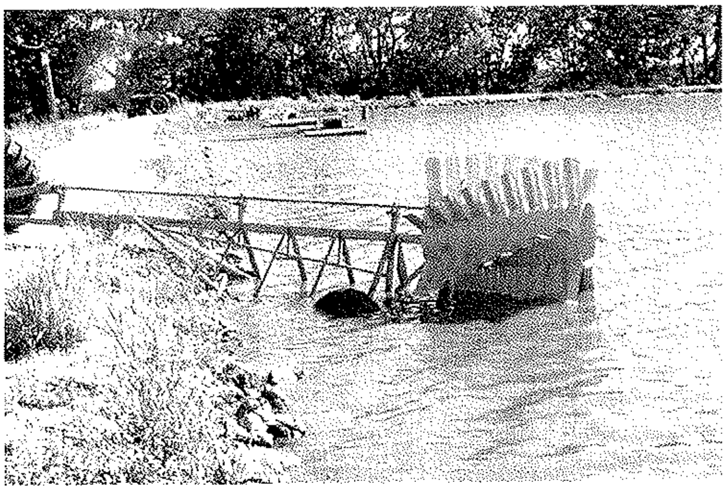
The tops of embankments not routinely used as roads should be covered with grass. Embankment tops subject to regular traffic should be covered with a 2- to 3-inch layer of gravel (See USDA-NRCS Alabama Guide Sheet No. AL 561). This will prevent erosion and allow embankment tops to serve as all-weather roads.

References

USDA NRCS AL Guide Sheets:
No. AL 655 – Erosion Control on Forest Land,
No. AL 561 – Heavy Use Area Protection.
USDA NRCS AL Conservation Practice Standards:
Code 362 – Diversion,
Code 410 – Grade Stabilization Structures,
Code 560 – Access Road,
Code 728 – Stream Crossing.
Yoo, K. H. and C. E. Boyd. 1994. Hydrology and Water Supply for Pond Aquaculture. Chapman and Hall, New York, New York.

Pond Management to Minimize Erosion

BMP No. 4



Definition

Erosion occurs in ponds as a result of wave action, water currents from aerators, inadvertent damage from vehicles or other equipment, and rain impacting on bottoms, dams, and embankments of empty ponds. Soil particles suspended by erosion increase total suspended solid concentrations in pond waters and effluents, and clay particles increase turbidity. Sediment removed from ponds and improperly disposed of can erode and cause contamination of surface water with suspended solids.

Explanation

Wave action causes water to impact on embankments and detach soil particles. Wave erosion is more severe in winter and spring because of greater wind velocity. Grass cover above the normal water level on the wet side of embankments provides protection from wave erosion. Erosion will be most severe when water levels are low and bare soil is exposed directly to waves and rainfall. When ponds are left completely or partially empty, rain falling on exposed bottoms may cause severe erosion, and turbid water containing high concentrations of suspended solids may exit through open drains.

Aerators generate strong water currents that can suspend soil particles from pond bottoms and detach soil particles from dams or embankments. Research has shown that the most severe erosion by aerators results when aerators are positioned to cause strong currents to travel close and parallel to embankments or when aerators are positioned so that strong currents impact directly against embankments.

Sediment accumulates in ponds over time, and ultimately ponds must be drained to remove sediment. If sediment is placed in unvegetated piles, rain falling on spoil piles will cause erosion and the runoff will be turbid with suspended soil particles.

Prevention of Erosion

Practices

- Close drains as soon as the maintenance or other activities for which the pond was drained are completed.
- Prevent if possible and repair immediately inadvertent damage caused by vehicles or other equipment.
- Install stationary mechanical aerators so that water currents caused by these devices do not cause erosion of pond earthwork.
- Position tractor-powered emergency aerators to avoid erosion.
- Use sediment where possible to repair pond earthwork. If sediment is removed from ponds, stabilize it to prevent erosion.
- Use earthen berms, riprap, or vegetation to minimize the effects of erosion from waves.

Implementation Notes

Pond water levels should be maintained in winter and spring so that bare soil is not exposed to wave action. Of course, this practice will not be effective unless grass cover is maintained on embankments (See BMP No. 3).

Heavy rainfall can cause severe erosion and suspension of soil particles. Bottoms of empty ponds are susceptible to impact of rainfall and can be a source of highly turbid water. It is very important to close the drains of empty ponds to prevent turbid water from entering streams.

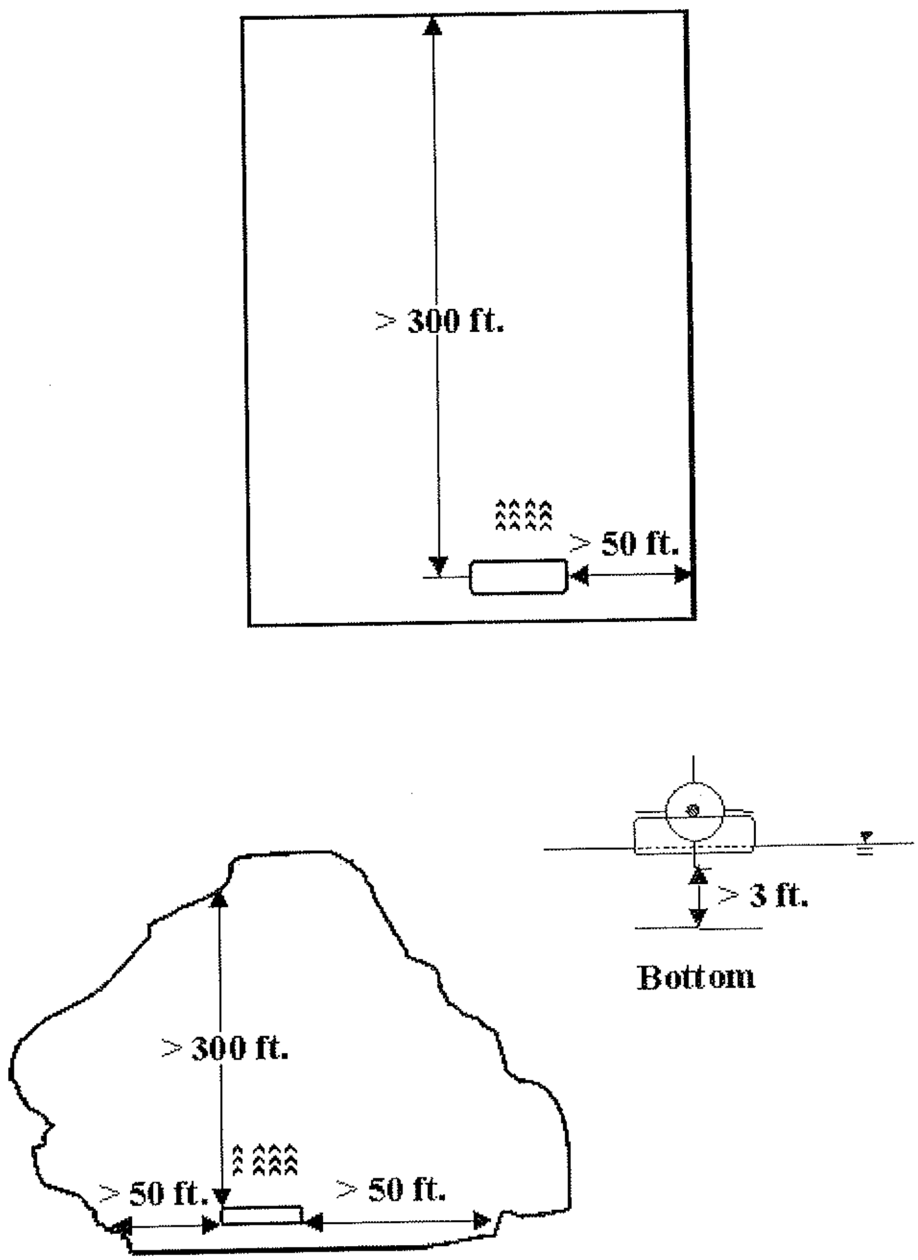
Stationary, electric paddlewheel aerators are used widely for pond aeration, but there still are many trailer-mounted, tractor-powered aerators in use. Both types of aerators can cause erosion.

Aerators usually must be installed near embankments, but water should be at least 3 feet deep directly below the paddlewheel. Aerators should be positioned so that the directed currents must travel for at least 300 feet before they impinge upon a dam or embankment. Aerator placement is illustrated in the figure.

Areas in front of aerators should be covered with stone. The location of the area to be protected from erosion will vary with type of aerator. The best way to identify the area is to investigate the erosion pattern in a recently drained pond. Information from old ponds can be used to identify the probable areas of erosion in new ponds.

This practice also can be used with tractor-powered emergency aerators. Because the trailers on which these aerators are mounted are long, they usually slide over

Illustration of aerator placement in a levee pond (upper) and a watershed pond (lower).



the edges of embankments when backed into ponds. Damage to earthwork is common when emergency aerators are positioned in ponds or removed from ponds. Emergency aerators should always be placed in ponds at the same locations and these locations should be reinforced with stone or other material to prevent damage.

When sediment must be removed from ponds, it should be used to repair the insides of embankments if possible. Use of the sediment to repair outsides of embankments also is acceptable, but it should be immediately covered with vegetation.

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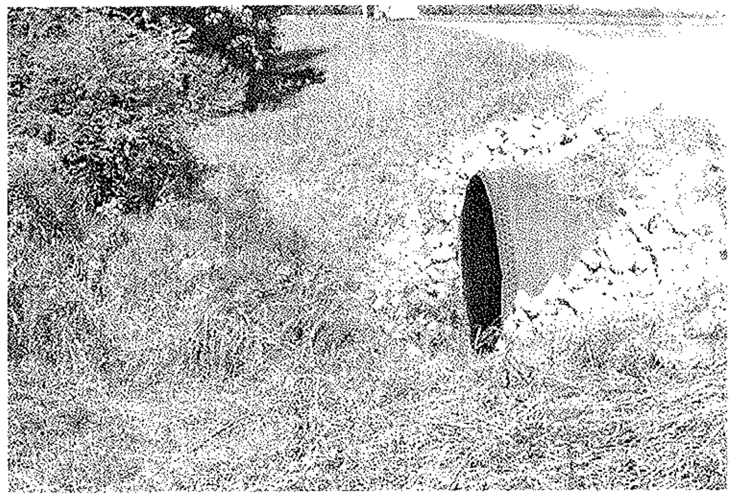
Boyd, C. E., P. Munsiri, and B. F. Hajek. 1994. Composition of sediment from intensive shrimp ponds in Thailand. World Aquaculture 25:53-55.

Control of Erosion by Effluents

BMP No. 5



Definition

Water discharging from ponds can cause erosion at the pipe outlet and in the downstream conveyance ditches or water courses. Suspended soil particles can increase the possibility of turbidity and sedimentation in receiving streams. On the other hand, if pipe outlets are properly protected and ditches are designed and constructed for permissible velocities, erosion will be minimal.

Explanation

Pond water is usually discharged through a pipe extending through the dam or embankment, into ditches or directly into streams. Erosion may occur at the point of exit from the drainpipe in ditches during conveyance of effluent from ponds to streams. Therefore, methods to reduce water velocity and impact on the soil are essential to maintaining quality of effluents from catfish ponds.

Control Methods

Practices

• Install structures such as riprap plunge basins to prevent drainpipe discharge from impacting and eroding soil.

• Construct discharge ditches of adequate size, with proper side slopes, and with proper vegetative or structural measures to prevent excessive water velocity and resulting erosion of bottoms and sides.

• Install riprap in bottoms of ditches in places that are susceptible to erosion.

Implementation Notes

Control of erosion by effluent is a simple matter that involves reducing the energy of impact of discharge upon soil, reducing water velocity in ditches to prevent scouring, and extending drainpipes beyond critical points for erosion.

Drainpipes from ponds should be extended at least 6 feet beyond toes of dams or embankments at an elevation near the ditch bottom. Also, the outlet area of the drainpipe should be protected with a riprap plunge pool (See Figure 1). The stone-protected pool will prevent water from impacting on soil, and it will reduce the energy of the water to lessen the potential for erosion as the water flows away from the initial impact zone.

Where drainpipes discharge directly into streams, they should extend far enough over the streambank to prevent discharge from causing erosion, and be located at an elevation near the normal water level of the stream. Erosion of the stream bottom by falling water can be avoided by installing riprap in the area of impact. This practice is illustrated in Figure 2. Where extension of pipes into streams is not practical, riprap protection should be provided from the pipe to a stable outlet.

Ditches for conveying water to streams should be designed according to permissible velocities for the type of soil and vegetation. Structural protection, such as riprap, may be necessary in ditch bottoms where vegetation cannot be maintained. Where permissible velocities cannot be maintained from the pond to stream, grade control structures may be necessary.

References

Yoo, K. H. and C. E. Boyd. 1994. Hydrology and Water Supply for Pond Aquaculture. Chapman and Hall, New York, New York.

Figure 1. Illustration of proper release of effluent from a pond into a ditch.

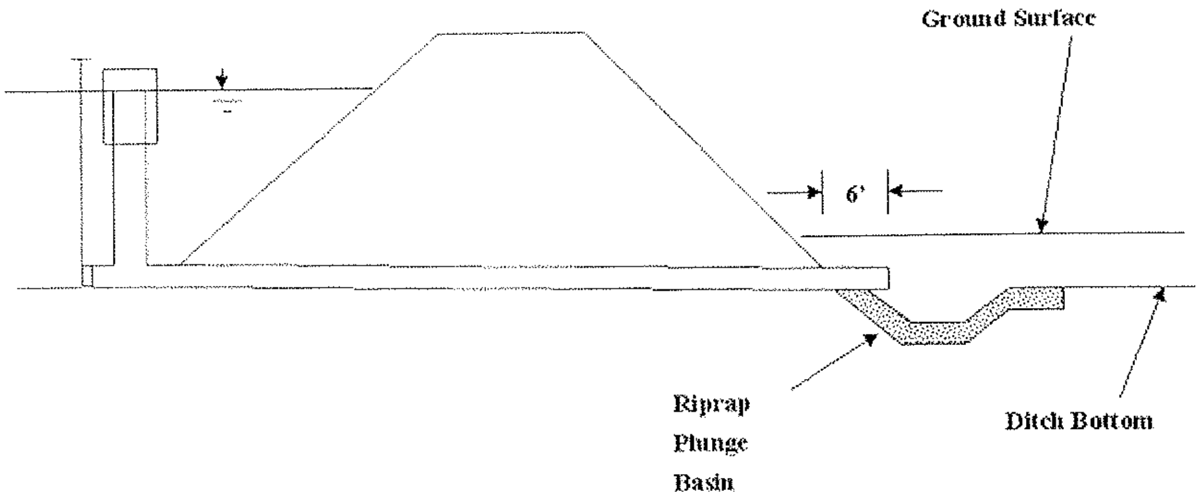
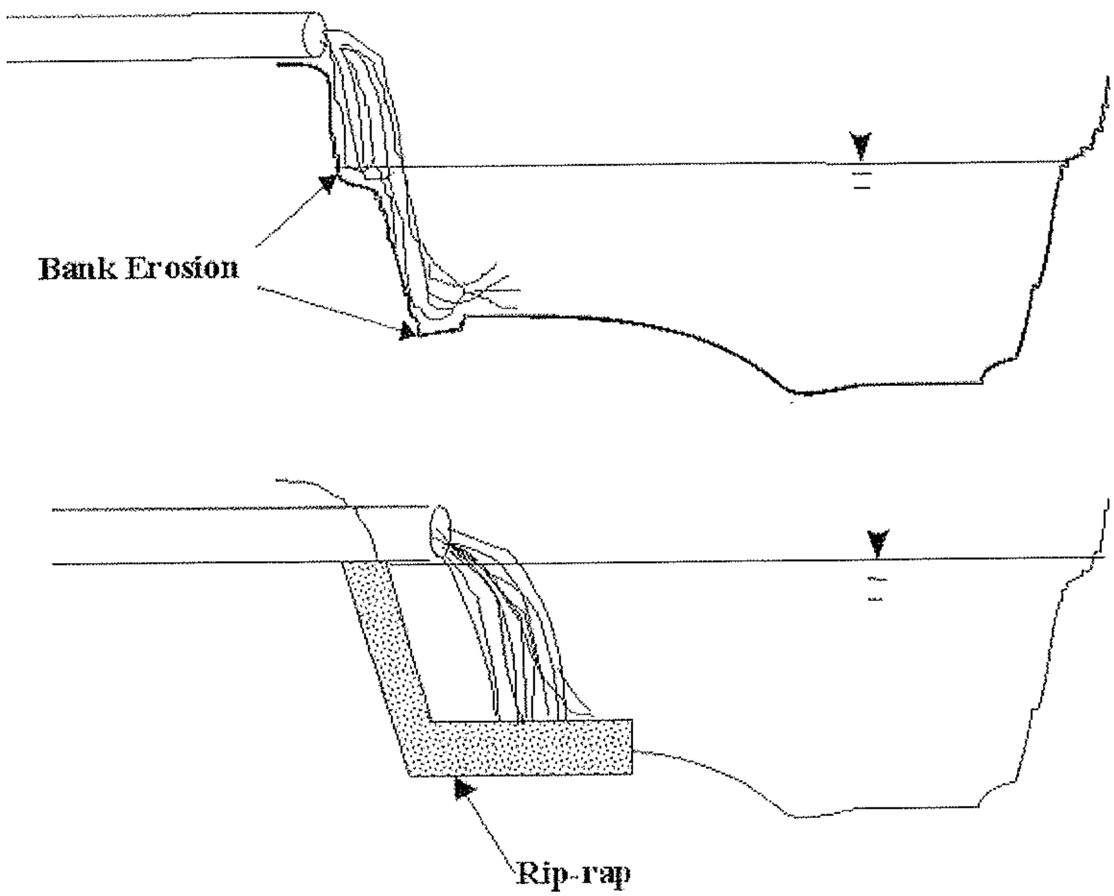


Figure 2. Illustration of improper (upper) and proper (lower) discharge into a stream.



Settling Basins and Wetlands

BMP No. 6

Definition

Properly designed settling basins retain water long enough for coarse suspended solids to settle. Water discharging from settling basins will be lower in suspended solids concentrations and concentrations of total nitrogen, total phosphorus, and biochemical oxygen demand than water entering them. Settling basins also provide the opportunity for pH adjustment.

Constructed wetlands are shallow water basins with dense stands of emergent aquatic vegetation. Wetlands act as settling basins and biological filters, can reduce turbidity, and they can be used as water treatment systems.

Explanation

Catfish ponds already act as settling basins because water remains in them under relatively quiescent conditions for long periods of time. Overflow usually occurs only in winter and spring after heavy rains. Storm overflow and the initial 75 to 80% of water drained to completely empty a pond cannot be treated effectively by sedimentation, because the suspended matter consists of very small clay particles and phytoplankton cells. Also, the volume of storm overflow and initial draining effluent is large and the size of a settling basin or wetland required for treating effluents can be substantial. The final 20 to 25% of effluent when a pond is completely drained would require a smaller settling basin or wetland than needed for storm overflow and initial draining effluent. Many catfish farms in Alabama extend to property lines or to streams and no space is available for constructing settling basins or wetlands. However, there are some farms where settling basins or wetlands could be used. Although initial construction costs can be substantial, settling basins or wetlands provide an alternative to holding the last 20 to 25% of water in a pond after fish harvest to allow time for sedimentation before final discharge (See BMP No. 9).

Research has shown that settling basins are as effective as wetlands for treating pond effluent. Settling basins are much simpler to construct and operate than wetlands. Nevertheless, constructed wetlands provide habitat for many species of animals and are attractive. There has been considerable effort by some to promote wetlands for treating aquaculture effluents, and a few farmers may want to use them.

Use of Settling Basins and Constructed Wetlands

Practices

- Use settling basins where space is available and construction costs are manageable. Settling basins are an alternative method for improving the quality of final draining effluent from catfish ponds.
- Where possible, lower the water level in an adjacent pond to accept pumped effluent from the pond being drained. The lower pond then functions as a settling basin.
- Use constructed wetlands as an alternative to settling basins.

Implementation Notes

On most catfish farms only one pond is drained at a time, and only one or two ponds are drained each year. A single settling basin can be used for all ponds on a single watershed. The volume of this settling basin should be about 37.5% of the volume of the largest pond in order to provide retention time for sedimentation. For example, if the largest pond in the watershed has an area of 10 acres and an average depth of 5 feet, the settling basin volume would be 18.75 acre-feet. For a 5-feet deep settling basin, the area would be 3.75 acres. To the extent possible, the settling basin should be constructed so as to exclude any outside drainage area. There must be a system to convey water from all ponds on the watershed to the settling basin. The settling basin should have grass cover on its embankments to prevent erosion (See BMP No. 3). Water should overflow from the surface of the settling basin when it is in use. A minimum hydraulic retention time (HRT) of 8 hours is suggested, but a HRT of 24 hours or longer will provide better treatment. When sediment accumulation begins to encroach on the HRT volume, the sediment should be removed and properly disposed of. The principle features of a settling basin are illustrated in the figure.

Inflow to the structure should be controlled so that the hydraulic retention time is not reduced in the settling basin thereby increasing outflow turbidity.

Some fish farms in Alabama could discharge effluent into natural wetlands. However, direct discharge into natural wetlands is not recommended as a best management practice. Wetlands are unique and ecologically-valuable habitat, and they could be harmed by sedimentation or excessive nutrient inputs. Of course, it might be possible to discharge effluent from a settling basin through a natural wetland to provide polishing of an already acceptable effluent. This would be a "site-specific" practice that should only be considered after consultation with local Natural Resources Conservation Service (NRCS) specialists.

References

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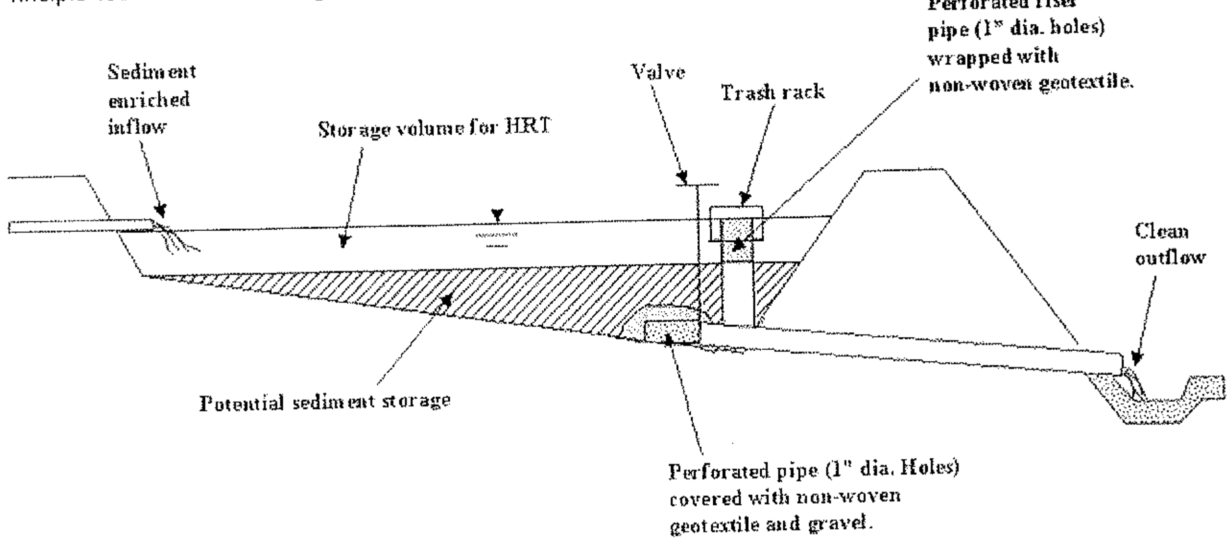
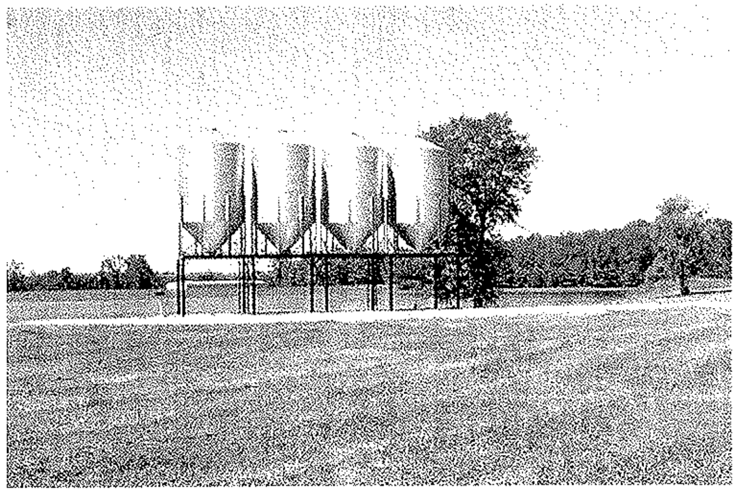
Principle features of a settling basin.



Feed Management

BMP No. 7



Definition

Feed is applied to channel catfish ponds to allow greater production of fish than possible with natural food organisms. Feeds are composed of a mixture of feed stuffs to include plant meals, fish meal, and grains as well as vitamins and mineral premixes that provide adequate amounts of essential nutrients and energy necessary for their utilization. Uneaten feed, feces, and metabolic wastes contribute nutrients to pond water. Good feed management minimizes nutrient inputs into pond water and is an important aspect of water quality management in catfish farming.

Explanation

Fish do not convert all of the applied feed to flesh. Fish harvested from ponds usually contain about 7.5 to 15% of organic matter, 20 to 30% of nitrogen, and 25 to 35% of phosphorous applied to ponds in feed. The difference in the input of a substance in feed and the amount of this substance in harvested fish represents the amount of the substance that enters the pond ecosystem as uneaten feed and in fish feces and metabolites. Uneaten feed and feces are decomposed to metabolites by pond bacteria. The metabolites of most interest are carbon dioxide, ammonia, and phosphate, because these substances are basic nutrients for production of phytoplankton. They also represent potential pollutants in pond effluent.

Nutrient inputs and phytoplankton abundance in ponds increase as feeding rates increase. Mechanical aeration is used to maintain adequate dissolved oxygen concentrations and to favor oxidation of ammonia to nitrate by nitrifying bacteria. However, if feeding rates exceed 100 to 120 pounds per acre per day, water quality in ponds tends to deteriorate unless mechanical aeration is increased substantially. Deterioration of water quality in ponds stresses fish and causes them to eat less, grow slowly, and to be more susceptible to disease. Moreover, effluents from ponds with lowered water quality have an increased pollution potential.

Feeds and Management

Practices

- Select high quality feeds that contain adequate, but not excessive, nitrogen and phosphorous.
- Store feed in well-ventilated, dry bins, or if bagged, in a well-ventilated, dry room. The feed should be used on a first in and first out basis by the expiration date suggested by the manufacturer.
- Apply feed uniformly with a mechanical feeder.
- Do not apply more feed than fish will eat.
- Maintain adequate dissolved oxygen concentrations in ponds to prevent fish stress and enhance the capacity of the pond to assimilate metabolic wastes.
- In un-aerated ponds, don't feed more than 30 pounds per acre. In ponds with 2 hp of aeration per acre, you can increase daily feed application to 100 to 120 pounds per acre. These feed amounts are the maximum amounts to be applied on a given day; they are not annual averages.

Implementation Notes

Because feed is the main source of nutrients in ponds, good feed management, reasonable stocking and feeding rates, and adequate mechanical aeration is the best way to enhance effluent quality. Use of high quality feed that has no more nitrogen and phosphorous than necessary is important. Reasonable percentages of these elements in feeds for grow-out are 4.5 to 5.1% (28 to 32% crude protein) for nitrogen and 0.75 to 1.0% phosphorous. Somewhat higher percentages may be necessary in feeds for fry or fingerlings. Proper attention to feed storage to prevent excessive heat and moisture and care to always use fresh feed protects feed quality and improves the efficiency with which fish can use it.

Mechanical feeders that spread the feed uniformly around the edges of ponds assure that all fish have an opportunity to eat an adequate amount of feed. This procedure also allows the manager to better observe feeding activity.

Overfeeding is wasteful, costly, and results in unnecessary feed and nutrient inputs to ponds. Although feed consumption depends largely on the weight of fish in a pond, other factors are important in controlling feed consumption. Fish will not eat as well when water temperature is too low or too high. Poor environmental conditions, such as low dissolved oxygen concentration and high ammonia concentration or high pH, stress fish and depress their appetite as well as their ability to convert consumed food into growth. Disease and parasite problems also will lead to decreased feed consumption by fish. Thus, managers must observe conditions in ponds and the feeding behavior of fish to prevent overfeeding. A sure sign of overfeeding is the accumulation of feed in corners of ponds.

Moderate stocking and feeding rates and adequate mechanical aeration are necessary for assuring good water quality. Mechanical aeration prevents low dissolved oxygen concentrations, and fish stress can be avoided. Aeration also improves the effectiveness of the pond ecosystem to assimilate wastes from feeding, and effluents from properly aerated ponds will not have low dissolved oxygen concentrations.

Dissolved oxygen concentration should be monitored at night, and frequent excursions of dissolved oxygen concentration below 3 or 4 milligrams per liter suggest excessive feeding and less than adequate aeration (See BMP No. 9). Underwater visibility in ponds should not be less than 12 inches even where dissolved oxygen concentrations are adequate. Underwater visibility can be measured best with a Secchi disk (see figure). This disk is lowered into the water by a calibrated line until it just disappears. The depth at which the disk disappears is called the Secchi disk visibility. Ponds with excessively dense phytoplankton blooms may have high ammonia concentrations and other water quality problems.

Secchi disk.

Comment

The feed conversion ratio (FCR) is the weight of feed applied divided by the weight of fish produced. This ratio is very important in pond aquaculture because it indicates the efficiency of feed use. In catfish culture, FCR values on different farms often range from 1.5 to 2.5. A value of 2 is usually considered acceptable, but farmers should strive to reduce the FCR to 1.8 or less. A better FCR will make catfish production more efficient. It will protect effluent quality because nutrient inputs per unit of fish production decline as FCR improves.

References

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Lovell, R. T. 1988. Nutrition and Feeding of Fish. Van Nostrand Reinhold, New York, New York.

Pond Fertilization

BMP No. 8

Definition

In the early spring, catfish ponds may have clear water. Fertilizers are applied to increase nitrogen and phosphorous concentrations for the purpose of promoting phytoplankton growth. Phytoplankton is the base of the food web that provides natural food organisms for fish. The turbidity created by phytoplankton restricts light penetration in ponds to prevent or limit the growth of large aquatic plants (aquatic weeds).

Explanation

In the early spring, feed inputs to catfish ponds usually are low, and there is not enough nitrogen and phosphorus in pond waters to promote growth of microscopic plants known as phytoplankton. Ponds may have clear water and rooted aquatic weed infestations may develop on pond bottoms and in the water column in response to light penetration. Aquatic weeds obtain nutrients from pond bottom soils through their roots. These weeds can interfere with feeding and fish harvest. Also, ponds infested with aquatic weeds are not as productive as ponds with good phytoplankton production. An abundance of natural food organisms is especially important in fry and fingerling ponds to supplement manufactured feed. Large catfish also gain some benefit from natural food organisms. Fertilization is a proven technique for improving conditions for catfish production in ponds with clear water.

As water temperature increases, feed input increases due to increased fish activity. Phytoplankton becomes more abundant as a result of increased food input and warmer temperature. An abundance of phytoplankton is called a phytoplankton bloom. Fertilization is generally unnecessary to maintain phytoplankton blooms in most ponds during the warmer months because there are plenty of nutrients from feeds. Fertilization is counterproductive in ponds where feeding rates are high enough to maintain adequate phytoplankton blooms. Fertilization encourages excessive phytoplankton and a greater oxygen demand. Unnecessary fertilization is detrimental to water quality in ponds and may lead to higher concentrations of nitrogen and phosphorus in effluents.

Fertilizers often are not effective in promoting phytoplankton growth in pond waters with total alkalinity concentration below 20 ppm. Applications of agricultural limestone to increase alkalinity can improve the response to fertilization. Higher alkalinity also is beneficial to fish production. Few commercial catfish ponds in Alabama have acidic, low alkalinity waters, and applications of agricultural limestone seldom are necessary.

Manures and organic fertilizers such as plant meals have historically been used to fertilize ponds. These materials are decomposed by bacteria resulting in an oxygen demand and low dissolved oxygen concentration. Manures also may contain antibiotics or other drugs that could contaminate effluents or fish flesh. Moreover, manures can contain a high abundance of bacteria. Use of animal manures in catfish ponds, and especially in food fish grow-out ponds, is not a recommended practice.

Fertilizing Catfish Ponds

Practices

• Apply fertilizers only when necessary to promote phytoplankton blooms.

• Do not use animal manures for fertilizers.

• Avoid excessive fertilization by using moderate doses and relying on the Secchi disk visibility to determine if fertilization is needed.

• Manage pond water levels to prevent or minimize effluent release to the extent possible.

• Do not fertilize ponds 1 or 2 days before expected periods of significant precipitation if overflow is expected.

• Apply agricultural limestone to ponds with total alkalinity below 20 ppm.

• Store fertilizers under a roof in a dry place to prevent rain from washing over it into surface waters.

Implementation Notes

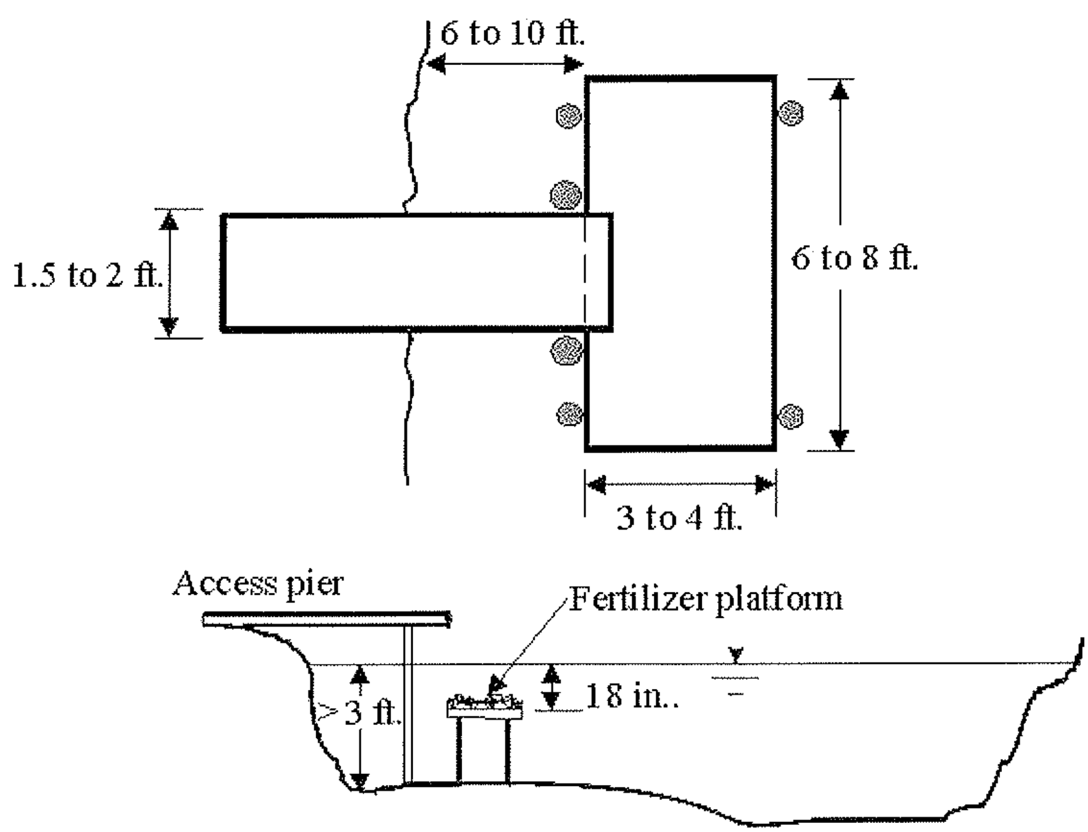
The most common fertilizers for catfish ponds are triplesuperphosphate, ammonium nitrate, diammonium phosphate, and liquid fertilizer. A suitable N:P_2O_5 ratio for ponds fertilizers in Alabama is about 1:3. Inputs should be around 2.7 pounds of nitrogen per acre and 8 pounds of P_2O_5 per acre per application. Suitable fertilization programs can be based on periodic applications of the following amounts and types of fertilizers:

1. Triplesuperphosphate, 18 pounds per acre and ammonium nitrate, 8 pounds per acre.

2. Diammonium phosphate, 18 pounds per acre.

3. 10 – 34 – 0 liquid fertilizer, 24 pounds per acre.

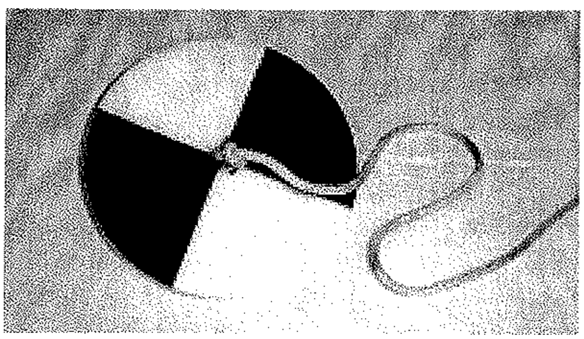
Figure 1. Underwater platform.



Fertilizers should be applied only when there is not enough phytoplankton. The Secchi disk is a good tool for assessing phytoplankton blooms. If Secchi disk visibility is greater than 18 inches in the spring, fertilizers should be applied.

Granular fertilizers should not be broadcast over pond surfaces. They should be mixed in a container of pond water (10 or 20 parts water to 1 part of fertilizer) and splashed over pond surfaces. An alternative is to apply granular fertilizers on an underwater platform such as illustrated in Figure 1. As nutrients dissolve from fertilizer on the platform they are mixed throughout the pond by water currents. Liquid fertilizers may be sprayed over pond surfaces or released into the propeller wash of an outboard motor as a boat is driven over the pond surface. Alternatively, liquid fertilizers may be mixed with pond water and splashed over pond surfaces behind paddlewheel aerators.

Figure 2. Secchi disk.



Fertilizers may be applied at weekly intervals if plankton is scarce and water is clear. The Secchi disk (Figure 2) is used to estimate visibility into the water. The depth that this disk disappears from view is called the Secchi disk visibility. Water with a Secchi disk visibility of less than 24 inches usually is considered too clear and fertilizer can be applied to promote phytoplankton. Once a Secchi disk visibility of 18 inches or less is achieved and feeding rates are above 20 or 30 pounds per acre per day, pond fertilization should be discontinued to avoid introducing unnecessary nutrients.

Fertilization of muddy ponds often helps clear the water of excessive turbidity. Application of agricultural limestone also can help clear muddy water in ponds with low alkalinity. Agricultural limestone application rates can be obtained by sending a sample of pond bottom soil to the Auburn University Soil Testing Laboratory for analysis. Agricultural limestone application rates usually are 2,000 to 4,000 pounds per acre, and the limestone should be spread uniformly over pond surfaces using a boat.

References

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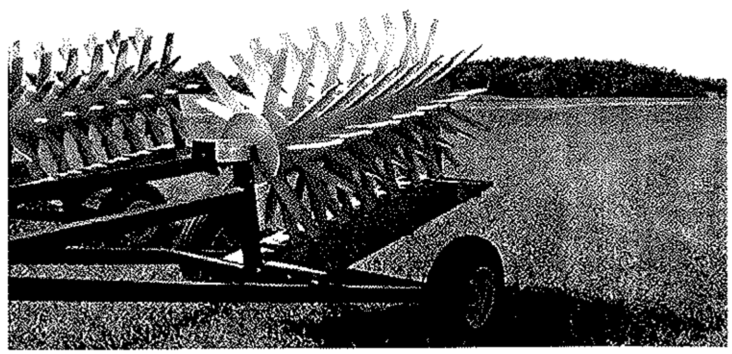
Managing Ponds to Improve Quality of Overflow Effluent

BMP No. 9



Definition

Mechanical aeration is the primary means of maintaining good water quality in ponds. Aeration maintains adequate dissolved oxygen concentrations and mixes pond water, but it does not prevent stratification entirely. Proper mechanical aeration and discharge from pond surfaces can enhance effluent quality.

Explanation

Mechanical aeration is a highly successful procedure for maintaining adequate dissolved oxygen for fish, but aeration provides several other benefits. Water circulation caused by aeration mixes pond water, provides more homogeneous water quality, and prevents strong thermal stratification. Dissolved oxygen introduced by aeration minimizes the occurrence of anaerobic (oxygen-depleted) zones in pond bottom water and soil. The presence of dissolved oxygen favors efficient oxidation of organic matter by bacteria and lessens the likelihood for potentially toxic concentrations of nitrite, sulfide, and other metabolites. The conversion of ammonia to nitrate by nitrifying bacteria is stimulated by enhanced dissolved oxygen supplies from mechanical aeration. Ammonia is potentially toxic to aquatic organisms while nitrate is not. Thus, nitrate is not as undesirable in effluents as ammonia. The amount of aeration used per acre of ponds has increased during recent years. Nevertheless, aeration is still not used in sufficient amounts on all catfish farms.

Livestock on watersheds produce manure that may wash into ponds. Manure is a source of nutrients and it decomposes to exert an oxygen demand. Thus, water often tends to be better in catfish ponds that do not have livestock on watersheds.

Water quality in ponds tends to be better in the upper 3- to 4-foot layer than in the bottom 1- or 2-foot layer even when mechanical aeration is applied. Most ponds overflow from their surface into a standing drainpipe that passes through the bottom of the embankment. However, some ponds have deep-water overflow structures, and discharge in response to storm overflow originates at or near the bottom. Deep-water discharge is less desirable than surface discharge because bottom water usually is of lower quality than surface water. Bottom water discharge structures should be modified to discharge near the surface.

Improvement of Quality of Overflow

Practices

- Apply mechanical aeration with the objective to maintain adequate dissolved oxygen concentrations. The higher the dissolved oxygen concentration of the effluent, the better for in-stream water quality.
- Do not have deep water overflow structures in ponds.
- Avoid the practices of rearing livestock on farm watersheds and allowing livestock to walk on embankments and enter ponds.

Implementation Notes

Mechanical aerators should be efficient in transferring oxygen, and aeration should be applied at rates great enough to maintain dissolved oxygen concentrations above 4 ppm at night. The night-time decline in dissolved oxygen concentration increases with increasing feeding rate and phytoplankton abundance. In order to prevent low dissolved oxygen concentration, phytoplankton abundance should not restrict Secchi disk visibility below 12 inches. The most effective way of preventing excessive phytoplankton is to use good feeding and fertilization practices (See BMP Nos. 7 and 8). In ponds where Secchi disk visibility often decreases to 12 inches or less, mechanical aeration should be applied at 2 horsepower per acre or more with efficient aerators. The 10-horesepower electric paddlewheel aerators commonly used in catfish farming are highly efficient. Aerators should be operated whenever dissolved oxygen can be expected to fall below 4 milligrams per liter. Aeration should be positioned in ponds as explained in BMP No. 4.

In many ponds, it is necessary to operate aerators from midnight until 8 a.m. almost daily from late May until late September. A nighttime dissolved oxygen-monitoring program is necessary to determine if aeration is maintaining dissolved oxygen concentrations within a desirable range for fish growth.

Because the worst quality water in a pond is near the bottom, structures for storm overflow that take in water from near the pond bottom should not be installed in new ponds. These structures also should be replaced in existing ponds. (Check with NRCS for the correct size trash rack to use.)

References

Boyd, C. E. and T. Dhendup. 1995. Quality of potential effluents from the hypolimnia of watershed ponds used in aquaculture. Progressive Fish-Culturist 57:59-63.

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Managing Ponds to Improve Quality of Draining Effluent

BMP No. 10

Definition

Water released from ponds that are partially or completely drained has greater concentrations of nutrients, organic matter, and suspended solids than overflow from ponds following storms. The majority of food fish ponds are partially drained at 5- to 6-year intervals with complete draining after 15 to 20 years. However, some ponds are drained each year; these include most fry and fingerling ponds and food fish ponds that are not seinable. Concentrations of most water quality variables are highest in the final 20 to 25% of water released when ponds are completely drained. Thus, particular attention should be given to techniques for enhancing the quality of pond draining effluent and especially the final effluent from ponds.

Explanation

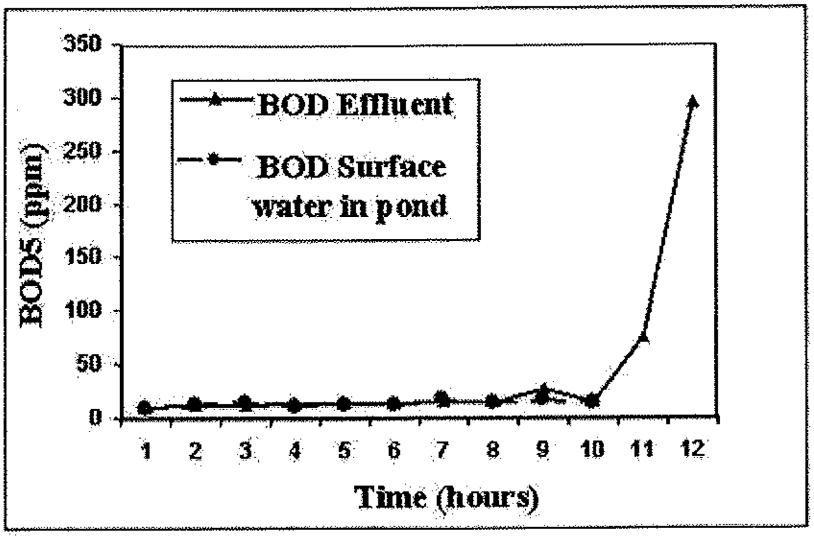
Ponds normally overflow after heavy rains when large amounts of runoff enter ponds. The pond serves as a settling basin, so coarse suspended solids entering in runoff have opportunity to settle. Overflow is most common in winter and early spring when pond waters do not have high concentrations of nutrients and organic matter. Thus, water quality is usually quite good when overflow occurs, and overflow also occurs when stream flow is high.

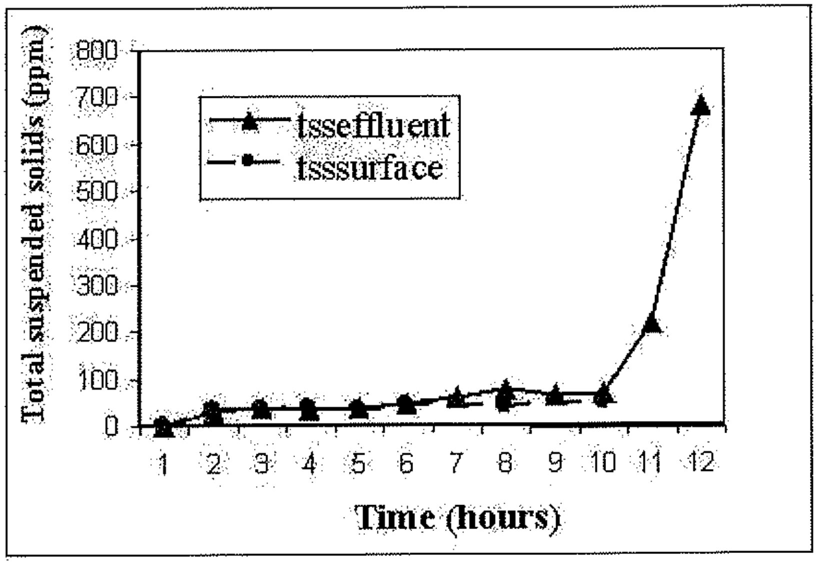
Pond draining may be done at anytime during the year. In late spring, summer, and early fall, pond waters contain higher concentrations of nutrients and organic matter than in winter and early spring.

When draining ponds from a bottom release, there will be a surge of water when the valve is first opened, and the water entering the pipe from near the pond bottom will contain suspended organic matter and soil particles. Discharge initially will be highly turbid, but it will clear as loose particles are removed from the pond bottom around the pipe intake. This problem has been avoided when draining research ponds at Auburn University because the ponds are fitted with swivel-type drains that take in water from the surface and can be lowered to completely drain the pond. However, catfish pond drains usually have the discharge pipe inlet at the pond bottom.

When ponds are completely drained for fish harvest, water quality is much better in the first 75% to 80% of effluent than in the last 20% to 25% of effluent (Figure 1). This results because fish activity and harvest operations suspend particles of soil and organic matter from the bottom. In some studies at Auburn University, drains were closed after about 75 to 80% of water had been discharged from ponds and fish removed by seining. The suspended solids were allowed to settle after fish were removed, and the water was discharged slowly to prevent sediment resuspension. This effected a large reduction in the pollution load (see table).

Figure 1. Differences in water quality.





Average Concentrations of Selected Water Quality Variables in the Final Water[1] Discharged from Ponds after Channel Catfish were Harvested by Seining

Discharge schedule	Total suspended solids	Total Kjeldahl nitrogen	Total phosphorus	Biochemical oxygen demand
	(mg/L)			
Immediately after seining	370	11.9	0.97	30.1
1 day after seining	408	12.2	0.52	19.2
2 days after seining	16	3.1	0.30	12.4

[1] Approximately 20% of pond volume was discharged.

Improvement of Draining Effluent Quality

Practices

• Where possible, construct seinable ponds that do not have to be drained for harvest.

• Design new ponds with structures that allow ponds to be drained near the surface instead of from the bottom. Where practical, alter drain structures for surface discharge when old ponds are drained for harvest and renovation.

• Maximize periods between partial or complete draining by managing ponds to prevent erosion of earthwork and to maintain good water quality.

• Where possible, avoid discharge when harvesting fish. When ponds must be drained completely, it is recommended that the final 20 to 25% of pond volume discharged into a settling basin or held for 2 or 3 days to minimize suspended solids and then discharged slowly.

• Investigate new technology and innovative methods for reducing concentrations of suspended solids in draining effluent.

Implementation Notes

When ponds are drained for fish harvest, water levels should be lowered to 20 or 25% of full volume, drains should be closed, and fish harvested by seining. Once fish have been removed, the water should be allowed to stand until suspended solids have settled. This will normally take only 2 or 3 days. The water should then be released slowly to prevent resuspension of solids. It is recommended that the valve only be opened to one-quarter of its maximum capacity during final draining and that the valve be closed at the beginning of rainfall and not reopened until water has cleared.

Some catfish farms have space for settling basins to treat effluents (See BMP No. 6). Where effluents can be introduced into settling basins, there is no reason to hold the last 20 to 25% of water for sedimentation following fish removal.

On farms where several ponds are located in close proximity, it might be possible to transfer water from the pond being drained for harvest to adjacent ponds for reuse. Once harvest is complete, water could be pumped back to the harvested pond. Of course, additional pumping costs would be incurred.

An example of a "swivel-type" drainpipe is illustrated in Figure 2. Another possibility is to install a second drain valve on the pond standpipe at the seineable depth elevation. This allows only the better quality water to be discharged and doesn't require the owner to close the valve to prevent total pond drainage.

References

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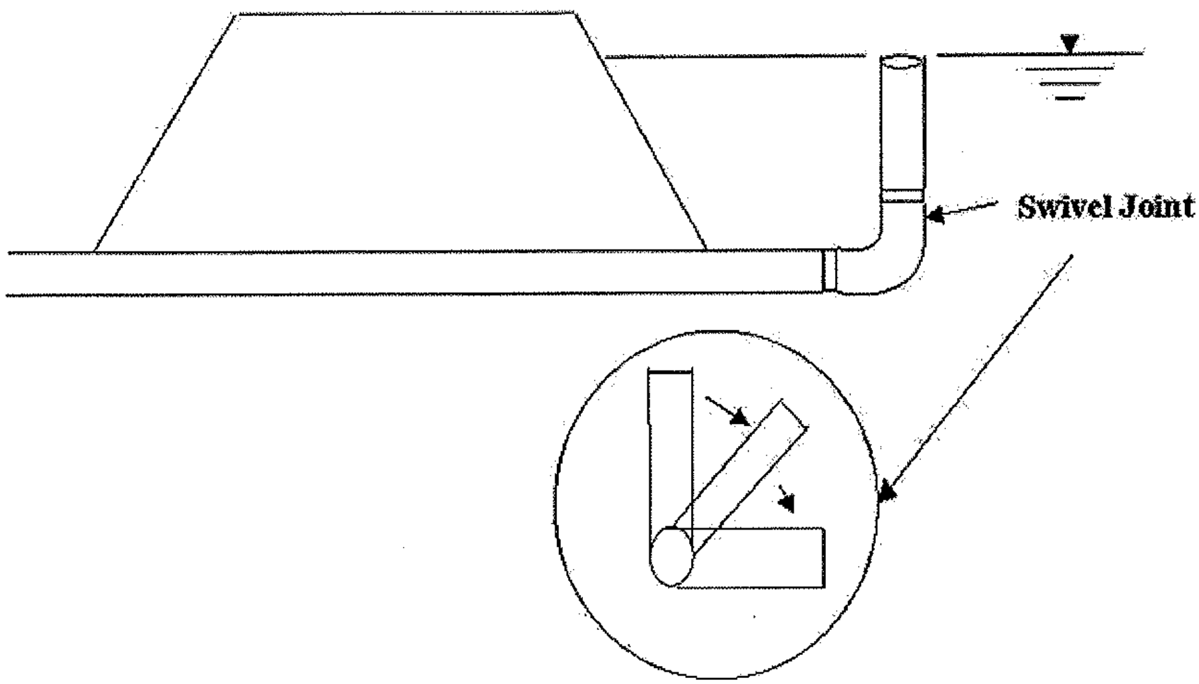
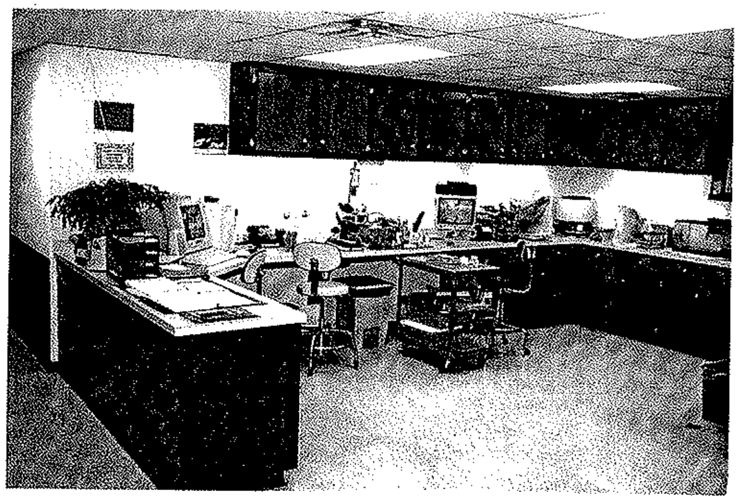
Seok, K., S. Leonard, C. E. Boyd, and M. Schwartz. 1995. Water quality in annually drained and undrained channel catfish ponds over a three-year period. Progressive Fish-Culturist 57:52-58.

Figure 2. Swivel connection used to maintain appropriate level.



Theraputic Agents

BMP No. 11



Definition

Infectious diseases are common in catfish culture, and antibiotics may be added to feed (medicated feed), or certain drugs or chemicals may be applied to pond waters for disease treatment. Because antibiotics, drugs, or other compounds applied for disease control could occur in effluents, guidelines for use of therapeutic agents are necessary.

Explanation

Infectious diseases in catfish culture are more common and severe when fish are stressed by poor diet, environmental stress, improper handling, or other factors. The first principle of disease control should be to prevent stressing the fish. The most common stress in ponds usually is low dissolved oxygen concentration. When ponds are aerated to maintain adequate dissolved oxygen, stress may still result if high feeding rates cause elevated ammonia concentration. Thus, compliance with good water quality management procedures (See BMP Nos. 7, 8, and 9) can reduce stress and minimize the likelihood of disease. Nevertheless, fish disease may still occur in ponds with good water quality.

When diseases occur in ponds, samples of fish should be examined and the disease identified. Once the disease has been identified, an antibiotic, drug, or other chemical known to be effective against the disease often is recommended. Dose rates, application techniques, and withdrawal times for therapeutic agents should follow instructions provided on product labels. Water should not be intentionally discharged from ponds until the therapeutic agent has degraded.

Use of Therapeutic Agents

Practices

- Store therapeutics so that they cannot be accidentally spilled to enter the environment.
- Manage pond water levels to prevent or minimize overflow until therapeutic agents have degraded.
- Use good water quality management procedures to prevent unnecessary stress to fish.
- Make a diagnosis for diseases and a recommendation for disease treatment before applying therapeutic agents.
- Follow instructions on labels of therapeutic agents for dose application method, safety precautions, etc.

Implementation Notes

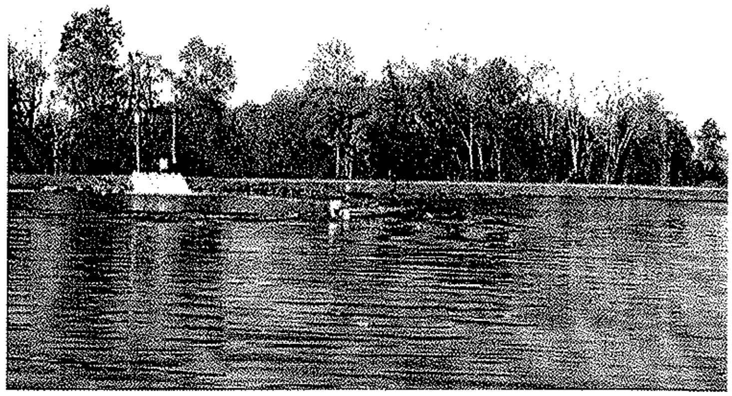
Disease diagnosis and recommendations for treatments should be done by fish health specialists. The Alabama Fish Farming Center can provide assistance with disease identification, treatment recommendations, and treatment oversight.

References

Browson, M. W. 1996. Catfish quality assurance. Publication 1873, Mississippi Cooperative Extension Service.

Water Quality Enhancers

BMP No. 12



Definition

A number of chemicals are used in pond aquaculture to enhance pond water quality. The compounds used most commonly in Alabama catfish ponds are calcium oxide or hydroxide (lime), sodium chloride (salt), copper sulfate, calcium sulfate (gypsum), aluminum sulfate (alum), and calcium hypochlorite. Water normally is not discharged from catfish ponds for several weeks after these compounds are applied, and their concentrations in effluents would not normally be high enough to cause adverse effects in receiving waters. Because improper use of these compounds could possibly impair effluent quality, guidelines for their use are needed.

Explanation

Agricultural limestone often is applied to acidic waters to increase total alkalinity. Harmful effects resulting from applications of agricultural limestone to aquaculture ponds have not been reported. Agricultural limestone is not used often in Alabama catfish farming because few catfish farms are located in areas with acidic, low alkalinity waters.

Hydrated lime often is applied to ponds in small doses for reducing phytoplankton growth or to remove carbon dioxide. The main effect of lime application is to increase pond water pH. Hydrated lime doses of 200 pounds per acre or more may increase water pH above 10. Applications usually are less than 100 pounds per acre, because high pH following large lime applications could be harmful to fish. Nevertheless, lime application may cause pH in pond surface water to increase to 9.0 to 9.5. The pH will decline within 1 or 2 days as the hydroxide from lime reacts with carbon dioxide. Lime applications normally are made in summer when ponds are not discharging water. Thus, there is little danger of high pH in catfish pond effluents as a result of liming.

Sodium chloride applications are made to increase chloride concentrations and counteract nitrite toxicity. Fish in waters containing 10 to 20 times more chloride than nitrite will not be harmed by high nitrite concentration, for chloride interferes with nitrite absorption across the gill. Sodium chloride applications usually are between 50 and 100 ppm, and such small doses will not increase chloride concentration or salinity enough to harm freshwater aquatic organisms. Effluents from salt-treated ponds do not represent an ecological threat.

Copper sulfate usually is applied at 0.25 to 1.0 ppm for phytoplankton control. Copper sulfate precipitates from water within a few hours (see figure), and problems with high copper concentrations in effluents have not been reported. Copper sulfate should not be added to ponds that are discharging water.

Calcium sulfate may be added at rates of 500 to 2,000 pounds per acre to increase calcium hardness in waters and to precipitate suspended clay particles and reduce turbidity. No adverse effects of effluents from calcium sulfate-treated ponds have been reported. Also, this compound seldom is applied to channel catfish ponds. Aluminum sulfate sometimes is applied to ponds at concentrations of 25 to 50 ppm to remove turbidity from suspended soil particles. Aluminum sulfate is acidic, but if the alkalinity of pond water is equal in parts per million to the aluminum sulfate-treatment rate, the pH will not decline appreciably and aluminum will rapidly precipitate. No environmental hazards should result where effluents from alum-treated ponds enter natural waters.

Calcium hypochlorite is sometimes applied to catfish ponds at 0.05 to 0.1 ppm with the intent of controlling bacteria and phytoplankton abundance. Research has shown that this treatment is ineffective, and chlorination of pond waters is not recommended.

Use of Amendments

Practices

• Store amendments under a roof where rainfall will not wash them into surface waters.

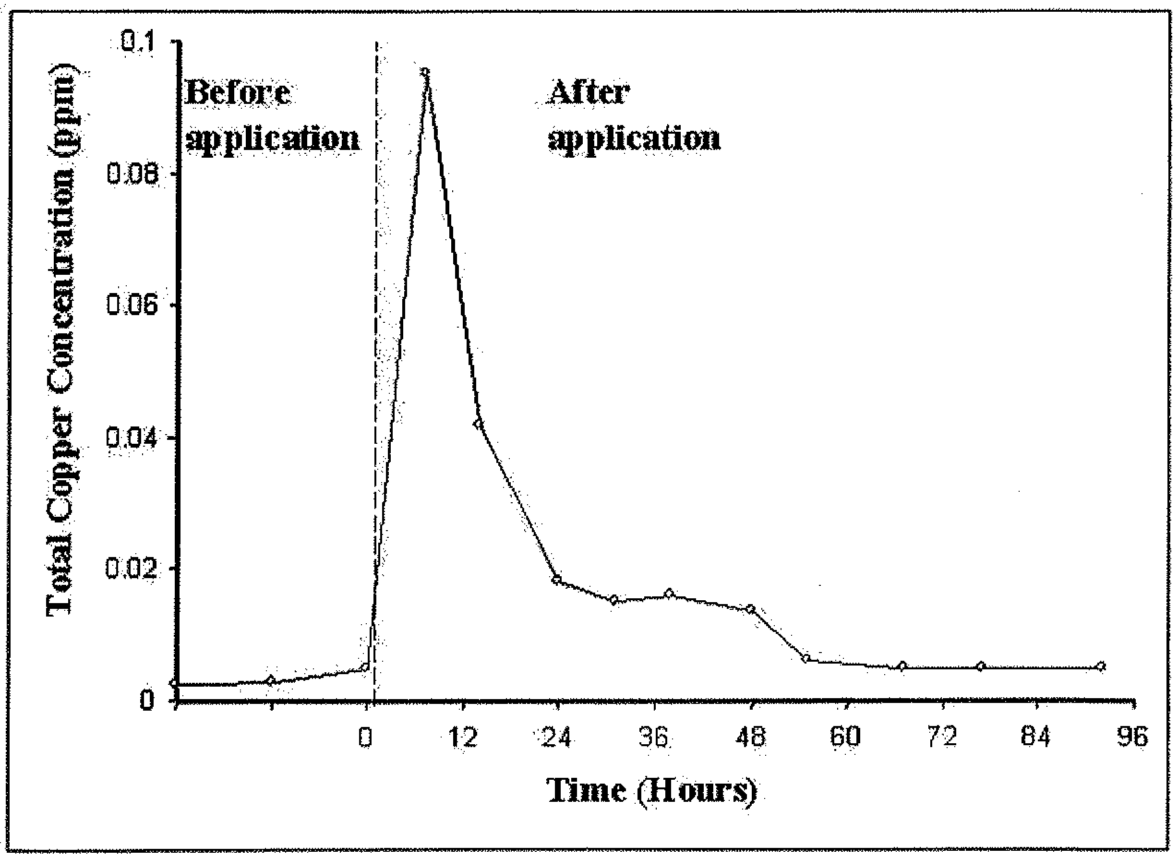
• Apply copper sulfate in parts per million at rates not exceeding one-one hundredth (0.01) of total alkalinity also measured in parts per million. Do not release pond water for 72 hours after application of copper sulfate.

• Apply sodium chloride at rates not exceeding 200 parts per million per application.

• Apply lime (calcium oxide or hydroxide) at rates not exceeding 100 pounds per acre per application.

• Apply agricultural limestone and gypsum (calcium sulfate) at rates not exceeding 5,000 pounds per acre per application and 2,000 pounds per acre per application, respectively.

Average total copper concentrations in three earthen ponds. (All ponds were treated at 12 pounds copper sulfate per acre to achieve a concentration of 0.3 ppm copper.)



• Do not apply calcium hypochlorite or other chlorine compounds to catfish ponds.

• Use only water quality enhancers that have been approved by the Food and Drug Administration and the Environmental Protection Agency, and carefully follow instructions on labels.

• When rotenone is used in ponds, do not discharge water until the rotenone has detoxified naturally. Rotenone will detoxify in 1 week at water temperatures of 20°C and above, and in 2 weeks at lower temperatures.

Implementation Notes

Dose rates for water quality enhancers depend upon pond volume. Accurate estimates of pond volume upon which to calculate the amounts of water quality enhancers needed to provide target concentrations are important. If the pond volume is overestimated, the concentration of the water quality enhancer also will be overestimated. An excessive dose could harm fish and result in a harmful concentration of a substance in the effluent.

Water samples from ponds can be analyzed for concentrations of chloride, chlorine, copper, and other water quality enhancers. These analyses should be made when there are questions about the influence of the substances on fish or their concentrations in effluents.

References

Boyd, C. E. 1979. Aluminum sulfate (alum) for precipitating clay turbidity from fish ponds. Transactions of the American Fisheries Society 108:307-313.

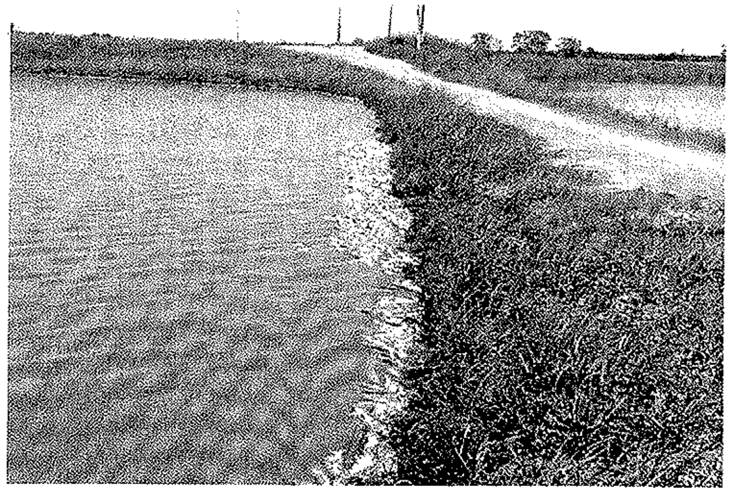
Boyd, C. E. and L. Massaut. 1999. Risks associated with the use of chemicals in pond aquaculture. Aquacultural Engineering 20:113-132.

Masuda, K. and C. E. Boyd. 1993. Comparative evaluation of the solubility and algal toxicity of copper sulfate and chelated copper. Aquaculture 117:287-302.

Potts, A.. C. and C. E. Boyd. 1998. Chlorination of channel catfish ponds. Journal of the World Aquaculture Society 29:432-440.

Fish Mortality Management

BMP No. 13



Definition

Mortality of fish in production ponds can occur soon after stocking as a result of handling stress or at anytime during culture as a result of disease or in-pond water quality deterioration. The amount of mortality is variable among ponds ranging from a few to large numbers of fish, but high mortality is the exception. Dead fish may sink and not be seen, but they usually float to the surface and accumulate around the edges of ponds. There are three main environmental concerns with dead fish: (1) carcasses and associated bacteria may be released from ponds if outflow of water occurs; (2) decomposition of dead fish following sudden, massive mortality could impair in-pond water quality and cause effluent water quality to decline; and (3) where ponds are near dwellings, bad odors from large fish kills could be a problem. Fortunately, most mortality occurs during hot summer weather when ponds seldom overflow, and most catfish farms are in rural areas where dwellings or gathering places seldom are located near ponds. Nevertheless, ponds should be operated in a manner to prevent dead fish from entering natural waters, causing objectionable odors, or causing in-pond water quality to deteriorate.

Explanation

Fingerlings usually are stressed to some degree by handling and during transportation from hatcheries to ponds. As a result, some fingerlings usually die soon after stocking. Because of their small size and numbers, mortality of fingerlings soon after stocking does not present an environmental problem.

Investigations by the Alabama Fish Farming Center suggest that annual mortality of catfish in ponds is about 10 to 20%. Fish may die at any time in the culture period, but small fish are more vulnerable to cannibalism, bird predation, in-pond water quality imbalance, and disease than larger fish. Thus, the majority of the mortality occurs in small fish. Significant numbers of large carcasses can be expected after episodes of dissolved oxygen depletion or other severe in-pond water quality problems. However, such catastrophic events are rare in commercial catfish ponds because producers use mechanical aeration and monitor in-pond water quality (Boyd and Tucker 1998).

In winter and early spring, it is not uncommon to observe a few to several hundred dead fish floating along the edges of some ponds. During the rest of the year, the number of dead, floating fish normally will be diminished. Dead fish decompose quickly and disappear within a few days in warm months, but in cold weather, carcasses may persist much longer. This partly explains why more carcasses are found around pond edges in winter. Winterkill also is a common phenomenon in catfish ponds (Tucker and Robinson 1990). Several species of wildlife feed on fish carcasses. The most common are vultures, wood storks, cormorants, herons, opossums, raccoons, turtles, and alligators. Large numbers of scavengers come to ponds after fish kills, and they can quickly consume many carcasses. It would be extremely difficult to remove fish carcasses from ponds on a regular basis, and it is not necessary to do so. Ponds have an ability to "digest" organic residues, so fish carcasses usually do not significantly impact pond water quality. Moreover, routine mortality does not cause an odor problem, and massive mortalities with odor problems seldom will occur near residences. The main problem is that carcasses can be lost from ponds in overflow. Most fish kills occur in the hot, drier part of the year when ponds normally do not overflow. Water often flows from ponds in response to winter and early spring rains, so riser pipes in ponds should be equipped with trash racks to prevent floating dead fish from entering discharge pipes. It also is in the farmer's interest to contain carcasses from massive mortality in the pond where the event occurred. Most ponds in Alabama are built in series with water flowing from the uppermost pond through one or more other ponds and exiting from the lowest pond. Carcasses in one pond can enter the next pond below and harm pond water quality or even spread disease.

Fish disease usually causes a prolonged, gradual mortality and does not result in large numbers of floating carcasses. However, massive mortality of fish may occur following dissolved oxygen depletion, toxic algal blooms, or other in-pond water quality problems. Many hundreds or even thousands of floating carcasses may accumulate at pond edges following massive mortality. When this occurs, ponds should be prevented from discharging. The majority of the mass die-off of fish should be removed promptly and transported to a permitted landfill, incinerated, composted, rendered, or ground up and applied to the land as fertilizer. Of course, when ponds are near residential areas, dead fish should promptly be removed or managed to prevent odor.

Some farmers apply calcium oxide (burnt lime) or calcium hypochlorite to carcasses that may accumulate after a fish kill with the intention of accelerating decomposition. This practice should not be used because it will actually retard the rate of decomposition of carcasses by killing bacteria.

Fish Carcasses

Practices

• For routine mortality, implement measures to assure that fish carcasses do not exit ponds in overflow.

• Following massive mortality, prevent overflow or other discharge from ponds. Allow a minimum period of 1 month for decomposition of carcasses by processes in the pond. (Note: Do not restrict overflow for watershed/runoff type ponds.)

• In cases where overflow cannot be prevented for a minimum period of 1 month following massive mortality, remove fish carcasses from ponds for sanitary disposal.

• In cases where massive mortality may cause offensive odors to neighbors, remove fish carcasses from ponds as soon as possible for sanitary disposal.

Implementation Notes

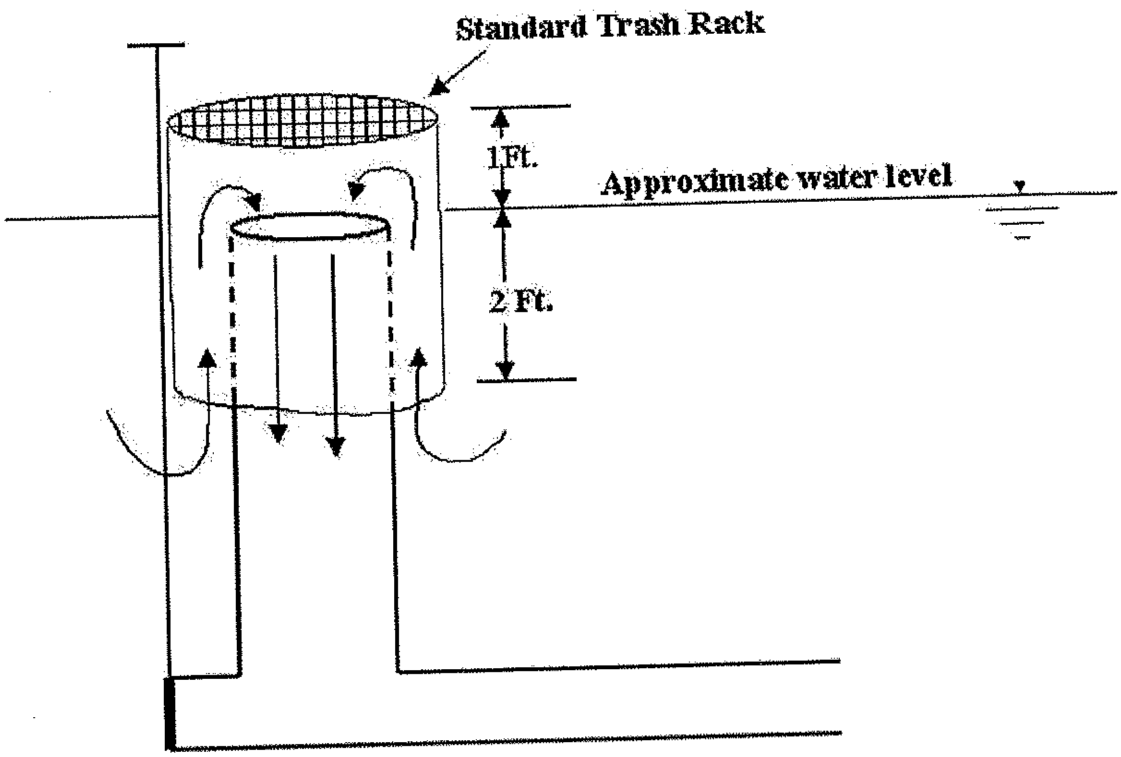
Water should discharge from the surface of ponds because in-pond water quality is better in surface water than in deeper water. Dead fish tend to float, and they may enter overflow pipes. A screen can be put around entrances to overflow pipes of levee ponds to prevent fish from entering. The trash rack (see figure) on the riser of watershed (embankment) ponds will prevent the dead floating fish from exiting the pipe system. Fortunately, dead fish usually drift into corners of ponds or along shorelines and move to the drain only during periods of heavy rain where there is considerable inflow and outflow.

References

Boyd, C. E. and C. S. Tucker. 1998. Pond water quality management. Kluwer Academic Publishers, Boston, Massachusetts, USA.

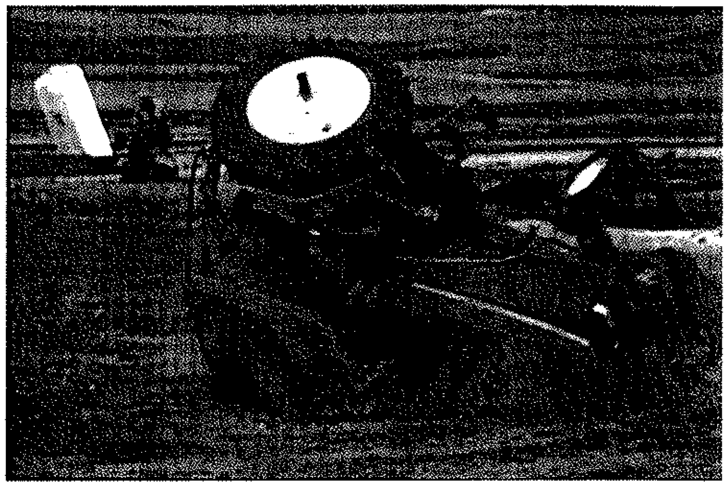
Tucker, C. S. and E. H. Robinson. 1990. Channel catfish farming handbook. Van Nostrand Reinhold, New York, New York, USA.

Standard trash rack over an upright pipe.



General Operations and Worker Safety

BMP No. 14



Definition

In aquaculture, like in other kinds of agriculture, worker safety and prevention of adverse environmental impacts should be major concerns in all operations. Moreover, farm infrastructure and equipment, which are properly maintained, and a neat appearance of the grounds convey a positive image of environmental stewardship and responsibility.

Explanation

Best management practices (BMPs) for preventing environmental impacts of specific aspects of pond management are presented in other guide sheets. In preparation for conducting pond operations, aquaculturists must store and handle fuels, lubricants, and agrichemicals. They must operate tractors, trucks, aerators, and other equipment. Moreover, this equipment and the farm infrastructure should be maintained properly. These general operations necessary to support specific pond management tasks should be done safely and in an environmentally responsible manner. The purpose of this guide sheet is to provide BMPs for general farm operations and worker safety.

Responsible Operations

Practices

• Provide secondary containment for fuel storage, and post a sign warning of flammable material near the storage area.

• Store chemicals in a well-ventilated, water-tight building. Make sure that the concrete floor slopes to a center basin for containing spills. Post a warning sign and keep doors locked.

• Dispose of used oil and out-of-date chemicals in a responsible manner according to applicable state and federal regulations.

• Collect solid wastes on a regular basis and dispose of them in a responsible way according to applicable state and federal regulations.

• Provide workers adequate instructions and training on safety in all farm operations, including regular refresher training.

• Design storage and staging areas to prevent erosion.

• Encourage vegetative cover on farm grounds, make sure fences and buildings are well maintained, and do not allow junk piles.

Implementation Notes

Secondary containment for fuel storage should be provided for individual tanks over 660 gallons or a combination of tanks over 1,320 gallons. The containment volume should be 110% of the largest tank. Additional details on spill prevention control and countermeasures can be found in Alabama NRCS Guide Sheet No. AL 701.

Oil leaks from tractors, trucks, and other equipment should be prevented through good maintenance. Oil changes should be done in a way to avoid spills. Used oil should be sent to a recycling center. Out-of-date chemicals and wastes collected after chemical spills should be confined in sturdy plastic containers, labeled, and sent to a hazardous waste disposal site. Solid waste containers should be installed at appropriate locations on the farm. These containers should be emptied on a regular basis, and the refuse disposed of at a permitted landfill or put in a county-operated dumpster. Refuse should not be allowed to accumulate on the grounds.

Workers should be given proper instructions on farm safety such as those found in "Safety for Fish Farm Workers" published by USDA/Cooperative State Research, Education and Extension Service. Material Safety Data Sheets (MSDS) provided with chemical products should be available to workers. Pesticides should be stored and used according to instructions provided on labels.

The appearance of a farm is important, for a well-organized and properly maintained farm conveys the message that operations are being conducted in a responsible manner. The visitor or passerby is much less likely to question the environmental status of a farm with a good appearance than that of one not properly maintained. It is especially important to prevent erosion, provide vegetative cover, and maintain roads, fences, and building in good condition. Junk piles and abandoned, worn-out equipment on the grounds are especially detractive.

References

Alabama Soil and Water Conservation Committee. 1995. Protecting water quality on Alabama's farms. Alabama Soil and Water Conservation Committee, Montgomery, Alabama, 124 pages.

Minchew, D.C. 1999. Safety for fish farm workers. USDA/Cooperative State Research, Education and Extension Service, 16 pages.

USDA NRCS AL Guide Sheet:

No. AL 701 – Spill prevention control and countermeasures,

No. AL 561 – Heavy use area protection.

Emergency Response and Management

BMP No. 15

Definition

Emergency situations, which require a swift response and proper management to avoid harming the environment or jeopardizing human safety, can arise on fish farms. Planning for such eventualities will aid farm personnel in making timely, responsible decisions when an actual emergency occurs.

Explanation

Some emergencies that could possibly occur on a fish farm are sudden, massive mortality; spills of fuel, feed, or chemicals; fire involving machinery or structures; serious injury to one or more workers from accidents involving machinery, electrical shock, heat stress, lightning strikes, chemical contact, insect stings, snake bites, and fish spines; need to resuscitate a drowning person; and dam failures. As indicated in BMP No. 14, workers should be given safety training, warning signs should be posted in potentially dangerous places, and technical information should be provided for products that can cause negative environmental impacts or harm humans. Also, farm infrastructure should be designed to prevent emergency situations as much as possible.

The purpose of this guide sheet is to provide suggestions on management of actual emergencies.

Emergency Management

Practices

• Develop procedures for managing spills of oil, fuel, chemicals, feeds, or other products. Locate the equipment and supplies needed for managing and cleaning up these spills so that they are readily available and easily accessible. Train workers to use the equipment. Report spills promptly following USDA-NRCS AL Guide Sheet No. AL 701 recommendations.

• Locate fire extinguishers in appropriate places on the farm and in farm vehicles. Notify the county fire department immediately for major fires.

• Train workers in first aid of electrical shock, profuse bleeding, drowning, and other possible medical emergencies. Always call the emergency medical service to deal with the medical emergency.

• Report dam or embankment breaks to the county emergency management office. If public infrastructure such as roads are affected, notify the Sheriff's Department.

• Provide workers with a mobile telephone to allow prompt communications about emergencies. Post the appropriate telephone numbers for notification of emergency response agencies or teams at several locations and so that they are available to all employees.

Implementation Notes

The most important aspect of emergency management is prevention of emergencies through design and construction features, regular employee meetings to discuss and verify effective response procedures, and regular worker safety training. Once an emergency occurs, it is critical to know how to respond in a rapid and efficient manner. Promotion of safety and planning for response to emergencies should be on-going processes.

References

Minchew, D.C. 1999. Safety for fish farm workers. USDA/Cooperative State Research, Education and Extension Service, 16 pages.

USDA NRCS AL Guide Sheet:
No. AL 701 – Proper fuel storage on the farm.