Repairing and Upgrading Older Classroom Recirculating Aquaculture Systems

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Introduction

The secondary educational system in Arkansas has many recirculating aquaculture systems (RAS) in schools across the state. Some of these systems are currently in operation while others are in storage. The operation of older RAS is explained in fact sheet FSA9620, *Understanding and Maintaining Older Recirculating Aquaculture Systems*. As teachers discover the stored systems or encounter problems with systems in operation, they may need assistance with repairs. Systems from the 1990s are simple to operate but produce less fish biomass than similarly sized units sold since 2010. Upgrades to older systems will be necessary if producing greater biomass is desired. This fact sheet explains what to look for when a fallow RAS is put back into operation, common repairs needed and potential upgrades to enhance these older systems.

Newer is not necessarily better, and the teacher who is a novice to RAS operation should not feel pressured to buy new systems or upgrade an existing unit. The same lessons can be learned from large, small, repaired, upgraded or new systems. One aspect of newer systems is the use of airlifts rather than water pumps to move water. Noise levels may not be important in a greenhouse or shop, but airlifts make the system quieter which can be advantageous if the RAS is in the classroom. In addition, airlifts cannot pump as much water out of a system compared to a catastrophic pump accident. Generally, the main difference between old and new is the amount of product harvested at the end of the school year.

Common Problems

Common problems include leaky tanks, pipes, bead filters and pumps. Pumps may not run correctly and water may not flow through bead filters properly. The following headings will address these common problems and present viable solutions. After repairs are addressed, system upgrade options will be reviewed.

Repair Strategies

Tank Leaks

After running for several seasons, being moved to new locations or sitting fallow for a long time, tanks may develop leaks. The most likely place for a leak to occur is at the fittings around the tank. In a one-tank system this is the drain. In a two-tank system

FIGURE 1. A two-tank system composed of two 500-gallon polypropylene tanks, a ⅙-hp pump and a bead filter.

this includes the leveling pipe that is about halfway up the tank and connects the tanks to keep water levels the same throughout (Figure 1). Usually, drains are connected to tanks by a bulkhead fitting. This is often true for the leveling pipe, but sometimes a Uniseal® is employed. It is necessary to determine if the leak emanates between the fitting and pipe (the inside) or from the fitting/tank interface (the outside).

If the leak occurs from the inside and the fitting is threaded, simple tightening may be required. Do not over-tighten and strip the fixture. If this does not solve the problem, separate the threaded items and make sure Teflon® tape or paste is used on the threads. When using paste, be certain it is rated for PVC. If it still leaks after tightening, separate the parts again, clean all the threads, remove any Teflon® and wash with alcohol. Then apply a thin coating of silicone glue and thread the parts back together. Wait overnight and check for leaks. This will seal the connection and make it difficult but not impossible to separate again in the future (Figure 2).

If the leak is inside and the fixture is "slip" instead of "thread," make sure it was glued together with PVC glue in the first place. If not, clean all parts to be glued, then use primer and glue to chemically weld the joint (Figure 3). If separation of this joint is desired in the future, silicone glue may be used instead of PVC glue. Silicone may be substituted for PVC glue only in non-pressure situations like drains and leveling pipes.

If the leak is inside and a Uniseal® is used, replace it with another Uniseal® or a new bulkhead fitting. Treat the situation similarly if the leak occurs outside the Uniseal®. Once a Uniseal® leaks, it cannot be repaired.

If the leak is outside the bulkhead fitting, it may need to be tightened. Again, do not over-tighten and strip the threads. Alternatively, a new gasket(s) may be needed. If these techniques fail, replace the fitting

FIGURE 2. Sealing a leak between threads inside a bulkhead fitting. 2a: threads to be sealed; 2b and c: applying silicone sealant; 2d: threading complete, note the bead of silicone formed between the bulkhead and the pipe joint.

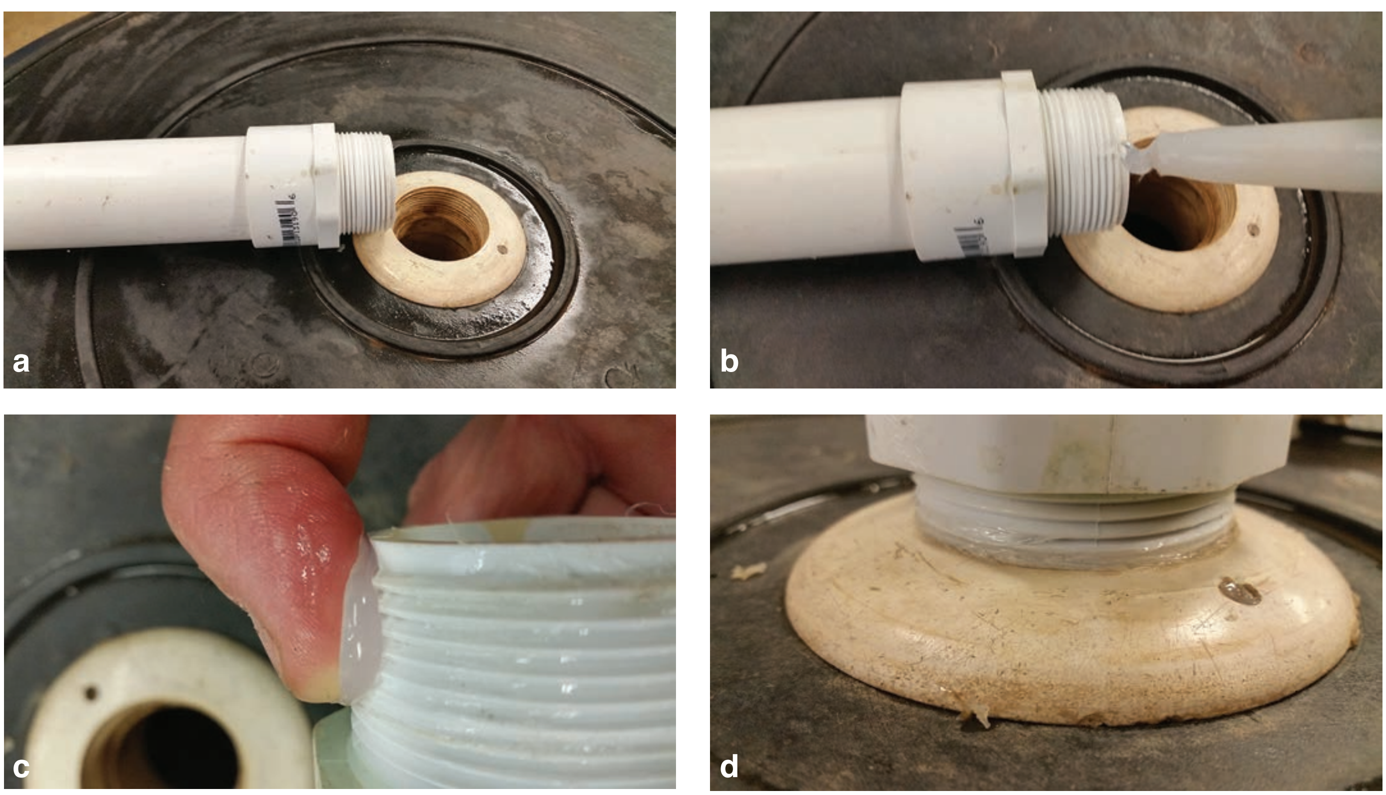

FIGURE 3. Gluing PVC pipe. 3a: The clean pipe with no burs is primed with purple primer on both surfaces, then, 3b, glue is applied to both surfaces. In 3c, the pipe is pushed into the fitting and then turned a quarter turn from position 1 to position 2 for a proper weld as seen in 3d.

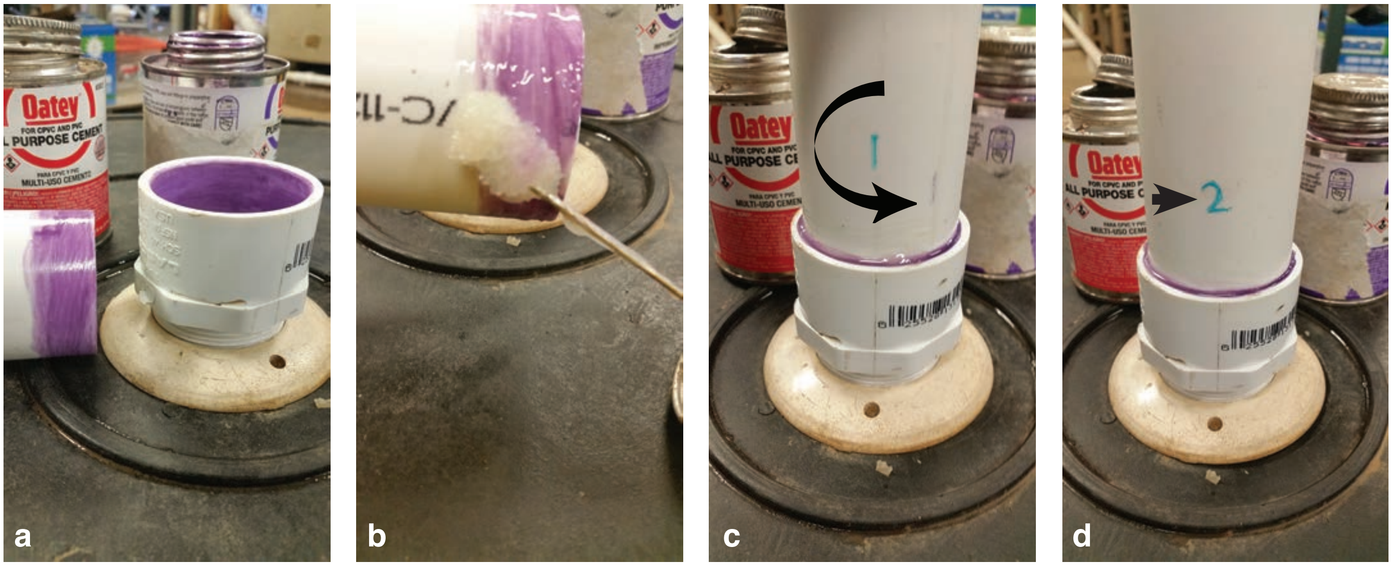

FIGURE 4. Frequently, a bulkhead fitting is equipped with one gasket, but if leaking persists, a gasket may be used on both sides of the wall.

or use two part epoxy putty to seal around the fitting (Figure 4). In this case, if the fitting ever needs to be removed, it will need to be replaced. Before applying the epoxy, rough up the plastic with a wire brush, file or sandpaper. Apply a wedge of epoxy around the entire fitting both inside and outside of the tank (Figure 5).

Sometimes tanks leak because there is a hole in the tank. Heaters may burn a hole in the tank or a hole may have developed if the tank was stored improperly on or near a sharp object. A plastic welder may be used to repair a hole in a plastic tank (Figure 6). If the hole is large, a piece of plastic may be needed to cover the hole and then be welded to the surrounding tank wall. If a plastic welder is not available, this may be accomplished with silicone glue or two-part epoxy putty. Silicone easily fills in holes ¼ inch or less in diameter. Epoxy putty may also be used for holes up to 1 inch in diameter (Figure 7).

Moving tanks around, especially after they have been exposed to UV light for long periods, may result in cracking. In this instance, the tank may not be repairable. Even following a repair, if the material is brittle, the crack will continue beyond the repair after the tank is filled with water. To test the brittleness, press on the plastic at each end of the crack. If the plastic flexes, the crack is contained. If the crack continues, keep applying pressure until the plastic flexes and no longer cracks. This shows the length of crack to be repaired.

Remember, silicone glue is a sealant and not designed to bond things together. Silicone will hold a patch in place and seal it as long as forces are pushing the items together. But silicone is not designed to withstand shearing forces. Always test repairs with the full amount of water in the tank for a few days before adding fish.

Pump Leaks

In the case of leaks at the pipe/pump interface, follow the instructions for fittings outlined above under Tank Leaks. Remember, silicone may be used on the intake side of the pump but not on the outflow side of the pump. At that point the water and pipes are under pressure. The pump may leak at the seal between the motor and pump. In this case there is little to be done. Although seal kits are available for larger pumps, smaller pumps will not be economically repaired this way. If the leak is a drip that does not cause a problem for the floor (uprooting vinyl tile for example), the system may be run with that pump until the pump quits altogether. The leak is a sign that a new pump will need to be purchased and installed sometime in the future. If the pump is

FIGURE 5. Use of epoxy putty to seal in a bulkhead fitting. 5a: Clean and rough up the area with a wire brush or sandpaper; 5b: cut off a portion of the epoxy putty; 5c: knead the putty together (always use gloves with this material) until the color is uniform; 5d: when the color is uniform roll into a ring and place around the bulkhead fitting; 5e: put the bulkhead fitting in place; 5f: tighten the fitting in place which will push the excess epoxy out; 5g: use the excess to form a wedge to help lock the wall and the fitting together. If there is not enough excess, prepare more putty and make a sufficient wedge.

spraying water, the water loss to the system will be too great to sustain for long. Always consider allowing a professional to inspect the pump for a final determination.

Burned Up Pump

Aquaculture supply companies constantly search for the most efficient equipment with the least cost to use in a system. Consequently, the model and make of the pump on the system being worked on may no longer be available. As long as the horsepower and the voltage of the old pump are matched, a reasonable replacement should be obtainable. As years pass and pump technology improves, less horsepower may provide a similar volume of water. In this case, the efficiency curve of the existing pump may be examined and compared to others that are available. Local hardware, pool, electrical or plumbing supply stores may have or be able to order the pump needed. It is also a good idea to take the old pump that seems not to work to a local electrical repair shop and have the suspicion verified. Schools with electrical programs or electric shops may be able to do this work on site. Take the pump to the store so it can be used to properly size a new pump. Sometimes a more powerful pump can be purchased for less than the current pump size. This is tempting, but unless expansion of the system is planned, what will be done with the extra water?

Clogged Bead Filter

Backwashing may be done on a schedule or determined by pressure, but a pressure gauge is rarely found on these systems. If the operator notices a reduction in the flow of water to the fish tanks, backwashing is needed. The restricted flow indicates a buildup of pressure within the bead filter and back pressure on the pump. By the time this happens, organic matter accumulation on the beads is so intense that the beads may not separate during the backwash cycle. If this happens, the filter must be backwashed several times as noted in FSA9620, *Understanding and Maintaining Older Classroom*

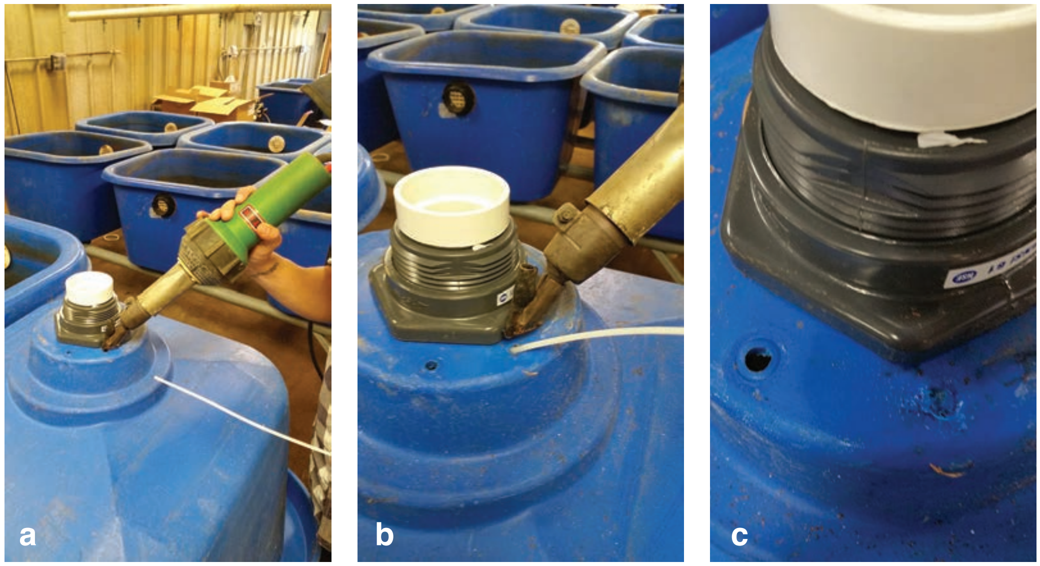

FIGURE 6. A plastic welder repairing a hole in a tank. 6a. The welder may be used to melt the tank plastic and seal the hole or, 6b, a plastic rod may be melted to fill the hole. 6c is an example of a hole and repaired hole in a tank.

FIGURE 7. Using epoxy putty to repair a 1-inch diameter hole. 7a: Follow plastic and putty preparation instructions in Figure 5; 7b: make two thin discs and apply one to each side of the wall; 7c: this will create a wall that will set and be impervious to water, 7d.

Recirculating Aquaculture Systems. If this does not solve the problem, the filter must be disassembled and the beads should be removed, washed and replaced.

If organic matter is left in place at the end of the school year and left to dry over the summer, the beads will harden into a mass similar to concrete. They may harden and adhere to the top or the bottom of the bead filter. In either case, when water is introduced the next time, there will be little or no water flow through the bead filter. If this condition is suspected, the filter should be filled with water and the beads should be soaked for a day, removed, washed and replaced. Wash the beads with water and do not use detergents or soaps. Use bleach or other disinfectants only if advised to do so by a professional who has diagnosed a pathogen in the system that must be eradicated.

Upgrade Strategies

Drain From Bottom Port

Remember that the large port on the bottom of the bead filter draws water from the pump up into the filter and out the top to the spray bar(s). The main route for backwashing is the 1-inch flex hose. This process is described in FSA9620, *Understanding and Maintaining Older Classroom Recirculating Aquaculture Systems*. However, if beads are frequently lost, the bottom 1½-inch port may be fitted with a T and valve so when the pump is turned off, the 1½-inch valve may be opened to drain and gurgle the filter. The advantage is this port has an interior screen, and if the bead filter is drained too far, beads will not be lost. The disadvantage to this solution is if large clumps of solids accumulate in the bead filter, they will not easily evacuate past the port's interior screen.

By not using the flex hose, some solids might be trapped and eventually clog the bead filter. The operator may use the flex hose for part of the backwash and the screened drain for the rest. However, this still requires operator diligence not to drain too long while using the flex hose. Draining a full bead filter with the flex hose should never exceed 30 seconds to avoid bead loss.

Water-Driven Backwash

An alternative to bubble backwashing is a water-driven backwash system. This adds on to the process of turning the bottom port into a drain and is demonstrated in Figure 8. The advantage to this approach is that the force of water from the pump will easily clean beads in almost any condition. Due to shearing forces, it reduces large particles to small ones, allowing them to pass through the bottom screen. In this configuration, the 1-inch backwash hose is no longer needed. The bottom port is turned into a drain as described above, and in addition, a pipe is attached from the bottom pipe to the top exit pipe. Tee joints and valves are installed to force water from the pump to the top of the bead filter so water flows down the bead filter while not entering the spray bars and exits the bottom port/drain without becoming part of the water flow back to the top. If water flow is routed back to the top, dirty water will cycle through the filter.

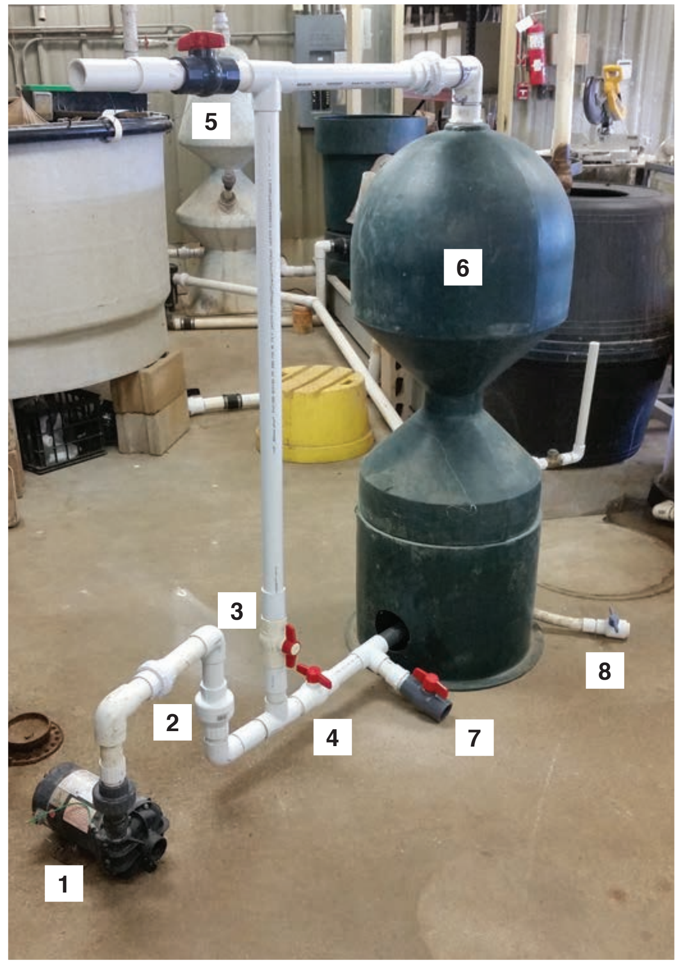

FIGURE 8. Use the water pump to backwash the bead filter (6). This loop is currently set for backwash mode. The pump (1) pushes water past the check valve (2). Valve 3 is open and valve 4 is closed so water must move up the pipe. Valve 5 is closed so water may only enter the bead filter from the top and push down to clean the beads. Valve 7 is open and valve 4 is closed, so water can only exit the drain. Normal operation requires valves 3 and 7 to be closed and valves 4 and 5 to be open. By eliminating the pipe and Ts between valves 4 and 5, water cannot be used for backwash, but the regular air backwash can exit through valve 7, thereby using the screen at the bottom of the bead filter to prevent bead loss. The flex hose (8) may still be used to flush backwash water, but it has no screen to prevent bead loss.

Add a Sump

Another method to keep the bead filter clean is to prevent solids from entering it in the first place. By adding a sump between the culture tank drain and the pump, most solids removed from the culture tank will be trapped in the sump, which prevents their entrance into the bead filter. In this case, the bead filter primarily nitrifies nitrogen waste and no longer performs the second duty of solids capture. It is important to remember the bead filter will still need to be backwashed at least once a week to prevent caking of the beads caused by growing bacteria (Figure 9).

Add a Heater

If the RAS has a chance of dropping below 75°F (24°C), tilapia are to be raised and a high level of growth is desired, install a heater. For most applications, 3-5 watts of heating are needed per gallon of water. A 1,000-gallon system will need enough heaters to provide 3-5,000 watts of heat. It is best to use two to three heaters if possible. Multiple heaters provide a backup system in case a heater fails. Contact the supplier or an extension specialist for an exact calculation. Though inexpensive, a cattle trough heater will not work. This heater only emits enough heat to prevent freezing and will allow water to stay at a temperature far below the lethal limit for tilapia.

An alternative is to heat the air, but generally the air must be 7°-10°F warmer than the desired water temperature which may create a hot working environment for humans and a large heating bill depending upon the volume of air and water to be heated. Greater heat transfer efficiency can be achieved with this method if the tanks are off the floor and the heated air flows along the floor and under the tanks. This way, as the hot air rises, it has a better chance to be absorbed by the water. Even with this adaptation, the efficiency is far lower than with a water heater. A final option is to raise a species that does not require high temperature for good growth.

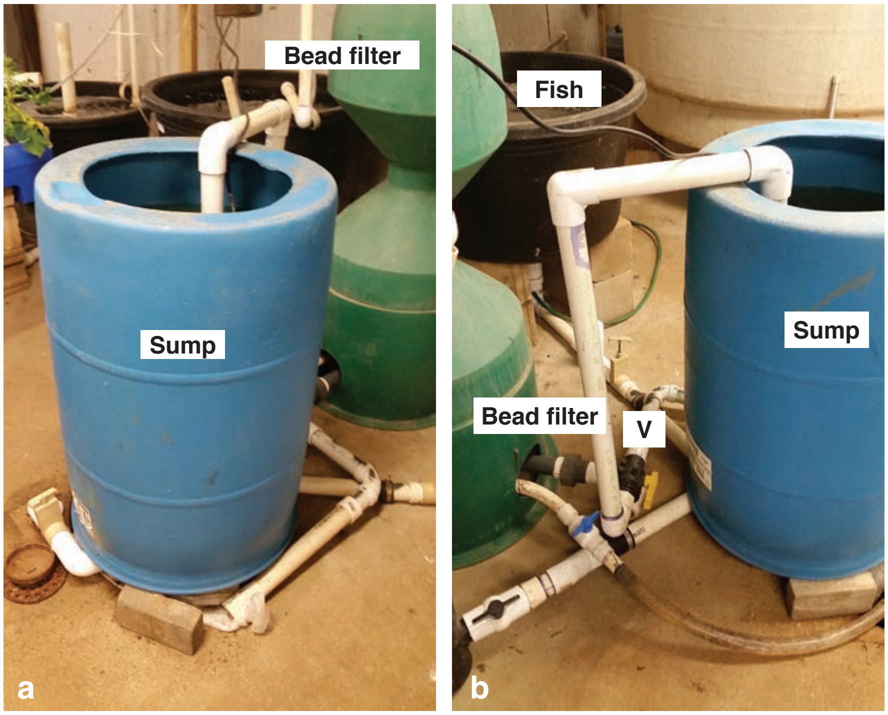

FIGURE 9. A sump between the culture tanks and the bead filter removes solids that will quickly clog the bead filter. Two drains from the two culture tanks enter the bottom of the sump. The pump inside the sump moves water up and over the sump to the bottom of the bead filter. A three-way valve (V) can send water to the bead filter, to the drain or stop flow completely.

Add an Air Supply

A linear piston pump or small regenerative blower with air hose and airstones is a useful addition to an RAS. These units continue to become more compact with less noise, making them highly desirable. Although the fish are still endangered in cases of complete power failure, if the water pump is the only component disabled, the air pump can continue to supply oxygen until the problem is resolved. In this case, it is important that the water and air pumps are not running on the same electrical circuit.

The depth of the tank will determine what size air pump is required. Read pump specifications carefully before buying. If the pump can provide air up to 40 inches of head and the water is 48 inches deep, the pump is useless in this situation unless the airstones are set at 40 inches or less. Airstones should not be placed at the point of maximum head as this is also the point of least airflow before the pump can no longer deliver air to the water. Use a pump that can easily deliver the air required. In the example, if the given pump is the only choice, the water depth can be reduced or the airstone may be raised to a higher position (30 inches for example). Using a pump with greater head tolerances will allow the airstone to sit lower in the water and give more contact time and better gas exchange. Air, like water, follows the path of least resistance. So, if the airstones are set at 30 inches in the culture tank, but at 15 inches elsewhere in the system, the air will preferentially flow to the 15-inch deep airstones. In this case, an inline valve on the 15-inch airlines will restrict the volume of air that may pass and force the remainder to the 30-inch airstones. Providing each airstone with its own control valve is always a good idea.

Add an Emergency Backup System

The most effective and expensive method when assembling an emergency backup system is to add a generator with a transfer switch to the system. In the event of electrical power loss, a transfer switch will automatically start a generator and then switch the energy supply from utility company power to generator-supplied power. When the regular power supply is reinstated, the transfer switch automatically detects the change, moving power back to the normal supply and turning off the generator. A less expensive method is to have the generator ready and manually start it as needed. In order for best performance with this option, an alarm system that can automatically contact the system operator is required to alert that person of a power outage so he or she may respond in a timely fashion.

Many RAS operators also have access to compressed oxygen. This can be an effective and inexpensive backup system in the event of a power outage. In this case, a tank of oxygen with a regulator, flow meter and oxygen diffusers is prepared (Figure 10). The diffusers are always in the water and ready to deliver oxygen in case of a power outage. The control mechanism is a solenoid valve placed after the flow meter. The solenoid valve with a closed normal position is plugged into a receptacle. If the electricity fails, the lack of current opens the solenoid and oxygen from the cylinder flows into the tank(s). The flow rate should be regulated and tested with the solenoid unplugged to determine the amount of oxygen needed to keep the water well oxygenated for the longest time possible. This information tells the operator how much time is available for resolution of the problem. Using an alarm system lets the operator know exactly when the emergency oxygen started. This system can also be coupled with a manual generator if a protracted power outage is expected.

FIGURE 10. A solenoid valve (cube in b.) and oxygen tank can be a useful combination for oxygen backup. The solenoid valve is plugged into an electric receptacle (a.) which keeps the valve closed. In the event of a power outage, lack of electricity opens the valve and oxygen can flow to the fish. The tank should be well secured and all fittings in good condition to ensure oxygen does not leak from the system. Although this setup has a regulator, it does not include a flow meter, which is preferable.

Oxygen is commonly supplied in 84, 128 or 282 cubic foot cylinders. Flow meters are normally calibrated in liters per minute. There are 28.3 liters per cubic foot. Therefore, a cylinder with 282 cubic feet × 28.3 liters/cubic foot = 7,980.6 liters of oxygen gas. If the flow meter is set at 2 liters/minute, the tank can supply 7,980.6 liters divided by 2 liters/minute = 3,990 minutes or 66.5 hours of oxygen. If the flow rate is raised to 5 liters/minute, the supply will last 26.5 hours. This will vary if there is a leak in the delivery system from oxygen tank to fish tank. Since the system is under pressure, even a small leak will reduce a day's worth of oxygen to a few hours.

Construction and Deconstruction

When constructing an RAS, the operator should always consider if it will be taken apart or if parts of the system may be shut down while allowing the rest of the system to operate. Valves and unions are very important tools in the implementation of this consideration. While they allow the operator to remove parts of the system without draining, they also increase initial construction cost. However, the flexibility gained for future work may be far more valuable than those initial costs. Students may be able to add and test new components without causing too great a disturbance for the fish.

Summary

Arkansas educators interested in using aquaculture in the classroom should consider resurrecting fallow systems to reduce costs associated with a new system. Generally, the most common problems include leaks, pump problems and bead filter issues. If the system is usable, it is well worth adding a sump to the system to reduce solids retention by the bead filter. It is also important to check the bead filter and make sure the 1-2 ft^3 of beads are still in the filter and if not, replace them.

These systems can be used without modifications as long as biomass levels are in sync with original design. However, if greater volumes of fish are desired, the operator can modify drains and bead filters and add sumps, heaters and air delivery systems, as well as backup energy, alarm and oxygen systems. System repair time requirements vary from project to project, but once in place they are sure to be rewarding for students. Teachers should consider contacting schools with stored systems they might be allowed to use. This may be made easier by connecting with the local educational cooperative. Frequently, the science or agriculture education specialist at the cooperative can connect teachers in need with unused systems via their cooperative network, as well as with the network of other educational cooperatives in the state.

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