Oxygen Depletion in Ponds

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Introduction

Fish ponds may experience a loss of oxygen at any time of the year, depending on the weather and amount of nutrient enrichment the pond has received; however, most oxygen depletions occur in warm weather and usually follow a period of cloudy, overcast conditions. Low oxygen concentration in pond water means stress and possibly death for the pond fish. When fish die from low oxygen, there can be serious financial consequences for commercial fish operations; for example, largemouth bass, bream and grass carp can be worth more than $3,000.00 per acre. Therefore, pond owners should consider a plan to provide aeration for their ponds before oxygen depletions occur.

Continuous aeration of aquaculture ponds has been a normal operating procedure only when the pond is heavily stocked with fish. More common is a method of emergency aeration or intermittent aeration using timers or sensors. Methods of aeration vary from blowers to paddlewheels. A careful examination of the cost of each method will help guide your choice of aerator type and aeration schedule.

How Oxygen Becomes Depleted

Oxygen demand is usually lower than oxygen production when fish populations are properly managed, nutrients are limited and fish feed is applied sparingly. Oxygen depletion begins when fish and other pond organisms use oxygen faster than algae, plants and diffusion can produce it.

With enough light, the algae and plants in the pond can provide sufficient oxygen by the process of photosynthesis, and at the water surface, some oxygen from the air also diffuses into the pond water. Therefore, during the day, oxygen is usually abundant in pond water and increases from dawn to dusk. However, at night and during cloudy weather, plants do not produce oxygen. Instead, they begin to use oxygen like all the other pond organisms. Stored oxygen is used to support respiration and chemical processes that use oxygen in the pond water. The difference between the highest oxygen level during the day and the lowest level at night is called the oxygen demand. When demand exceeds both the supply of oxygen that is stored and new oxygen production, a pond's oxygen supply rapidly becomes depleted.

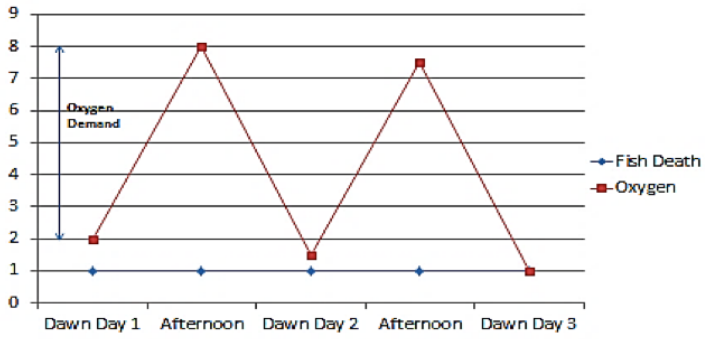

Figure 1. Oxygen change in ponds during days with cloudy, overcast weather.

Common causes of oxygen depletion include cloudy weather, sudden death of algae or plants in the pond, and wind mixing the pond water. Just two to three days of overcast weather can cause oxygen production to diminish. When the oxygen demand remains the same or increases, oxygen levels begin to decrease. When oxygen production stops suddenly due to algae or plant death, oxygen demand can exceed oxygen supply in a day or less.

Wind mixing causes deep water, which has low oxygen concentrations, to mix with surface water and reduce the overall pond oxygen supply very rapidly. Chemicals in deep pond water, such as carbon dioxide, can further stress fish when a pond is mixed by high winds.

Heavy rains can also mix the pond water, and flooding from excess runoff can wash the algae out of the pond, robbing it of its oxygen-generating plants.

How to Predict Oxygen Depletion

Watching both the pond and the weather can help predict oxygen problems in ponds. When a weather front approaches, begin to watch how many hours of sunshine the pond receives. If the skies are overcast for more than a few hours each day, oxygen production may be limited. Hot weather with no wind is another signal to prepare for oxygen depletion. Bright sunlight may kill some algae, and without wind, diffusion is lower and water temperature can be higher. Hot temperatures mean less oxygen can be stored in the pond water.

Pond color may change just before oxygen depletion. Algae death is signaled when water color turns from green to brown. Water mixing can turn the water brown as well. Dead algae cells and an increase in the bacteria that is suspended in pond water may cause a brown color. However, if the pond normally has a green-brown or light brown tint, the oxygen levels may be okay. Know your pond, and be observant for sudden changes in pond color.

Fish behave differently when pond oxygen begins to decrease. Oxygen depletions can best be detected in the early morning by watching for fish swimming at or near the surface. Fish will seek areas of higher oxygen when the pond oxygen level begins to decrease. For that reason, look for fish gathering near seeps and springs that feed the pond. Fish will also not eat as actively when oxygen levels begin to decrease. (Of course, if the fish are not being fed, this method of observation does not work.)

Types of Aeration

Aeration is a way to mechanically add oxygen to the pond water. Electrical power is necessary for easy and reliable operation, although remote ponds may be aerated with gas-powered pumps or aerators in an emergency. The most common type of pond aerator is a floating aerator that uses a submersible motor and propeller to move and disperse water. Bubblers, paddlewheels and centrifugal pumps can also be used to add oxygen to pond water.

Floating Vertical Propeller Pump Aeration

An example of a floating aerator is a 3/4 HP, 3,400 rpm, single phase, 110/220 volt motor with a single plastic propeller. The Standard Oxygen Transfer Rate (SOTR) is about 1.9 pounds of oxygen per hour of operation. The Standard Aeration Efficiency (SAE) is 2.5 pounds of oxygen per horsepower-hour. The ¾ HP aerator costs about $800 to $1,000 to purchase and install, and about $0.05 per hour to operate.

Fountains that lift water high above the pond water surface may be useful, but typically have lower oxygen efficiency per unit of horsepower because they work harder to get the "fountain" effect.

Blower or Compressor Aeration

Blowers or compressors sit on the pond bank and are attached to pipes or tubes that connect to air stones or diffusers in the pond. An example of a compressor system with bubblers uses a 3/4 HP, 110/120 volt compressor with 100 feet of weighted diffuser tubing. The compressor is capable of expelling about 6 cubic feet of air per minute underwater to a depth of about 10 feet. Since bubbles need a long time to completely diffuse in water, some air is wasted. Therefore, the SOTR is about 1.4 pounds of oxygen per hour and the SAE is about 1.9 pounds of oxygen per horsepower hour. Cost of operation is about $0.05 per hour in addition to initial purchase and installation costs of at least $1,200. Blowers provide more cubic feet of air but usually cannot provide enough air pressure to operate in water deeper than 5 feet.

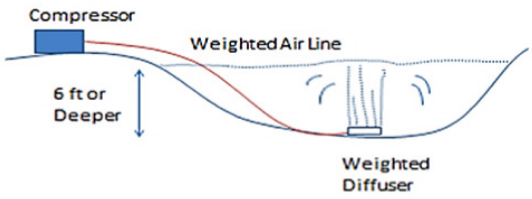

Figure 2. A compressor and diffuser system provides oxygen when bubbles diffuse into pond water.

Paddlewheel Aeration

Paddlewheel aerators float on the water surface and are connected to a power source on the bank using a waterproof cord. Paddlewheels move water away from the aerator as the water is mixed with air. After the paddlewheel has operated for several minutes, a circulation pattern is created in the pond that brings water with low oxygen to the aerator while pushing oxygenated water away into the pond. Because paddlewheels tend to be more efficient, these aerators are often used in commercial aquaculture. An example is a paddlewheel powered by a 2 HP, single phase, 110/220 volt motor with a gearbox rated at 109 rpm. The SOTR is about 5.4 pounds of oxygen/hour and the SAE is about 2.7 pounds of oxygen per horsepower-hour. Operating costs of approximately $0.16 per hour do not include purchase and installation costs, which average about $1,350. Maintenance needs include gearbox and bearing repair.

Figure 3. Paddlewheels are installed to create water circulation in ponds.

The Case for Intermittent Aeration

Aeration costs add significantly to the cost of operating prawn farms. Continuous aeration during the entire season may cost more than $500 per acre. Aerators with more horsepower cost a great deal more to operate per unit of time, but usually impart more oxygen into the water and also stir the pond water more effectively. However, too much agitation can cause a muddy turbidity that shades the desirable plankton and can ultimately reduce prawn production. In ponds with relatively low nutrient content and sparse algal blooms, continuous aeration may not be necessary.

Pond water stratification can be eliminated with aeration times of six to 12 hours per day. A good method of scheduling aeration involves measuring dissolved oxygen every morning and evening. Although commercial fish farms perform those checks, recreation pond owners can usually rely on weather observation to determine pond aeration needs. In general, it is best to set aerators to operate during the night, usually between 10:00 p.m. and 6:00 a.m. Aeration during the day is only necessary when the dissolved oxygen concentration is expected to be low due to cloudy weather or other signs of low oxygen.

Summary

Pond aeration is a good way to protect fish populations from oxygen depletion. The expense of providing aeration is reasonable when compared to the cost of losing the fish population, especially for commercial or sport fish operations.

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