Aquaculture System Manual

Model AQUHS300

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Congratulations on your new Aquaculture System! This manual will take you through the steps to set up the system as well as present some general operational principles and management techniques. We recommend that you read the manual thoroughly before setting up.

Your system comes with a bottle of beneficial bacteria to help you get the system started.

ASSEMBLY

The only items you will need are a screwdriver to attach the band clamps and a pair of pliers to squeeze shut the three "snap clamps." First, familiarize yourself with the names of the components in your Aquaculture System.

Figure 1: Tank on stand

Figure 2: Valve Assembly

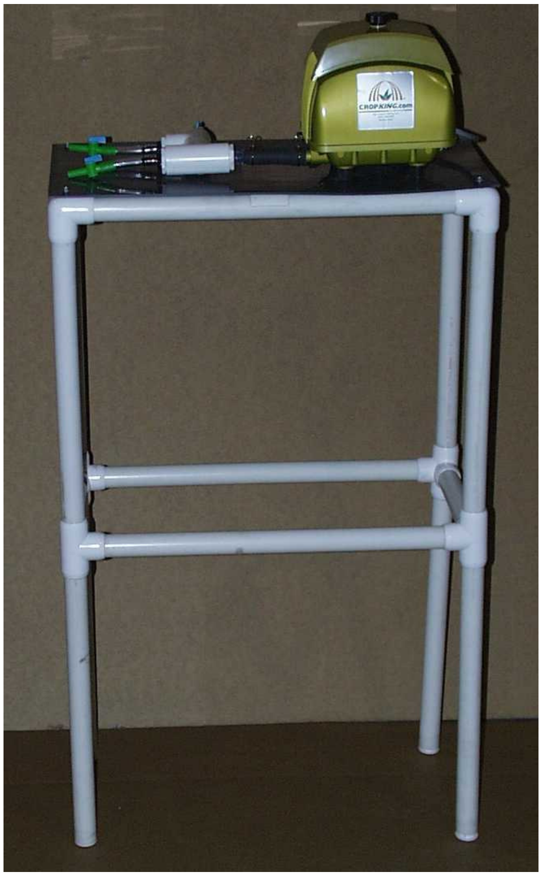

Figure 3: Air Pump on Stand (shows air header assembly as well)

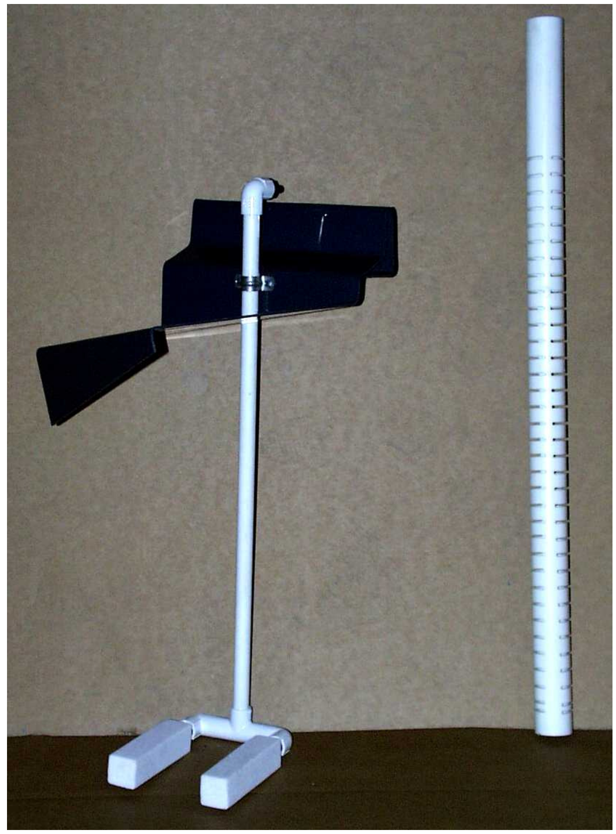

Figure 4: Flow Hood and Drain Strainer Pipe

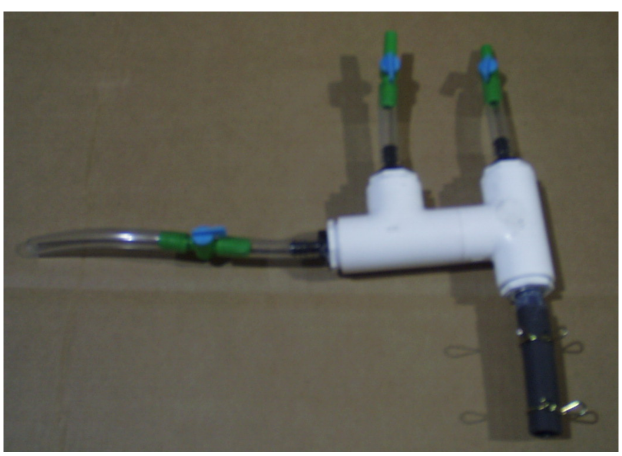

Figure 5: Air Header Assembly

Figure 6: Water Return Flow Arm


Figure 7: Filtration Unit on Stand

1. Pick a spot to place the system. The floor should be strong enough to hold 400 gallons of water, which will weigh about 3400 lbs. Ideally, you'll want to orient it so that the filtration drums have their spigots pointing to an easily accessible drain. If you have a window on the fish Tank, it of course will face the desired direction. The location should also be convenient to a water source like a faucet or hose bib, and a drain.

2. If the room that the system is going to be in has a door that is too narrow for the package to fit through upright, take the individual pieces off the palette, tip the Tank on its side and move through the door way. A Tank with a window should be given extra caution when moved on its side, since undue pressure will break the seal and it will no longer be water tight. (If this happens, use the enclosed silicone sealant or any 100% silicone, non-mildew-resistant, RTV sealant to re-seal.)

3. If necessary, the stand can also be removed to get it in through the door.
    a) Turn the Tank upside down, resting on its upper rim.
    b) Loosen the stainless steel band clamp on the barbed elbow and remove the black tubing.

c) Take the wooden stand off the Tank and then unscrew the barbed elbow.

d) Move the Tank into the room and set it on its side. If there is a window, make sure it faces up.

e) Since the gasket on the bulkhead fitting may have loosened in this process, it's best to be as certain as possible that it won't leak:

   i) Remove the retaining ring on the bulkhead fitting (located on the bottom of the outside of the Tank) by turning clockwise (it's reverse-threaded).

   ii) Apply a thin (1/8" - ¼") bead of silicone sealant (included) to the rubber gasket, so that when the gasket comes in contact with the Tank bottom again, the silicone will help re-form the seal.

   iii) Insert the stem of the bulkhead fitting through the hole (gasket is on the inside of the Tank).

   iv) Apply a dab of silicone sealant to the threads of the bulkhead and tighten the retaining ring by turning counter-clockwise. Make sure that it is not so tight that the gasket is squeezed out from under the bulkhead's rim.

   v) Turn the Tank upside down, so that it is resting on its upper rim.

   vi) Screw the barbed elbow back into the bulkhead fitting.

   vii) Put the stand back on the bottom of the Tank. Note that there is a gap in the supports that the barb will point through.

   viii) Push the black tubing back onto the barb and secure it with the stainless band clamp.

   ix) Rotate the Tank's stand and black tubing so that the tube will point towards the back of the filter stand.

   x) Turn the Tank/stand assembly back upright and move it into the spot you've chosen.

4. Set the Filtration Unit into position next to the Tank, but leave the strapping on the drums for now. Loosen the stainless steel band clamp on the end of the Tank's drain tubing and slide it back a few inches on the tube.

5. Put a light smear of silicone sealant onto the horizontal barb of the drain valve assembly. This is for lubrication. Push the end of the Tank's drain tubing as far up the barb as it will go. Slide the band clamp back over the area where the barb is under the tubing and tighten securely.

6. Apply another light smear of silicone sealant on the barb that points downward on the side of the first filter drum (the Clarifier). Loosen the band clamp on the other end of the drain valve assembly and push the black tube onto the barb. Secure with the band clamp. The white gate valve should be open (handle pulled all the way up) and the faucet valve should be closed.

7. The bulkhead fitting at the bottom of the Tank is strong and provides for a watertight seal. Just the same, for added insurance, it is always a good idea to run a bead of the silicone sealant around the joint where the bulkhead rim meets the bottom of the Tank. Do this now, using a good ¼-3/8" bead.

8. Place the stand for the air pump in the gap between the filter stand and the Tank. The fit should be fairly close, but not touching—see the Figure below.

Figure 8: Placement of Air Stand, Pump and Header Assembly

9. Cut the strapping off the filtration unit. Take the cover off of the second filter drum (the Biofilter), pull the clear tubes through the hole in the cover and replace the cover on the drum.

10. The drums are connected by a bridge. For shipping, this bridge is left unglued. Now pull the drums a few inches apart from each other and apply a bed of silicone sealant around the exposed stem. Push the drums together again, re-connecting the bridge. Apply a bead of sealant around the stem at both ends, to ensure a drip-free connection.

11. Put the Air Pump on the Air Pump Stand. Taking the Air Header Assembly, loosen the clamp on the end of the ½" black tube. Slip the black tube onto the barb of the Air Pump, orienting the assembly as shown in the picture above. Move the clamp back over the barb and secure it in place.

12. The water Flow Hood simply snaps over the rim of the Tank. Position the Flow Hood next to the air pump header so that the tubing does not kink or bend excessively. Attach the short air hose from the header to the black barb on the Flow Hood, and secure with a white "snap clamp," found in a separate bag in your kit.

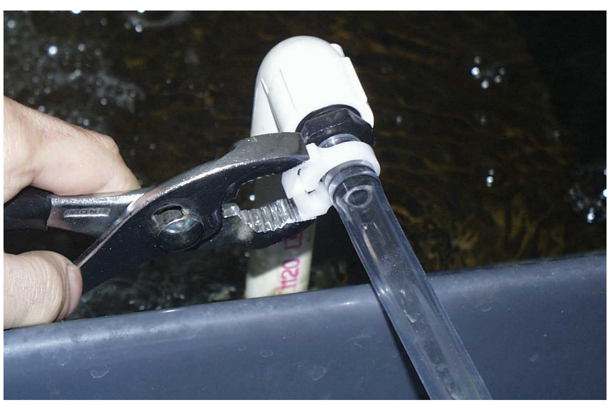

Figure 9: closing the snap clamp with pliers

13. Slide the two clear tubes from the Biofilter to the pair of green valves as shown in Figure 8. Secure each tube over the green barb with a white "snap clamp." For now, all the green valves should be in the "open" position.

14. There are two elbows that form an “S” shape on the end of the Return Flow Pipe. These two elbows should be together and placed onto the end of the Return Flow Pipe. This “S” allows the returning water to flow back onto the surface of the fish Tank with a minimum of splashing. Importantly, it also enables you to direct the water flow to assist in gently spinning the water in your round Tank. The circular motion of the water moves the dirt in the Tank in towards the center, thereby facilitating removal of debris through the center drain.

Figure 10: Adjusting the “S” on water return arm

15. A slotted Strainer Standpipe is included with your Aquaculture System. You may install this now or later, just before the fish are stocked. It simply slips into the center drain in the Tank. This strainer has narrow slots to prevent small fish from going down the drain. (For extremely small fish you may wish to cover the strainer with a sleeve of small mesh screen, such as window screening.) When the fish get larger, you can switch up to a strainer with larger slots or dispense with it entirely when the fish get too large to fit down the drain hole.

16. Check again to make sure that the faucet valves are closed, that the Clarifier drain valve is closed and that the white gate valve between the Tank and the Clarifier drum is open.

17. Read the section in Operations on water sources, then begin filling the system with water.

18. While the bulkheads on both the Tank and the Clarifier drum are sealed and checked at the factory, things may loosen up during shipment and the handling of installation. As your system fills, double check for any leaks both under the Tank and under the Clarifier drum. In either case, should there be signs of leakage during filling, it will be necessary to drain that container. A leak from the bulkhead area is easily dealt with by making sure that the surrounding area on the Tank or drum is very dry (paper towels work well for this), then applying a good bead of the silicone sealant to the joint where the bulkhead meets the bottom of the container. Allow to cure for at least several hours before re-filling.

19. When the Tank is full, the water will be just at the top of the rim's "shelf." It is now time to adjust the valve that controls the pumping rate of the water from the Biofilter back into the Tank. The water is moved from the bottom of your Biofilter back to the Tank by means of an airlift. The airlift is a simple device, where air bubbles are injected into the bottom of the vertical pipe; as the bubbles rise, they push the water on top of them up and out the pipe. Start with all the air valves in the completely open position. Determine which is the correct valve by closing off one of them. If the water stops flowing back to the Tank, that's the right one. Open the air lift water pump's valve again and then close it just slightly. The idea is to pump just enough water out of the Biofilter so that the level in the Biofilter does not drop below the top of the honeycombed black media that's inside the drum. The other valves normally just stay in the fully open position.

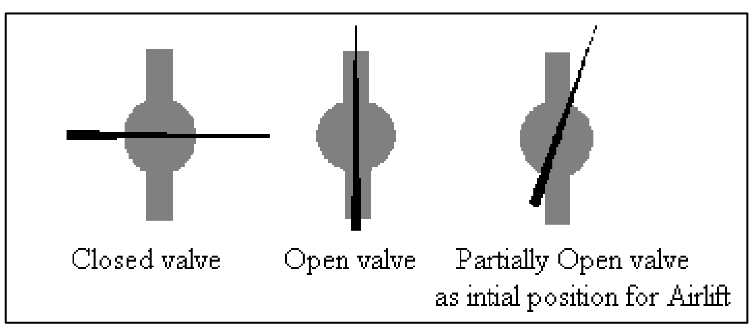

Figure 11: Valve positions for the air lines

Figure 12: Assembled system, filled with water

OPERATIONS

This part of the manual provides an orientation to the nature of aquaculture and presents guidelines on how to maintain your system. As you read through this section, just bear in mind that it really boils down just to feeding the fish, re-stocking fish as needed and monitoring water quality. While no manual could ever hope to cover every contingency for every individual's situation, details from many years of experience are distilled into these next pages to try to give you a feel for the techniques and particulars of growing fish at this level.

I. System Basics

A. Functional Overview

The Aquaculture System has a two-stage filtration. The first stage is the Clarifier, which removes solids through gravity separation. The second is the Biofilter, which uses beneficial bacteria to convert liquid waste found as harmful ammonia into nitrite and then nitrate. Water flows from the Tank into the Clarifier, goes up through the Clarifier to the top of the Biofilter and then down to the airlift, which carries the water back to the Tank again. The water in the Tank is induced to move in a circular pattern by both the Water Return Arm and the Flow Hood. This helps with solids collection within the Tank.

Your Aquaculture System is a complete ecosystem. That's because you're setting up a natural balance between animals and a supportive microbial community. Each one has it's own role and thrives because it is an integral part of a larger whole.

All animals make waste nitrogen in the form of ammonia. It is a metabolic byproduct that comes from the fish eating the food that you give them. The ammonia comes as a liquid, a dissolved gas and it leaches from the solid waste as well. In the case of a closed system, where there is no new water constantly flushing the wastes downstream, ammonia can quickly reach a high enough concentration to be toxic to the fish if it is not dealt with.

Certain bacteria will break down the waste and organic matter by making use of these materials as their "food." In the Aquaculture System, we combine fish and naturally occurring, beneficial bacteria to provide complementary processes to make this circle of Life.

The following is a more detailed discussion of each of the key components used to raise fish in your Aquaculture System.

1. Bacteria, the keystone to it all:

a) **How they work for you**. There are two naturally occurring kinds of aerobic (oxygen consuming) bacteria that work to help you raise fish. The first kind, *Nitrosamonas*, takes oxygen and the harmful ammonia and changes the ammonia into nitr*ite*. Nitrite can also hurt the fish, but another kind of bacteria co-exists with the first. *Nitrobacter* bacteria also use oxygen, changing nitr*ite* into nitr*ate*. (Nitrate is harmful to most fish only in concentrations so high that they are rarely seen.) So the bacteria have actually detoxified the nitrogen in the system. This natural biological process can be roughly described as follows:

$$\underbrace{NH_3 + O_2}_{\text{ammonia + oxygen}} \xrightarrow{\text{Nitrosamonas}} \underbrace{NO_2 + O_2}_{\text{nitrite + oxygen}} \xrightarrow{\text{Nitrobacter}} \underbrace{NO_3}_{\text{nitrate}}$$

This process is called "nitrification," and it is facilitated by a "biofilter." "Bio-" meaning "living," and "-filter" meaning to "purify" or "separate." The surface area of the media in the second drum is the "living filter," the biofilter. After the first month or so you should be able to feel that the walls inside the Tank are slippery. That's your beneficial bacteria! The vast majority of your beneficial bacteria will live on the Biofilter media, but the beneficial, autotrophic bacteria (*Nitrosamonas* and *Nitrobacter)*, will colonize on all the wet surfaces, e.g., the Tank walls, inside the pipes, etc. Without the added surface area for the bacteria to live on, the Tank would normally sustain 10-20 lbs of fish. With the enormous surface area on the Biofilter, the Aquaculture System can grow 100 lbs of fish or more, and *that's* the benefit of using a biofilter.

b) **How to treat them right**. It's important to provide the bacteria with an appropriate living environment:

1) don't expose them to harsh chemicals like bleach, other cleaning solutions or pesticides;
2) try to keep the pH between 7 and 8;
3) keep the alkalinity and hardness each above 50 ppm; and
4) maintain the temperature between 60^{o} and 90^{o}.
5) Depending on the hardness of your water, the pH may have a tendency to go down. Adding baking soda (bicarbonate of soda) or soda ash a little at a time will correct this and increase the buffering capacity of the system.
6) If you have a window on your Tank, keep it clean with a soft cloth but you needn't worry about scrubbing the rest of the inside of the Tank. The walls harbor a lot of hard working microbes and scrubbing will remove them.
7) Keep your system topped off with water so the bacteria living on the Biofilter can do their job. Remember that if the beneficial bacteria are exposed to the air and allowed to dry out they'll die, and with them, the system's ability to handle waste nitrogen.

Take care of your beneficial bacteria and they'll take care of you by helping you to grow a healthy crop year round.

2. **Air:** Oxygen from the air is consumed in the Biofilter by the bacteria and in the Tank for the fish to breathe. The air is also sent to the bottom of the Airlift to return the water from the Biofilter to the Tank, and to promote a circular flow of water within the Tank. Each of these air lines has it's own valve. You will develop a feel for the best adjustment of the valves, but to start off with, just follow the instructions in Step 17 of the Assembly.

3. **Circulation:** Water in the fish Tank is driven in a circular motion to take advantage of the Tank's round shape. The water spinning in the Tank moves the settled solids in towards the center, where the dirt is then removed down through the drain and away from the fish. The circular pattern is induced in two ways:

    1) The Flow Hood is placed over the rising column of bubbles coming from the air stone or diffuser. The pitch of the Flow Hood drives the bubbles and the water they bring up with them in a single direction.

    2) Water returning from the Biofilter via the Airlift can be directed down into the Tank using the pair of PVC "elbows" on the end of the delivery pipe. The elbows insert into each other to form an "S" shape, and one end of the "S" inserts onto the end of the delivery pipe. To operate efficiently, the open end of the "S" should be submerged no more than half way into the Tank's water (adjust by rotating the upper elbow). The outlet of the "S" should be aimed along the wall, somewhat towards the center of the Tank (adjust with the lower elbow).

The actions of the Flow Hood and returning water complement each other and help to provide for maximum efficiency in inducing the circular flow pattern.

B. Let's Grow Some Fish!

1. First, consider your water source.

    Where does the water come from that goes into the Tank? Just about any source will do, including tap, rain, well, spring and pond water. Each has it's own advantages and potential drawbacks. Most are minor considerations with two exceptions.

    a) If it has been chlorinated, e.g., from a municipal reservoir, the chlorine and/or chloramine will have to be removed. Tap water can be dechlorinated just by bubbling with the air stone and/or exposing to warmth and/or sunlight. Depending on circumstances, this can take up to a week. Chlorine can also be instantly removed with Tap Water Conditioner, which is available from

CropKing. Chloramine, however, can only be removed chemically, e.g., with Tap Water Conditioner.

b) If your water is very hard, you may find it difficult to bring the pH down, due to the buffering capacity of the dissolved salts. In this situation you may not be adding baking soda for quite a while (could be weeks or many months). If your water is so hard that the pH won't budge to go below 8.0, and you feel that it may be affecting the Biofilter's function, call CropKing's Aquaculture Department to discuss.

2. Season your Biofilter.

After filling the Aquaculture System with good water, the next thing to do is get the Biofilter started. Start by adding the "food" for your beneficial bacteria: take 3 tablespoons of clear household ammonia (no suds, no detergent, no scent, just plain, clear household ammonia from the supermarket or hardware store) and add it to your Tank. Then add the beneficial bacteria. Monitor the ammonia and nitrite levels. When both are below 1 part per million (ppm) again, it is safe to add the fish. Depending on how long and the conditions your bacteria were stored in, the process could be as short as 3-4 days or it could take up to several weeks. If, however, you do *not* see a reduction in the ammonia at all within the first week, fresh bacteria should be added. This is available from CropKing.

3. Add the fish.

a) A table is appended to the end of this Manual to give you an idea of the water quality tolerances of various fish species. When planning this part, pay closest attention to the temperature needs of the fish and make sure the Aquaponic System will be operated within the necessary range.

b) We recommend starting off with a hardy and robust fish such as tilapia, particularly if you haven't raised fish before. The many kinds of tilapia are generally quite tolerant of a wide range of environmental conditions and they taste great too! Our

Aquaculture Department can recommend many reputable sources of tilapia fry—just give us a call. If you want to operate with warmer water, Nile (*Oreochromis niloticus*) and Mozambique (*O. mossambicus*) would be good choices and will grow fastest in their optimum temperature range of about 85°F; Blue tilapia (*O. aurea*) will fare better in cooler waters down to 60-70°F on a daily basis.

c) Stocking mortality can be reduced by making the fish's introduction to their new environment as gentle as possible. If they arrive in a plastic bag (usually inflated with oxygen), float the bag in the Tank for 15 to 20 minutes to get the temperature inside the bag evened out with the Tank. Open the bag and scoop some water from the Tank into the bag. Wait a few minutes and introduce some more Tank water. After a few more minutes, the fish will probably be anxious to get out: tip the bag and let the fish swim out into their new home. Wait at least a few hours before trying to feed them—many fish are anaesthetized for shipment and won't have much of an appetite right away. When they are ready, try to feed at the same times each day, and only give what they'll readily eat in a 15-minute period. A healthy system can have 100 pounds or more of fish in it that you can continually harvest.

Of special note: Mortality is a natural part of life—animals can die for sometimes no apparent reason at all at any stage of the life cycle. When this happens, remove the body so that it won't decompose and become a source of disease, poor water quality and/or raise the ammonia level too high. (If the ammonia suddenly spikes, say over a one or two-day period, look for a body!) Don't worry if mortality seems high, particularly right after stocking —commercial growers often expect 20%, sometimes more, of the fingerlings they stock to die before harvest.

d) How many fry to get? Add enough fish to make 100-120 lbs at harvest. For example, say we stock with tilapia and plan to take them out at a 1 lb size on average. Some will come out larger than a pound, and some will be less. Some mortality is natural and to be expected; many growers expect 80-90% of what they stock to be available for harvest at the end of the grow-out period. Therefore, you would put in, perhaps, 150 tilapia fry. You may wish to put in half or two thirds of that amount on your first try and consider it "training." The number to stock works out differently for each species and for how long you want to grow them. There is a chart in the Appendix that reviews the water quality requirements of many species to help you decide which one(s) to grow.

4. Feeding.

   a) Feed your fish by hand at least once a day to observe their behavior, which can tell you volumes even before the water tests are completed.

   b) Feed them (by hand or in an automatic feeder) only as much as they will consume in a 15 minute period. Feeding them in this way at least 2-3 times a day will keep them growing well for you.

   c) Try not to increase the amount being fed by more than 10% on a daily basis so as not to overload the filtration capacity of the system.

   d) Remove all excess feed.

   e) We strongly recommend using a floating feed for several reasons:

      i) it brings the fish to the surface where you can see them;
      ii) it makes it very easy to determine just how much to give them;
      iii) it dramatically reduces the amount of feed that slips by the fish, goes right down the drain and into the filter; and
      iv) if for some reason the fish are over fed, it is much easier to remove the excess before it can foul up the water quality.

   f) Fish feed is commonly available from farm feed stores or directly from the manufacturers. Call CropKing if you have difficulty in locating a source or have questions about quality.

g) Store the feed in a cool, dry area, away from sunlight, insects and rodents. Feed that is moldy must be thrown away immediately, since the molds are typically extremely toxic to the fish. Freezing is OK. Feed kept in optimal conditions should generally be used or discarded before six months, or sooner if the quality is at all in doubt. Check with the manufacturer to be sure.

h) How much feed should you get? Taking again the example of tilapia, they will generally have a food conversion ratio (FCR) of 1.5:1, that is, for every pound and a half of food put in, you can expect to get out a pound of fish. If your target is 100 lbs of fish, figure on around 150 lbs of feed going in. Pellet size should be matched to mouth size, since a small fish can't take in large nuggets of feed. Starting 1-2" fry on a #2 or #3 crumble is common. Ask the breeder what size feed pellet they are on when you get them, acquire this and then step up to larger sizes later. If you find you have to grind down larger pellets to get smaller pieces, just sift out the dust to reduce the fouling of the water. Tilapia are typically given feeds with protein that ranges from 25% to 35%. Perch and other carnivorous fish need a diet with higher protein levels. As the fish grow, pellet size is increased and protein levels can come down somewhat.

i) If the fish simply don't want to eat one day, pay close attention to them but don't panic. They may be "off their oats" for a number of reasons: a different kind of feed was used, they were subjected to a lot of undue splashing, vibration, lights flicking on and off or some other man-made disturbance, the temperature dropped or maybe the weather changed and they are feeling the adjustment in atmospheric pressure. For many fish (like tilapia), hiding at the bottom of the Tank, darting up to grab a piece of food and darting back down again and/or startling easily can mean the fish were recently subjected to something physical, but it can also be a sign of declining water quality. For peace of mind, when the fishes' eating or other behavior changes noticeably, we recommend to go ahead and check water quality.

5. Maintaining the Clarifier

   a) The Clarifier is cleaned on a daily basis simply by opening the drain valve. The 1 ½" drain should be used if at all possible, since it will provide the most cleaning action in the shortest time. If necessary, the Hose Adapter can be inserted into the end of the 1 ½" valve and a garden hose attached to facilitate cleaning. In either case, simply open the valve and close it again when the effluent runs clear again. This should draw off less than ten gallons and generally less than five.

   b) Water should be topped off in the Tank when it has dropped a couple of inches, or automatically with a float valve.

   c) Every one to two weeks the Clarifier should be completely purged. The frequency depends of such factors as feed rate, feed type, temperature and even the hardness of the water. Signs that it needs to be rinsed include a thick layer of "floc" (an accumulation of fine particles) visible on the media surface, and observing particulate matter regularly overflowing into the Biofilter. The process is as follows:

      i) Close the water valve leading from the Tank's center drain.
      ii) Open the Clarifier's drain valve and allow to drain completely.
      iii) When the rinse water has fully drained out, first open the Tank drain valve to flush out remaining solids. When the Clarifier drain runs relatively clear again, shut the drain from the Clarifier.

6. Maintaining strainer

   The strainer will occasionally get clogged. Signs of this include water level too high in the fish Tank and too low in the drums. While the strainer can be brushed off in place, it should be removed for greatest efficiency in cleaning. When removed, something else (clean) should be at the ready to put into the drain hole so that the fish don't find their way into the Clarifier. A solid pvc pipe can be put in, or draping a dip net's mesh over the open hole works well for this. The airlift should be shut off to reduce the draw of water (and fish) down the drain during strainer cleaning. A stiff bristle brush and/or a strong spray from a hose will clean the debris right off.

7. Water testing

The importance of water testing can not be over emphasized and should be done regularly. The Appendix has a sample data sheet to help you get started with the record keeping.

a) While you can get all of the meters and test kits from CropKing that will help you to monitor water quality, the most basic, important things to watch are pH, ammonia, nitrite and temperature. It's good to know what the alkalinity and hardness of the water is, so that you have a feel for its buffering capacity (resistance to major swings in pH). Testing these at least once a month should be adequate. Once you are confident of the initial levels of nitrate, oxygen, carbon dioxide (CO_2), chlorides and nitrate, they too can be monitored at least monthly. Temperature is easily noted for the daily log if you use a thermometer with a submersible tip or probe. A good test kit that encompasses the most critical parameters is available from CropKing for around $200.

b) Ammonia, nitrite, pH and temperature should be measured frequently enough to give you a feel for the status of your water quality. Testing on a daily (or at most weekly) basis is an excellent way to monitor the status of your system and provides you with records that will help you to anticipate and understand potential problems before they arise. In particular, new systems that are being started up should be tested for ammonia, pH and nitrite daily to assist in determining when stocking can begin. Monitoring can be done with test kits or electronic meters; all are available from CropKing for your convenience. Testing for nitrate can complete the nitrogen cycle picture for you, but due to its very low toxicity, nitrate normally does not need to be tested frequently.

c) Ammonia is actually present in two forms: the ionized "harmless" form NH_4^+, and the un-ionized or toxic form, NH_3. The amount of toxic un-ionized ammonia depends on the total ammonia ("Total Ammonia Nitrogen" or TAN), the pH and the temperature of the water. The table in the accompanying publication "Ammonia in Fish Ponds" gives the exact proportions of toxic to non-toxic forms, making it easy to calculate just how much you have in your system.

d) Different species of fish have different tolerances to ammonia and nitrite, e.g., tilapia and catfish tend to be quite tolerant while trout and other salmonids are less so. Refer to the table in the Appendix for guidelines on operational tolerance levels ("operational" because these are what the fish are considered to need on a daily basis while still maintaining good growth; many fish can handle temporary spikes far higher than what is given.)

e) pH in recirculating systems normally goes down over time due to the introduction of carbon dioxide and the generation of metabolic wastes. Increasing the buffering capacity of the system and bringing the pH back up to the "ideal" 7.0-8.0 range is normally done with the addition of baking soda. The amount you add will depend greatly on the water source you started with, so try adding a little at a time. No more than a ¼ cup every 4-6 hours will help to ensure adequate mixing before measuring the pH again.

8. Maintaining air pump
   The air pump is a high quality, professional-grade unit and should last for years with minimal maintenance. Once or twice a year unscrew the retaining bolt in the cover and examine to filter pad. If it is dirty, rinse in warm water or blow it clean with compressed air. Replace filter and secure cover with retaining bolt. If the air is very dusty, you may wish to check more frequently.

9. An outstanding reference for anyone wanting to learn more about fish farming is "Fundamentals of Aquaculture," by Dr. James Avault. It is available from CropKing.

TROUBLESHOOTING

1. Water tests:

a) Un-ionized ammonia is too high. Fish often won't tell you it's too high until they stop feeding or start to die, and the water test can give you advance warning of a potential problem. First off, determine what the cause may be. Possibilities include

1) Excess feed is usually the prime suspect: remove excess in the Tank and cut back until ammonia evens out again.
2) A dead fish hiding somewhere can do this too: find and remove. 3)
3) The Clarifier is not being drained adequately: increase frequency (should be done daily) and make sure it runs relatively clear before shutting off the valve.

Emergency measures include

a) using zeolite or a chemical means to "lock out" ammonia, e.g., "Amquel," and
b) a water exchange. Note that when exchanging water, drain and re-fill no more than about 20% on a daily basis so as not to shock the fish or the bacteria in the system too severely.

b) Nitrite is too high. Excessive nitrite reduces the gills' ability to absorb oxygen, so look for symptoms that indicate low oxygen in the water. This includes "gulping" for air at times other than feeding and "brown blood" in the veins or gills. One source of high nitrite can be an accumulation of solid matter from not purging the Clarifier daily. Nitrite can be dealt with in three ways:

1) it can diluted with water exhanges—no more than 20% per day to reduce the shock to the living things in the system,
2) adding chlori**d**e. Table salt or kosher rock salt may be added to mitigate the chlori**d**e, but make sure that it does not have iodine in it. Catfish growers reportedly like to have at least 10 ppm chlori**d**e for every ppm nitrite in the water.
3) Time and patience. Moderately high nitrite (e.g., measurably high but the fish are not showing signs of stress) will go back down on its own when the bacterial populations are healthy with little help from you. The bacteria the convert

ammonia to nitrite (*Nitrosamonas* spp.) work and multiply much faster than the bacteria that change nitrite to nitrate (*Nitrbacter* spp.). This means that the ammonia levels will always go down faster than nitrite. Waiting it out should be coupled with reduced feeding rate and careful monitoring.

c) pH is lower than 7.0 and falling. To bring back up, adding ¼ cup of baking soda will help buffer the water to increase pH stability. Doing this every 3-4 hours between pH checks will ensure adequate mixing.

2. The inside of the Clarifier needs looking at:
Issue: for some reason, you just have to look at the inside of bottom of the Clarifier. We really don't recommend this. There's little of functional interest under the media. If you still want to go there, say, to re-seal a damaged bulkhead, here's how but you should also take careful notes as you take it apart: Make sure the drum is fully drained and the drain valve to the Tank is shut off. Loosen the stainless steel band clamps and gently but firmly pull the black hoses off. The fitting between the drums is siliconed together to facilitate disassembly when absolutely necessary. Spreading the drums apart will break this seal. Lift the drum off of the stand. The media may be seated too tightly to pull out by hand, but if you try, wear gloves because the edges can be sharp. The other way is to turn the drum upside down and tap the rim on the ground or on the edge of a block and move the media down and out that way. When re-assembling, reconnect the tubing and start filling the drum, watching carefully for leaks. Once you are sure that the drum will not leak, replace the media, making absolutely certain that the flat side of the media is returned to its original position facing the inflow bulkhead. Be careful not to push the media down any further than the internal supports will provide for.

3. The inside of the Biofilter needs looking at:
Issue: For some reason you need to get inside the Biofilter. This is not recommended unless absolutely necessary. Never ever pull up on the airlift tube that rises from the center. There are air diffusers and a small nylon elbow that could be damaged this way. First drain the Biofilter, recognizing that the beneficial bacteria will die when allowed to dry out.

Disconnect the two drums by gently but firmly spreading them apart. With the cover and the arm that returns the water to the Tank removed, turn the drum upside down and tap the rim on the floor or the edge of a block to move the Biofilter media down and out. Wear gloves when handling the media, since the edges can be quite sharp. When re-assembling, make sure that the air line connections are secure and that one air stone points toward the Clarifier.

Further Notes

a) Power: While extremely energy efficient, the Aquaculture System does require electricity to operate 24 hours a day. In a "worst case" scenario (with a Tank fully stocked to capacity), the fish will run out of air to breathe in a very short time. (Time can vary with fish species and size, water temperature, altitude, indoor/outdoor, time of day and other factors. Generally speaking, in a fully loaded Tank, it can be as little as less than half an hour or up to a couple of hours.) If you run the Tank at maximum capacity and are prone to power outages longer than 5 or 10 minutes, we highly recommend one of the following options:

   1) Plug the Air Pump into an appropriately sized back up power source, such as an UPS (Uninterruptable Power Source, typically available from computer and office supply stores);
   2) Have a generator available to temporarily power the system up; or
   3) Have a DC powered air pump on hand for aerating the fish Tank only.

   Should the fish crop be lost in such a circumstance, you can keep your biofilter going by keeping it aerated and adding a little household ammonia to replace what the fish were contributing. It is important to keep the beneficial bacteria alive with a source of nutrients so that when new fish are re-introduced, the System is still ready.

b) Again, as noted above, water tests should be done frequently enough to make sure you know what's going on in the Tank. A sample data sheet is included in the Appendix of this manual. Good note taking can be worth a great deal when trying to determine cause and effect.

c) Your local Agriculture or Aquaculture extension agent can also be an excellent resource for assistance. They are based at the Land Grant or Sea Grant institution(s) in your state. Also feel free to call our Aquaculture Department for help at any time.

Appendix:

Sample Data Sheet

“Ammonia in Ponds”

Water Quality Tolerances of Certain Fish Species

Aquaculture Department

CropKing.com, Inc.

134 West Drive

Lodi, OH 44254

330-302-4203 (telephone)

330-302-4204 (fax)

ACCESSORIES

Float Valve

The Float Valve connects with a standard garden hose fitting to automatically maintain your Aquaponic System's water at its ideal level.

Water Test Kit

The importance of knowing the quality of your water can not be understated. This Test Kit comes with easy to use, step-by-step instructions for Total Ammonia Nitrogen, Nitrite Nitrogen, pH, Alkalinity, Carbon Dioxide, Dissolved Oxygen and Hardness. Also comes with an armored thermometer. (Additional test kits are available for Potassium, Iron, Phosphate and others--please inquire.) Aquaculture Test Kit

Heater

Many fish need to be warmer than standard room temperature to optimize their growth. This top quality stainless steel heater is a thoroughly reliable, industrial quality unit with digital temperature controls. If you need to keep your water warmer than the room temperature, this is **the** heater you want to be relying on. 1000 watts and comes with a custom clip-on bracket to hang on the side of the Aquaculture System Tank.

Tap Water Conditioner

The Conditioner eliminates chlorine and chloramine, both of which are toxic to your fish and beneficial bacteria. Either chlorine or chloramine will be found in water coming from municipal sources. Aeration alone can not remove chloramines. If you're using water from a public source, get Tap Water Conditioner to keep your critters and System safe.

Digital Thermometer

The large digit thermometer has a probe that stays inside the tank to monitor water temperature. Monitor water temperature with just a glance.

Beneficial Bacteria

Specially adapted and concentrated strains of *Nitrosamonas* and *Nitrobacter* have been tested by CropKing and found to provide exceptional denitrification and are now available to you! An absolute necessity for starting biofilters and an essential component of your Aquaponic System. 4 oz of highly concentrated beneficials come in a 6 oz. bottle and must be refrigerated until used.

Dip Net

White delta weave with 5' aluminum handle. Head of net is 16" x 16".

Other items are being added to the catalog all the time, so if you don't see what you want, just give us a call!

TOLERANCE OF WATER QUALITY PARAMETERS OF CERTAIN FISH

	Dissolved Oxygen (ppm)	Un-ionized Ammonia* (ppm)	Nitrite (ppm)	Temp. o F	pH (units)	Hardness (ppm)	CO2 (ppm)	Chlorides (ppm)	Alkalinity (ppm)
Tilapia	3.5-10	0-0.03	0-0.7	70-90	6.1-8.2	50-325	0-30	0-5000	50-250
Catfish	3-9	0-0.03	0-0.7	65-82	6.1-8.2	50-325	0-25	0-4000	50-250
Bluegill	4-9	0-0.03	0-0.6	60-85	6.1-8.2	50-325	0-25	0-2000	50-250
Goldfish	4-9	0-0.07	0-0.6	65-80	6.1-8.2	50-325	0-25	0-2000	50-250
Shiners	4-9	0-0.03	0-0.6	59-75	6.1-8.2	50-325	0-25	0-2500	50-250
Yellow Perch	4-10	0-0.03	0-0.5	50-70	6.1-8.2	50-325	0-25	0-2500	50-250
Koi	4-9	0-0.06	0-0.6	65-75	6.1-8.2	50-325	0-25	0-2000	50-250
Carp	4-9	0-0.03	0-0.6	65-80	6.1-8.2	50-325	0-25	0-4200	50-260
Minnows	4-9	0-0.03	0-0.6	57-75	6.1-8.2	50-325	0-25	0-2500	50-250
Hybrid Striped Bass	4-11	0-0.03	0-0.7	70-85	6.1-8.2	50-325	0-25	0-1400	50-250
Walleye	4-9	0-0.03	0-0.6	50-70	6.1-8.2	50-325	0-25	0-2500	50-250
Trout	5-11	0-0.02	0-0.2	45-70	6.1-8.1	50-325	0-20	0-1500	50-250

*Un-ionized form; see chart to calculate what portion of your water sample's total ammonia is in this toxic form. Range given is for long term care; many fish can tolerate short term spikes-- just back off on the feed until the toxic portion of the ammonia falls back down to the stated range.

** These are general guidelines. By keeping your fish within the ranges shown above, they should stay relatively healthy and grow well. Variations can be found based on the genetics of your fish. We recommend discussing with the breeder or supplier of your fish any particular requirements.

Example Data Sheet for the Aquaculture System

Date	Time	Temp	pH	TAN* (ppm)	Nitrite (ppm)	Nitrate (ppm)	Amount of Feed Added	**NOTES** and other test results		

*TAN is Total Ammonia Nitrogen-- this is what the test kit measures. Refer to chart to calculate un-ionized (detrimental) portion.

SRAC Publication No. 463

Southern Regional Aquaculture Center

January 1992

Ammonia in Fish Ponds

Robert M Durborow[1], David M. Crosby and Martin W. Brunson[2]

Ammonia is the major end product in the breakdown of proteins in fish. Fish digest the protein in their feed and excrete ammonia through their gills and in their feces. The amount of ammonia excreted by fish varies with the amount of feed put into the pond or culture system – increasing as feeding rates increase. Ammonia also enters the pond from bacterial decomposition of organic matter such as uneaten feed or dead algae and aquatic plants.

Forms and toxicity

Total ammonia nitrogen (TAN) is composed of toxic (un-ionized) ammonia (NH_3) and nontoxic (ionized) ammonia (NH_4^+). Only a fraction of the TAN exists as toxic (un-ionized) ammonia, and a balance exists between it and the nontoxic ionized ammonia:

$$H^+ + (NH_3) \rightleftharpoons (NH_4^+)$$

The proportion of TAN in the toxic form increases as the temperature and pH of the water increase. For every pH increase of one unit, the amount of toxic un-ionized ammonia increases about 10 times. The amount of toxic un-ionized ammonia in your pond can be found by measuring the TAN with a water quality test kit and then looking up the fraction of TAN that is in the toxic form on Table 1, which is based on water temperature and pH. Multiply this fraction by the TAN to find the concentration (mg/L or ppm) of toxic un-ionized ammonia present in the water. For example, if water pH is 8.6, water temperature is 30°C, and TAN is 3 mg/L (ppm), multiply 0.2422 (from Table 1) by 3 mg/L (ppm) to obtain 0.73 mg/ L (ppm) toxic un-ionized ammonia.

Uptake (assimilation) of ammonia by plankton algae is important in reducing the amount of ammonia coming in contact with fish. Ammonia increases in the fall and winter because of reduced algae populations in the pond and algae populations which are not as capable of taking ammonia from the water. Additionally, lower water temperatures slow down aerobic bacterial activity, thus slowing the vitrification process whereby ammonia is converted to harmless nitrate (Figure 1). Algae die-offs can also lead to very high ammonia concentrations, but, fortunately, the low pH associated with the disappearance of the algae reduces the proportion of toxic un-ionized ammonia present.

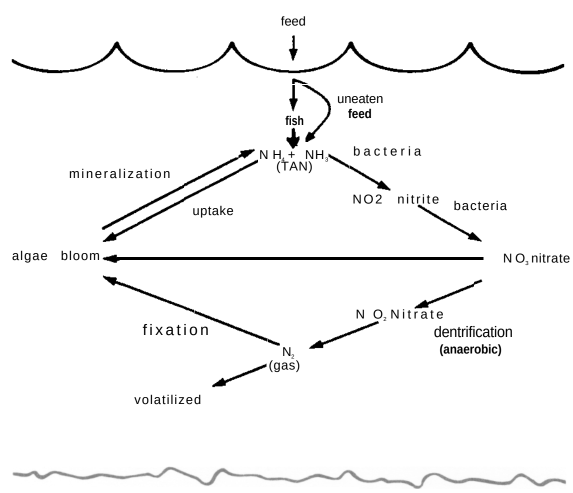

Figure 1. Nitrogen cycle in a fish pond.

Dangerous short-term levels of toxic un-ionized ammonia which are capable of killing fish over a few days start at about 0.6 mg/L (ppm). Chronic exposure to toxic un-ionized ammonia levels as low as 0.06 mg/L (ppm) can cause gill and kidney damage, reduction in growth, possible brain malfunctioning, and reduction in the oxygen-carrying capacity of the fish.

Treatments

Treatment for high TAN concentrations is difficult in large pond culture systems. Pumping fresh water into the pond is not a practical or economical means of reducing the ammonia level for the whole pond. It does, however, provide a small area near the inflowing water where fish can go to find some relief. Maintaining high dis-

[1]Cooperative Extension Program, Kentucky State University
[2]Mississippi Cooperative Extension Service

solved oxygen levels by aeration will slightly reduce the toxic effect of un-ionized ammonia. In addition, TAN levels may be reduced through increased aerobic bacterial activity due to higher oxygen levels. Temporary reduction of feeding rates is recommended until TAN levels decrease to an acceptable level.

Prevention of high TAN is a better approach to the problem. The use of lower feeding rates and good feeding practices play a big role in keeping TAN levels low. Problems with high TAN concentrations can be expected when feeding rates exceed 100 pounds per acre per day, or when excessive feed waste is occurring. Fish should not be overfed, and the feeder should be sure that fish are consuming feed offered. This is both of practical and economic importance, since feed costs are a major portion of production costs.

With pond and tank stocking densities continually increasing it is not often considered economically practical to reduce feeding rates. However, the organic loading in these systems is a major factor that must be dealt with. Intensive recirculating systems may be better suited to handle these excessive amounts of nitrogen, but most pond systems probably have a finite limit to the amount of nitrogen and organic loading that can be managed. Unless more efficient management methods are developed, nitrogen and organic loading may become a limiting factor in stocking and production rates in culture ponds.

Table 1. Fraction of toxic (un-ionized) ammonia in aqueous solutions at different pH values and temperatures. Calculated from data in Emerson, et al. (1975).
To determine the amount of un-ionized ammonia present, get the fraction of ammonia that is in the un-ionized form for a specific pH and temperature from the table. Multiply this fraction by the total ammonia nitrogen present in a sample to get the concentration in ppm (mg/L) of toxic (un-ionized) ammonia.

	Temperatures (°C)												
pH	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**
7.0	.0013	.0016	.0018	.0022	.0025	.0029	.0034	.0039	.0046	.0052	.0060	.0069	.0080
7.2	.0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0110	.0126
7.4	.0034	.0040	.0046	,0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0206	.0236	.0271	.0310
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743
8.2	.0210	.0245	.0286	.0332	.0385	.0445	.0514	.0590	.0676	.0772	.0880	.0998	.1129
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1998	.2241	.2500	.2774	.3062	.3362
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	.6045	.6373	.6685
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617
9.8	.4600	.5000	.5394	.5778	.6147	,6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892
10.2	.6815	.7152	.7463	.7746	.8003	.8234	.8441	.8625	.8788	.8933	.9060	.9173	.9271

Source: Emerson, K., R.C. Russo, R.E. Lund, and R.V, Thurston. 1975. *Aqueous ammonia equilibrium calculations: effect of pH and temperature.* Journal of the Fisheries Research Board of Canada. 32:2379-2383.

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 89-38500-4516 from The United States Department of Agriculture.

CropKing's Beneficial Bacteria

This product is specially formulated to treat re-circulated aquaculture water.
Use 1 teaspoon of product for 100 gallons of water. Add product once a month
Or as needed as water changes.Be sure to check the filters regulary. Keep testing the pH
As the microbial tends to lower the reading. Use baking soda to slowly increase pH

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Nitrite in Fish Ponds

Robert M. Durborow[1], David M. Crosby[2] and Martin W. Brunson[3]

Nitrite enters a fish culture system after feed is digested by fish and the excess nitrogen is converted into ammonia, which is then excreted as waste into the water. Total ammonia nitrogen (TAN; NH_3 and $NH4^+$) is then converted to nitrite (NO_2) which, under normal conditions, is quickly converted to non-toxic nitrate (NO_3) by naturally occurring bacteria (Figure 1). Uneaten (wasted) feed and other organic material also break down into ammonia, nitrite, and nitrate in a similar manner.

Brown blood disease occurs in fish when water contains high nitrite concentrations. Nitrite enters the bloodstream through the gills and turns the blood to a chocolate-brown color. Hemoglobin, which transports oxygen in the blood, combines with nitrite to form methemoglobin, which is incapable of oxygen transport. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate oxygen concentration in the water. This accounts for the gasping behavior often observed in fish with brown blood disease, even when oxygen levels are relatively high.

Nitrite problems are typically more likely in closed, intensive culture systems due to insufficient, inefficient, or malfunctioning filtration systems. High nitrite concentrations in ponds occur more frequently in the fall and spring when temperatures are fluctuating, resulting in the breakdown of the nitrogen cycle due to decreased plankton and/or bacterial activity. A reduction in plankton activity in ponds (because of lower temperatures, nutrient depletion, cloudy weather, herbicide treatments, etc.) can result in less ammonia assimilated by the algae, thus increasing the load on the nitrifying bacteria (Figure 1). If nitrite levels exceed that which resident bacteria can rapidly convert to nitrate, a buildup of nitrite occurs, and brown blood disease is a risk. Although nitrite is sel-

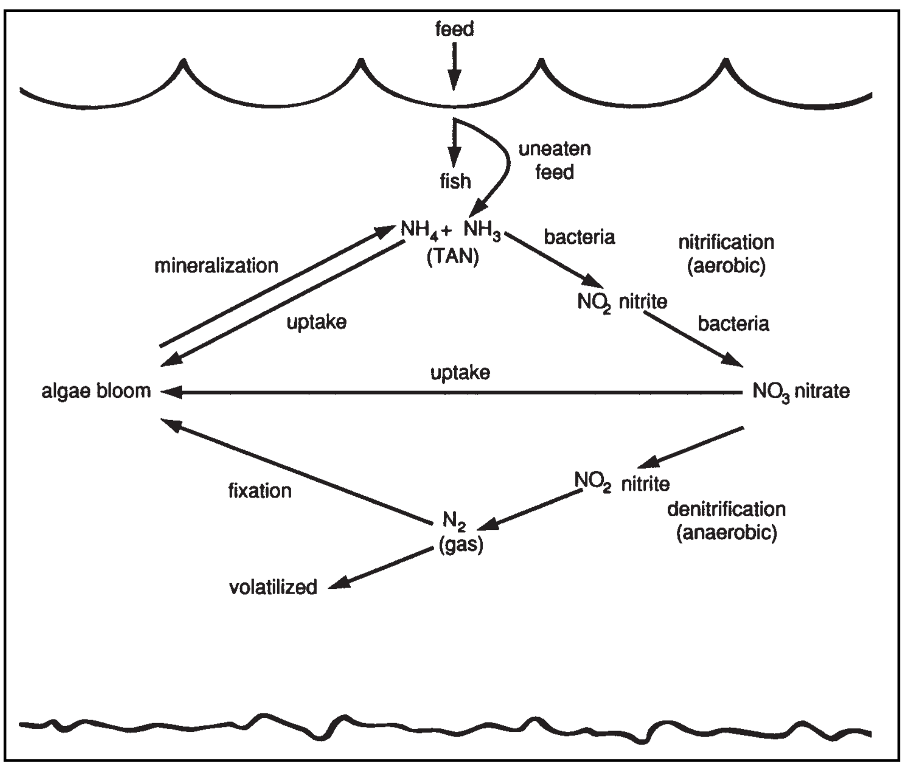

Figure 1. Nitrogen cycle in a fish pond.

[1]Cooperative Extension Program, Kentucky State University
[2]Virginia State University
[3]Mississippi Cooperative Extension Service

dom a problem in systems with high water exchange rates or good filtration, systems should be monitored year-round, and managed when necessary, to prevent severe economic loss from brown blood in any fish culture facility.

Susceptibility of fish species to nitrite toxicity

Largemouth and smallmouth bass, as well as bluegill and green sunfish, are resistant to high nitrite concentrations. The Centrarchids apparently are able to effectively prevent nitrite from entering the gills, but most other warmwater fishes grown in the Southeast apparently concentrate nitrite in the blood. Catfish and tilapia, for example, are fairly sensitive to nitrite, and trout and other coolwater fish are sensitive to extremely small amounts of nitrite. Goldfish and fathead minnows fall in between catfish and bass in their susceptibility to brown blood disease resulting from high nitrite levels. Striped bass and its hybrids appear sensitive to nitrite, but little is known about the relative sensitivity compared to other species.

Treatment and prevention

Since this is a nitrogen-related problem, the most obvious preventive measure is to reduce or minimize the amount of nitrogen incorporated into the system by reducing feeding rates. However, in modern intensive pond or closed system fish culture with high densities and rapid growout, longterm feed reduction is not considered by most farmers as a viable option. Luckily, although we often cannot prevent the occurrence of high nitrite, its effects can be minimized or neutralized safely and economically.

Sodium chloride (common salt, NaCl) is used to "treat" brown blood disease. Calcium chloride can also be used but is typically more expensive. The chloride portion of salt competes with nitrite for absorption through the gills. Maintaining at least a 10 to 1 ratio of chloride to nitrite in a pond effectively prevents nitrite from entering catfish. Where catfish (or other fish) have bacterial and/or parasite diseases, their sensitivity to nitrite may be greater, and a higher chloride-to-nitrite ratio may be needed to afford added protection from nitrite invasion into the bloodstream. As a general rule, catfish producers strive to maintain at least 100 ppm chloride in pond waters as "insurance" against high spikes of nitrite concentration. Culturists of other species may want to assume that nitrite is a potential problem and use salt as an insurance buffer as well.

How to calculate the amount of salt needed

Before treatment rates can be calculated, chloride and nitrite concentrations in the water, as well as pond or tank volume, must be determined. Commercially available water quality test kits can be used. Contact your Extension fisheries or aquaculture specialist for assistance in locating sources for test kits and conducting and interpreting these tests.

The amount of salt needed for the pond can be calculated using the following formulas:

Formula 1

(10 x pond nitrite concentration) - (pond chloride concentration) = parts per million (ppm) of chloride to add to the pond

The number "10" used in this formula is the minimum desired chloride:nitrite ratio number. It is used here to get a 10 to 1 chloride to nitrite ratio. If a higher ratio is desired, substitute the higher number for the 10.

If the answer is zero or a negative number, chloride concentration is sufficient to prevent brown blood disease.

Use the answer from Formula 1 above in the following formula:

Formula 2

Surface acres x average depth in feet x ppm of chloride to add to the pond x 4.5 = pounds of salt (NaCl) needed to add to the pond

You need 4.5 pounds of salt to increase the chloride concentration by 1 ppm in an acre-foot of water.

Example

The following readings are obtained from a 20-acre catfish pond with an average depth of 4 feet:

4 ppm nitrite
15 ppm chloride

Use Formula 1:

(10 x 4 ppm nitrite) - 15 ppm chloride in the pond = 40 - 15 = 25 ppm chloride to add to the pond

Now use Formula 2:

20 acres x 4 feet average depth x 25 ppm chloride to add to the pond x 4.5 = 9,000 pounds of salt needed to add to the pond

Application of salt

Distribute the salt evenly and quickly when fish are suffering from brown blood disease. Farmers have used feed trucks, airplanes, paddle wheels, and front-end loaders to distribute salt. It takes about 24 hours after salt is applied to a pond for the brown blood condition to be alleviated.

A good water quality monitoring program can help prevent brown blood disease. Pond water should be checked for nitrite two to three times a week during fall and spring, and at least weekly the remainder of the year. We recommend maintaining a chloride-to-nitrite ratio of at least 10:1 for catfish. Check ponds daily during a known high nitrite incident, even if adequate chlorides are in the ponds. Also check chloride after periods of heavy rain or active flushing from well water; both these events can dilute chloride concentrations and reduce the chloride:nitrite ratio.

Nitrite can increase very suddenly, so it is advisable to keep a 100 ppm chloride concentration at all times to act as a buffer when nitrite suddenly increases. This is a standard practice in the catfish industry, and incidents of brown blood disease in catfish ponds have become very rare. As an example, if your water has a chloride concentration of 20 ppm and you want to increase it to 100 ppm, simply add 80 ppm chloride to your pond. Use Formula 2 to calculate the pounds of salt needed.

Another way to help manage brown blood disease is by checking total ammonia nitrogen (TAN) concentrations in ponds every week. Every 1 ppm TAN can convert to 3 ppm nitrite in a relatively short period. High TAN levels can alert the farmer to anticipate nitrite problems within a few days, and nitrite problems can thus be predicted and then prevented.

In many areas, water contains high natural concentrations of chloride, and addition of salt as "insurance" is not needed. Water should still be monitored frequently, however, since chloride levels can fluctuate widely and frequently.

Outlook

Brown blood disease can be prevented, or at least minimized, by close monitoring of nitrite, chloride, and TAN, and by maintaining the proper chloride-to-nitrite ratio. If brown blood disease does occur, the condition can be reversed by adding salt to the water. Catfish (and likely other fish) surviving brown blood disease or nitrite stress are more susceptible to bacterial infections, anemia (white-lip or no-blood), and other stress-related diseases. Secondary problems, such as Aeromonas and Columnaris bacterial infections, often occur 1 to 3 weeks after brown blood disease occurs.

Research is currently underway to determine whether even higher levels of chloride may be beneficial in reducing sub-lethal, chronic stress on fish from nitrite or other stressing factors. Results have thus far indicated significant advantages to maintaining chloride levels as high as practically possible.

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