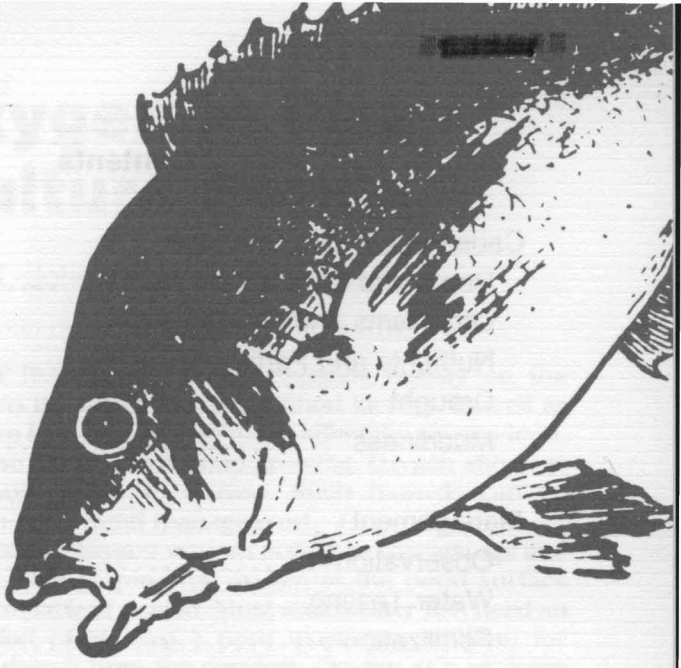

POND MANAGEMENT:

Oxygen in Fish Culture Ponds

The Texas A&M
University System

Texas
Agricultural
Extension
Service

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Contents

Oxygen in Fish Culture Ponds

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The quality of fish culture ponds depends heavily on the amount of oxygen in the water. Environmental factors, as well as oxygen consumption by plants and animals, affect the oxygen level. Low levels can cause fish to die or stop growing. Oxygen shortage also makes fish susceptible to disease. Such hazards can be minimized through good pond management.

The needs of fish for oxygen vary according to species, age and culture conditions. Fish gasping for oxygen at the pond surface definitely suffer from lack of oxygen. Most warmwater fish need an oxygen concentration of at least 1 ppm (parts per million) for survival and more than 3 ppm for comfort. Oxygen at 5 or more ppm provides the best growing conditions.

The oxygen in water comes from air and plants. Twenty-one percent of the atmosphere consists of oxygen, which dissolves into water when it hits the water's surface. Cold water holds more oxygen than warm water. Even if there were no biological activity, the water of a pond in winter would hold from 12 to 13 ppm, while in summer it would hold only 7 to 8 ppm. Unfortunately, most of the factors that cause serious low oxygen problems are more active in summer when there is less oxygen in the water to begin with. Some oxygen in water comes from underwater plants that release the element as they undergo photosynthesis. Since photosynthesis is dependent on light, the plants produce oxygen near the surface and only during daylight hours. This cycle and the total supply of oxygen to water is affected by a variety of factors.

Causes of Oxygen Shortage

Depth and Circulation

Most of the water mixing in ponds is caused by the wind. Ponds in Texas circulate all the way to the bottom in winter. Most ponds shallower than 1.5 meters (5 feet) circulate completely at intervals during the summer, and most ponds deeper than 2 meters have some deeper areas that do not circulate at all in the summer. The depth to which a pond circulates depends a great deal on how exposed to the wind it is.

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Oxygen is constantly being exchanged between the circulating water and the air, and can be renewed if used up. The deeper non-circulating water can't get more oxygen however, and if fish are to utilize all the depth of a pond, some mechanical circulation method will have to be used.

Organisms and Oxygen

All organisms use oxygen in respiration, except a few specialized micro-organisms. In a culture pond, most of the oxygen is used by fish and bacteria.

The more fish there are, and the more organic material there is available for bacteria to feed on, the greater the requirement for oxygen.

Green plants (algae and larger aquatic plants) add oxygen to the water when they have light and nutrients available, but in the dark they continue to require oxygen, and may contribute to a low oxygen problem at night. In an unfertile pond, oxygen values may not vary much over 24 hours, but in a fertile pond with high algal growth, oxygen may vary widely between day and night, with critical low oxygen situations coming at night. (See Figure 1).

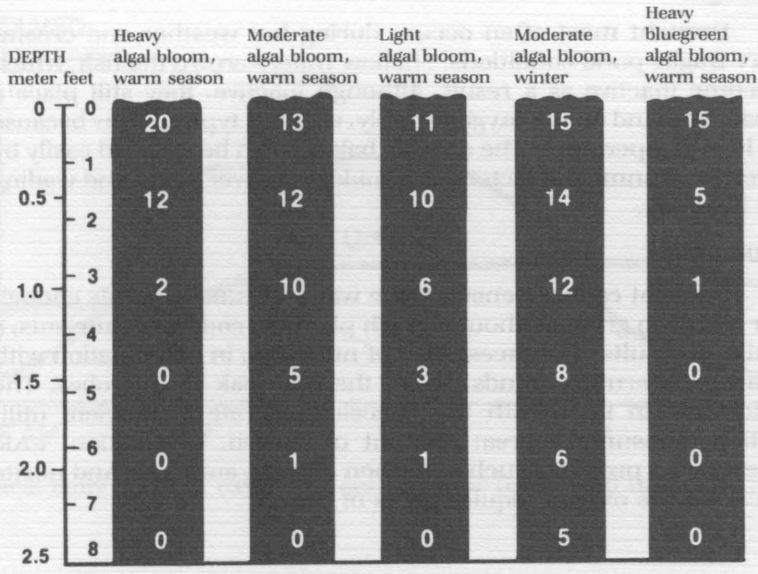
When conditions are just right algae may grow very rapidly and cause what is called an algal "bloom". This not only causes low oxygen at night, but in the case of some blue-green algae, the cells may float to the surface and form a layer which interferes with wind mixing and further decreases the oxygen supply. Another problem may occur when there is a sudden die-off of the algal bloom and oxygen drops dramatically as the mass of dead plant material decomposes.

One of the most dangerous situations occurs when a warm sunny period (which often encourages an algal bloom) is followed by cloudy weather, particularly if there isn't much wind. With low light the plants aren't releasing oxygen, but *are* requiring it for respiration. In such circumstances oxygen values may drop to near zero even at the water surface.

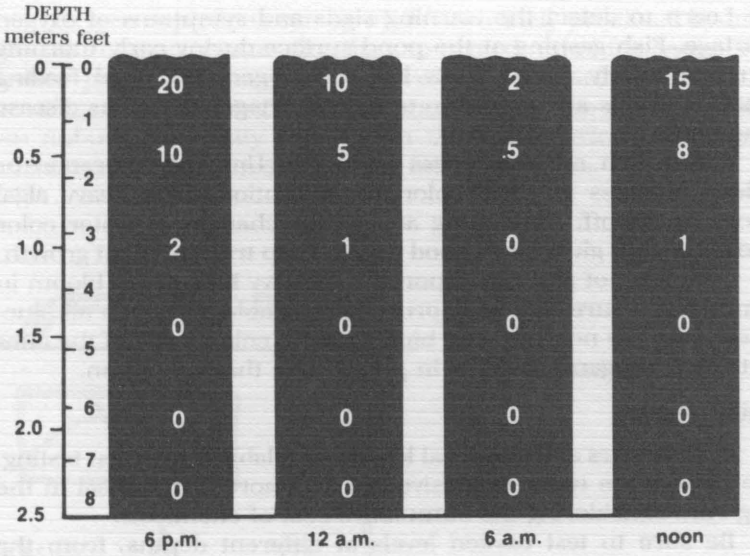
Moderate algal growth is often beneficial because they shade out larger aquatic plants, and provide food for small organisms that fish feed on.

Nutrients and Fertility

The nutrients available for plant growth are an indication of a pond's fertility. Technically, a fertile pond is one which is artificially fertilized or supplemented with fish feed. Overfeeding causes an excess load of nutrients. Decomposition of the nutrients places an extra demand on the oxygen supply of the pond and may cause a shortage.



Afternoon oxygen measurements during various pond conditions, expressed as columns of water and measurements in parts per million (= mg/1) dissolved oxygen.



Water column diagram showing daily variation in oxygen concentration (ppm) in a pond with heavy algae bloom. Ponds with lighter blooms have less daily variation. Measurements at dawn are lowest because of the preceding period of darkness.

Drought

Drought most often occurs during hot weather and creates very fragile pond conditions. Shallow waters crowd the fish, which become inactive as a result. Although inactive, they still place a heavy demand on the oxygen supply, which is typically low because of high temperature. The delicate balance can be strained easily by such environmental factors as a midday shower, wind and wading by livestock.

Muddiness

Sunlight cannot penetrate the water of muddy ponds enough for plants to grow. Without enough plants to consume nutrients, a buildup results. The excess load of nutrients, in combination with seasonal warming trends, spurs the outbreak of microbes. The microbes, in turn, with their accelerated rate of nutrient utilization, consume a great amount of oxygen. In addition, toxic breakdown products such as carbon dioxide, ammonia and nitrite increase the oxygen requirements of fish.

Management

Observation

Learn to detect the warning signs and symptoms of oxygen shortage. Fish gasping at the pond surface during early morning hours definitely suffer from lack of oxygen. Curtailed feeding behavior also is a response to oxygen shortage, as well as disease conditions.

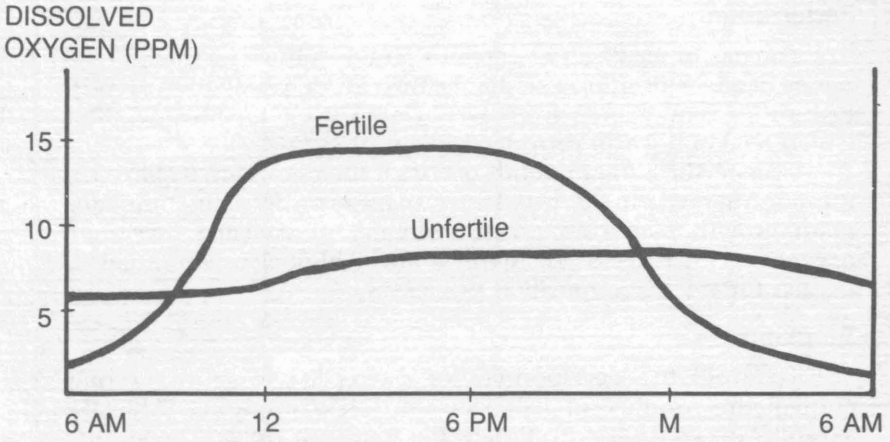
Also watch out for excess plant life. Unusual coloration or sudden changes in pond color are indications of a heavy algal bloom or die-off. Developing an eye for changes in water color takes time, but gives you a good way to keep track of plant growth.

That kind of algae is important. A heavy blue-green bloom in summer is a sure sign of approaching trouble. Although all blue-green algae are not distinctly blue-green in color, most of the ones that cause oxygen problems in ponds have that coloration.

Water Testing

Both meters and chemical kits are available for oxygen testing. The meters are more expensive but are more economical in the long run, considering the cumulative cost of chemicals.

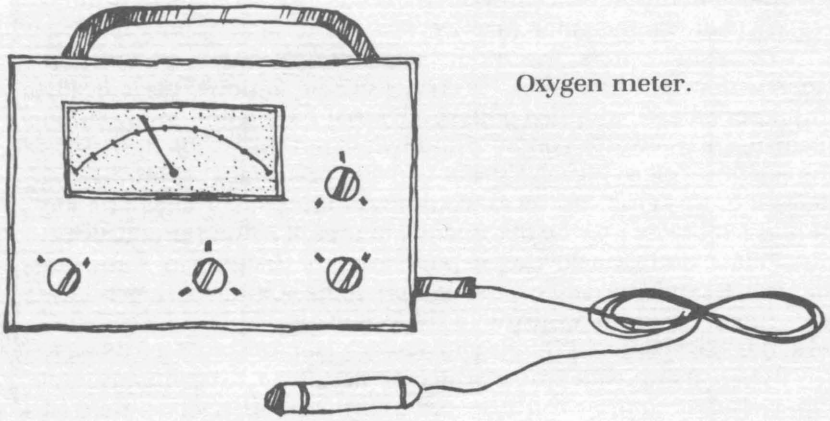
Be sure to test oxygen levels at different depths, from the surface to the bottom of the pond. Take the measurements at dawn during the most oxygen deficient period. As a rule, start corrective measures when the oxygen level falls below 1 ppm at 3 feet. Watch the pond carefully when the oxygen level falls below 2 ppm at 4 feet. At 6 feet, there is no likely danger with an oxygen level of 2



Typical daily cycle of oxygen in summer for fertile and unfertile ponds.

ppm. Interpretation of the test results includes assessment of the readings, as well as the detrimental actions of wind, cloudy days and other environmental conditions.

Oxygen depletions can be more accurately predicted by using oxygen measurements after dark to project value for dawn. Even better predictions may be acquired by comparing Secchi Disk readings with fish weight, temperature and oxygen measurements. An Auburn university publication (Alabama Agricultural Experiment Station Bulletin 505) gives a full explanation.



Oxygen meter.

Fertilization

The use of fertilization depends on the culture method. Unfed ponds need fertilization to enhance the natural production of food. Fed ponds may benefit from fertilization prior to stocking, after which feed and waste provide ample nutrients.

Over-fertilization in ponds occurs if the ponds are fertilized in the summer when there is heavy plant growth. The stimulated plant growth places an excess demand on available oxygen. If organic fertilizer is used, there is an additional requirement of oxygen for the decomposition processes.

Stocking

To avoid the development of excess fish weight, carefully control the number of fish stocked. When cropping fish, take samples periodically to estimate the total fish weight. Be sure to allow an adequate safety margin. Wild fish add an unknown weight factor so try to exclude them from your pond.

Feeding

Just as ponds can be overfertilized, they can be overfed. Fish are normally fed an amount equal to three percent of their body weight, except during hot months. During July, August and September in Texas, use no more than 30 pounds of feed per surface acre. If the fish do not feed, then withhold the daily ration. It is difficult to determine feeding activity with sinking feed so add some floating feed to observe feeding behavior.

Water Replacement

Ponds with a water source that allows a flow-through design maintain higher oxygen levels or larger fish weights during warm weather. Such ponds are often fed because the benefits of fertilizers are reduced by water turnover.

These fed ponds also often have a concentration of nutrient laden water on the bottom. This water can be removed periodically if the ponds are equipped with drains that have a bottom draining feature. Or the water can be siphoned. Often the problem may be the surface micro-algae. A drain capable of surface withdrawal is helpful in this case. However, routine removal of surface plant life in non-fed ponds may be detrimental to overall natural productivity.

Filling and overflowing a pond may be helpful in some instances. It could be dangerous, though, if the volume of flow is low. This might result in a mixing of the water instead of replacement, which is hazardous in ponds with oxygen-poor subsurface waters.

When using well water which is devoid of oxygen, spray or otherwise aerate it as it is released into the pond. Also aerate well

water with a high iron content to satisfy the oxygen demand of the unoxidized iron.

Plant Control

The use of herbicides in pond water may cause a sudden collapse of plant life in the pond and result in oxygen depletion. The risk is greatest in summer and early fall when plant life is heaviest. Spot application of algacides is the most practical method of controllng micro-algae, although spillway removal is sometimes used. Apply the algacide in one part of the pond at a rate that is effective for only that part. For example, attach a cloth bag of copper sulfate near the water surface to a pole which has been driven into the pond bottom. The net result is a partial algae kill. However, such "thinning" of algae with synthetic algacides may cause prolonged oxygen shortages and, consequently, stunted fish growth.

For aquatic weeds, start control measures in the early spring when there is new growth and the water is still cool enough to contain a larger amount of oxygen. Weed control during the summer is risky, unless a partial control method is used.

Oxidation

Certain chemicals such as potassium permanganate are effective in oxidizing organic chemicals. Use them to treat ponds with enrichment problems. The treatment is only preventative, however, and the problem should be corrected with other means. Application of potassium permanganate does not elevate or add oxygen to a pond, it merely reduces the demand by organic chemicals.

Aeration

Constant aeration of ponds maintains the oxygen supply at higher levels. Various commercial devices are available.

Handling

Fish require more oxygen when excited so be sure that they are handled in water with adequate oxygen levels. Over 5 ppm is sufficient for warmwater fish.

Harvesting

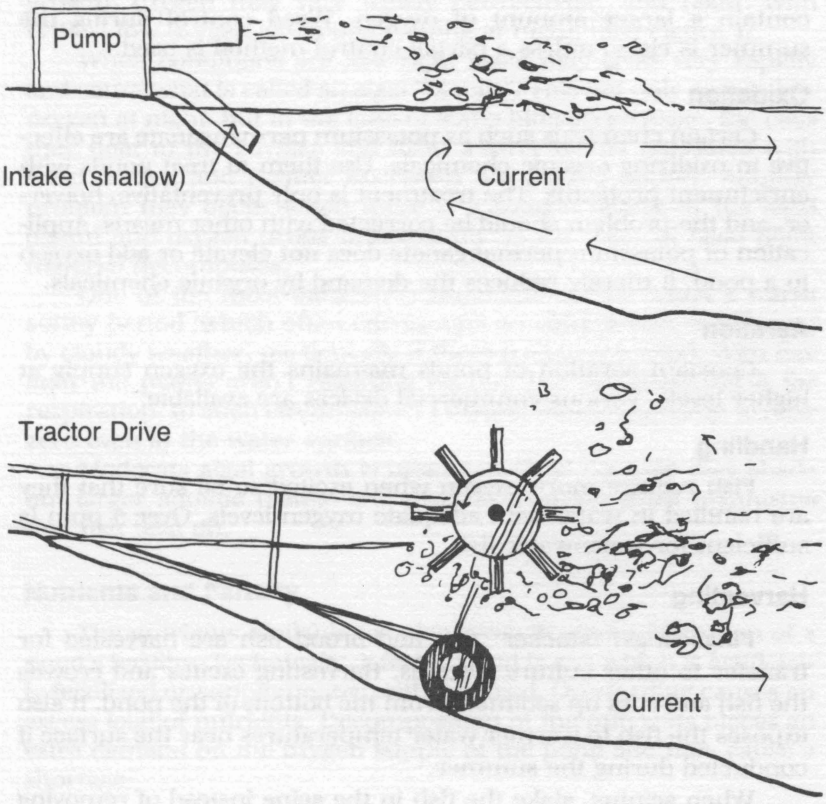
Fingerlings, "stocker" fish and brood fish are harvested for transfer to other culture systems. Harvesting excites and crowds the fish and stirs up sediment from the bottom of the pond. It also exposes the fish to warmer water temperatures near the surface if conducted during the summer.

When seining, stake the fish in the seine instead of removing them at the pond bank. Make the seine haul toward the shore and

then carry the captured fish, as though in a blanket, back into deeper water. There, stake the fish bearing portion of the seine with long rods that have forked ends. Thus, the fish are handled in water with somewhat better quality and circulation than that near the shore. Pump cooler, good-quality water, possibly from an adjacent pond, into the seining and dipping area to help prevent losses.

Catch basins are helpful if fish are harvested by draining a pond. Place a cement box just beneath the drain pipe inside or outside the pond to collect the fish for easy dipping. Circulate good-quality water in the catch basin to provide an adequate oxygen supply.

Emergency aeration devices: pump and paddle-wheel.



Emergency Measures

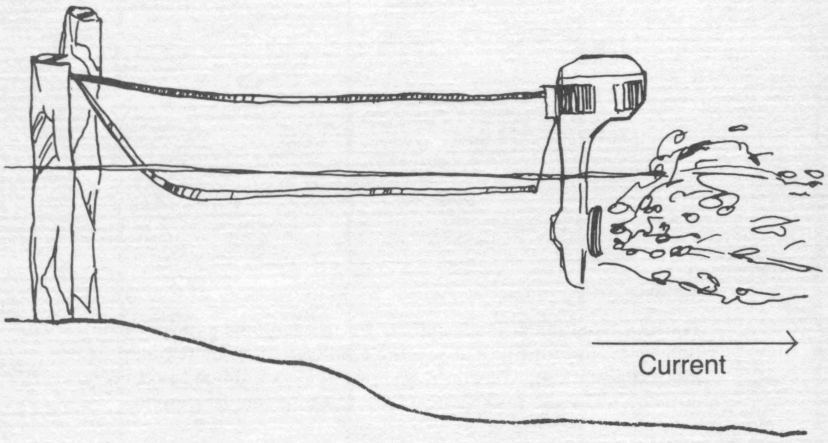
Aeration

Aeration, or exposure of water to air, is the best emergency method for replenishing the oxygen in ponds. Either spray the water into the air or start a current in the pond to cause a continuous upwelling of water to the surface. Use the most powerful equipment available for the best results.

Spraying and current production is used in combination if the water is blown by pump or other device across the pond surface. Spraying alone is not adequate unless a very large volume of water is sprayed. Paddle-wheel style aerators successfully create current and also provide splashing action.

Outboard motors also produce current if run in a fixed position. However, driving a boat in the pond with an outboard in order to stir the water is practically useless.

Fixed Position



Other Measures

Use chemical oxidation only as a preventative since it serves no real need in emergencies. Although phosphate fertilizers promote oxygen production, it is not wise to use them in most cases since the added plant life increases oxygen requirements. Addition of water with normal oxygen levels is helpful if enough volume (several thousand cubic feet per minute) is available.

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