LOW OXYGEN AND POND AERATION

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Water can hold a limited amount of oxygen. That is determined by atmospheric pressure, temperature and salinity. In a natural setting, oxygen is added to water by atmospheric diffusion at the surface, by wind circulation (augmented surface diffusion) and by photosynthesis (oxygen produced by phytoplankton or algae). Photosynthesis accounts for most of the oxygen in water. The oxygen content of water increases with increasing atmospheric pressure and decreasing temperature and salinity. The amount of oxygen in water is measured as milligrams per liter (mg/l) dissolved oxygen (DO).

Oxygen Depletion

A number of conditions may develop which result in oxygen depletion, DO at levels insufficient (less than 3 mg/l) to support aquatic life (e.g. fish). Oxygen depletions are typically associated with:

1. <u>Hot, cloudy, still weather</u> is common from the end of July to the beginning of September. High water temperature (86^o F or greater) reduces oxygen holding capacity. Cloud cover limits available light, slowing or halting photosynthetic oxygen production. No wind stops pond circulation and restricts surface diffusion of atmospheric oxygen.

Warm water increases fish consumption of oxygen by accelerating their metabolic rate. Fish are ectotherms (cold blooded); therefore, body temperature and activities are regulated by water temperature. Fish biomass (total weight in pond) and oxygen needs are usually greatest during the hot months of late summer.

2. <u>Sudden death of phytoplankton or algal bloom, "bloom crash</u>", may result from insufficient light (e.g. cloud cover) for photosynthesis, inadequate pond nutrients (a bloom too dense to be supported by available nutrients and oxygen) and/or bloom senescence (the plant cell line becomes too old to continue reproduction). Oxygen is consumed or depleted when dead phytoplankton/algae decay. During the nighttime hours, a dense phytoplankton bloom can remove all oxygen from the water for respiration (to breathe) alone. When a bloom crash occurs, the water appears to have become "black" or clear overnight.

3. <u>Pond stratification or turnover</u>. During summer months in deep ponds (8 feet or greater), the upper 4-6 feet of the water column warms quickly and becomes less dense or lighter than deep water. Because the upper layer is warmer and lighter, it does not mix with the cool, deep water. The cool water near the bottom becomes stagnant; oxygen is depleted and toxic compounds may be produced by bacteria and decaying organic matter. The deep layer remains unoxygenated (anoxic) because of stratification (layering). A sudden, heavy rain (2-3 inches or greater) or a strong cold front ("Blue Norther") can rapidly cool and/or mix (wind turbulence) the upper layer. The now cooler or circulating upper layer sinks or mixes and causes the deep anoxic layer to rise above or combine with the surface water. That depletes or reduces oxygen in upper waters where fish are being cultured.

4. Organic waste decomposition. When fish biomass becomes large in commercial ponds (late summer), waste and organic loads (ammonia, nitrite, feces and uneaten feed) can become high. Wastes and organics will decompose. That requires oxygen, often more than is available in pond water. Also, high waste loads can stimulate an algal bloom too dense to be supported by the pond (discussed above).

These situations can occur alone or in interrelated combinations. As just discussed, conditions may develop which remove oxygen from water faster than natural processes can replace it. When they occur, emergency or supplemental aeration may be required to bring oxygen back up to tolerable (3-5 mg/l) or safe (5 mg/l or greater) levels.

Aeration Equipment

Electric or mechanical aeration is used to place as much oxygen into contact with water as economically practical. That is normally accomplished by mixing large quantities of water (both volume and total surface area) with atmospheric oxygen. Several aeration devices are commercially available. Most aeration equipment requires electricity (preferably, three phase or 230 volt) or fuel powered engines (tractors or pumps) at the pond bank. Boyd and Ahmad (Auburn University); and Engle (University of Arkansas, Pine Bluff) and Hatch (Auburn University) have conducted individual studies rating pond aerators for performance and economic efficiencies, respectively. The following is a general summary that rates existing aeration equipment from highest to lowest efficiency, both performance and economics:

1. Electric paddle wheel aerators. A paddle wheel similar to that of the old river boat circulates and mixes pond water. An electric motor powers the device. These aerators can supply 1.8-4.9 pounds of oxygen/horsepower-hour (lb O_2/hp-hr). Most models will supply from 3.5-4.9 lb O_2/hp-hr. A tractor operated paddle wheel is effective for emergency situations but is not practical for supplemental or continuous operation.

2. Electric pump-sprayer aerators. Large volumes of water are pumped or sprayed over the pond surface. These aerators can supply 1.5-3.2 lb O_2/hp-hr. While tractor and engine powered versions of these devices are effective, as above, they are only practical for emergency aeration.

3. Electric propeller aspirator pump aerators. Water is pumped to the surface and mixed with air by propeller blades. These aerators can supply 2.1-3.1 lb O_2/hp-hr.

4. Experimental aerators. A number of experimental aerators are currently being developed; some of which may or may not be cost effective. One promising design is the airlift aerator. Air bubbles produced by a centrifugal air blower (electric) act as pneumatic pistons; pushing or drawing water up a pipe or stack as they rise and expand. Field studies demonstrated that a 1 hp blower can pump approximately 750-820 gallons per minute to the surface using individual 3-4 inch diameter PVC pipes. Extensive field trials and economic analyses will be needed to test the practicality of experimental equipment.

Aeration Methods

Recent work suggests 1.0 hp of mechanical aeration should be available for each 22 lb of feed/acre (4 acre-feet) fed per day for intensive aquaculture. Aeration equipment should be placed along the longest pond bank. Aerators should be started before DO falls below 3 mg/l. Oxygen levels are lowest just before sunrise each morning. If affordable and as a preventive measure, aerators should be operated at night during prolonged periods (2-3 days or longer) of cloudy, hot or rainy weather; immediately preceding and throughout a sudden cold front passage; and when dense phytoplankton or algal blooms have developed.

1. **Emergency** -- aerators are operated temporarily when oxygen falls to or below 3 mg/l, during a crisis. Tractor powered paddle wheels or irrigation pumps are typically used. Aeration is continued until oxygen levels have stabilized at 5 mg/l or higher.

2. **Supplemental** -- aerators are operated whenever conditions leading to oxygen depletion have developed, or nightly during the last 2-3 months of the season. Aerators are turned on between 10:00 pm-midnight and left running until 10:00 am the next morning or until oxygen levels have stabilized at 5 mg/l or higher. Supplemental aeration is recommended for intensive production densities above 2,000 lbs/acre.

3. **Continuous** -- aeration equipment is operated continuously (24 hours daily). Some producers manage highly intensive fish farms (greater than 5,000 lbs/acre) and run electric aerators continuously from July to the end of September or until water temperatures have dropped to 68-65^{o} F and are falling. The economics of that practice should be carefully evaluated.

The best way to deal with low oxygen is to take action before a problem develops, good management. If budget constraints prohibit purchase of aeration equipment, **no more than 2,000 fish** should be stocked per acre. And no more than 25-30 lb of feed/acre should be offered without aeration. Proper aeration can significantly increase the quantity of fish that may be produced commercially in 4 acre-feet of water.