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Aeration: O_2 introduction methods

The most important water quality parameter when raising fish is dissolved oxygen (DO). Oxygen (O_2) is essential to the metabolism of all aerobic (air breathing) aquatic organisms. We've all seen enough dead fish and struggling bodies of water to know the importance of monitoring dissolved oxygen levels and improving those amounts through the use of aeration devices. This column will describe the most common methods for introducing oxygen.

The units of measurement for dissolved oxygen levels in water are parts per million (PPM) or milligrams per liter (mg/l). Both can be used interchangeably and basically mean the same thing.

The air we breath is 20.9% oxygen with the balance mostly consisting of nitrogen. The minimal amount of oxygen that is measurable and needed to support aquatic life, such as the 5 PPM for coldwater species, is like a drop of food coloring in a 55-gallon drum so we are not talking about a huge concentration.

Initial dissolved oxygen levels, barometric pressure, altitude, salinity, and water purity affect the amount of naturally occurring dissolved oxygen in water.

Saturation level is what I'll term the dissolved oxygen holding capacity of water. For all practical purposes, it is a function of temperature, altitude, and salinity. Colder water, for example, holds more oxygen than warm. Water in higher elevations or with higher salinity levels has a decreased saturation level of oxygen.

Bob Robinson photo

Fish kill that is the result of a pond turnover.

Once you reach the saturation level more oxygen cannot be added without the help of photosynthetic plant activity or introduction of pure oxygen from a pure oxygen producing devise.

In nature oxygen is produced in water by: 1) Wind. 2) Diffusion at the air/water interface. 3) Photosynthesis from aquatic plants.

In ponds, the introduction of oxygen via some type of aeration device can:

- Allow for greater densities of fish.
- Eliminate the potential for a spring or fall turnover.
- Prevent winter kills caused by low oxygen levels.
- Improve overall water quality.
- Speed up the rate of organic decomposition of the bottom muck.
- Reduce the amount of phosphorus, which might otherwise be available for plant growth.
- Thermally and chemically destratify the water.
- Cause circulation currents that might create favorable conditions for more desirable algae to outcompete blue green algae.
- Cause algae blooms and die-offs to be less severe. And,
- Shift the level of carbon dioxide by venting it into the air, which could limit the amount available for plants.

Continued on next page

Bob Robinson

FROM THE FIELD

Horizontal aspirators.

Diffused air keeps an area ice-free for winter-kill prevention as well as refuge.

Cones which supersaturate the water with oxygen via pressure.

Bob Robinson photos

A shift in pH might result and potentially shift in favor of more desirable algae.

In tanks, the primary goal of introduction of oxygen via aerators or pure oxygen is to be able to increase fish density.

Different species of fish require different levels of oxygen, as seen below.

SPECIES	LETHAL LEVELS OF DO	MINIMAL LEVELS OF DO
Coldwater	2-3 PPM	5 PPM
Cool water	2 PPM	4 PPM
Warmwater	0.5-1 PPM	2-3 PPM

Oxygen consumption as it relates to fish size and species are seen below:

SPECIES	Oxygen consumption rate (pounds O_2 per 100 pounds of fish per hour)
Coldwater/Adult	.02
Coldwater/Juvenile	.03
Cool water/Adult	.025
Cool water/Juvenile	.035
Warmwater/Adult	.03
Warmwater/Juvenile	.05

The above numbers are averages and can increase directly after feeding, grading, moving, and general fish stress.

Aeration devices

There are many different types of methods to introduce oxygen into water. Most manufacturers have tested their units for efficiency under standard conditions.

One test gives the result as the Standard Oxygen Transfer Rate or SOTR. The unit of measurement is kilograms or pounds of 0_2 per hour.

Another measure is standard aeration efficiency or SAE, which is the SOTR divided by power. The resulting measurement is pounds of 0_2 per horsepower per hour.

It is unrealistic to be able to take the SAE rate and apply it to pond situations because there are many other oxygen consumers in ponds besides the fish. Quite frankly these numbers should be viewed more from a standpoint of the relative efficiencies of each device. There will also have to be some seat of the pants experimentation to figure out what works best for your application.

The following are the most common methods for introducing oxygen. Each description includes the advantages (+) and drawbacks (•) of each method.

FAR LEFT: Raceway system that picks up oxygen via 18" drops at every section.

DIFFUSED AIR (SAE rates of 1.0–4.0 depending on who you believe): This type of aeration will typically employ either a compressor or blower. A simple way of keeping track of what is what is that a blower is high in volume of air produced but cannot pump air very deep. A compressor is low in air volume but can push air much deeper.

In deep ponds a compressor with a diffuser assembly can be very effective at moving the water and transferring oxygen at the air/water interface. In a tank or raceway situation many small diffusers can be employed.

+ Most efficient for deeper ponds.
+ No electricity in the water.
• Tanks require main header line of PVC pipe.
• Not very portable.
• Not great for emergencies.

FOUNTAIN TYPE (SAE rates of 1.5–2.5): These units shall be defined as any device that splashes water into the air to create an aesthetically pleasing display.

+ Can have a pretty looking display device and get some aeration benefit for a dual-purpose unit.
+ Works fairly well in small ponds that a relatively shallow.
+ Very good at venting off gases.
• Typically will only draw water from the surface to less than 10'.
• Energy is wasted to create an aesthetically pleasing display.

WIND AERATORS/CIRCULATORS (SAE rate is not calculated because no electricity is used): Wind power units will either drive a small compressor that pushes air to a diffuser or will be connected to some type of paddle that enters the water and moves as the wind blows.

+ No electricity is required.
• Will not work in no-wind conditions.
• They are not portable.
• Will not work when they are needed the most (in the lazy hazy days of late summer with little to no wind and overcast skies).

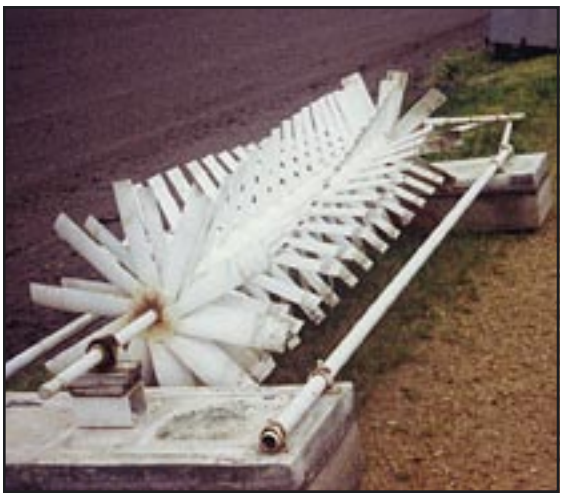
VERTICAL PUMP SURFACE AGITATORS (SAE rates of 2.6–3.2): These units will employ a float, motor, and prop to splash water at the surface.

+ Ideal for smaller ponds.
+ Fairly decent oxygen transfer rate.
+ Portable and lightweight
• Not very efficient at moving water at depths great than 8'-10'.

PADDLEWHEELS (SAE rates of 2.5–4.0): Paddlewheels have come a long way in the past 10 years. They used to be available only with a set of paddles on either side of a shaft. That design had inherent problems. The constant plunk-plunk of the paddles would cause the gearboxes from the motor to wear prematurely.

Recent design developments have made some paddlewheels more efficient and eliminated the gearbox problem.

Paddlewheel with spiraling blades.



Horizontal prop unit.

Bob Robinson photos

Blades have been designed to spiral around the shaft from one end to another. When one blade spins out of the water a blade on the opposite side is there to stabilize the thrust so that wear and tear on the shaft and gearbox is minimized.

A note of caution when buying an imported product. Most imported motors have a spline shaft that does not match the shaft of American-made motors. So when purchasing imported make sure that the gearbox will accept American shafts or order extra motors.

+ Most efficient surface aerator.
+ Can cause directional flow while aerating.
• Will not be efficient in deeper ponds.
• Units are typically bulky and not very portable.

LEFT: Windmill connected to an air pump.
BELOW: Fountain working as an aerator.

HORIZONTAL ASPIRATORS (SAE rates of 1.8–2.3): These units employ an above water level motor, extended shaft, propeller, and draft tube to suck in air. They can be adjusted to point the propeller to an angle of anywhere from about 20° to 50° from horizontal.

+ Great choice for causing directional flow to address dead spots.
+ The ability to angle the prop down into the water makes these units more effective at moving water in deeper ponds.
• Oxygen transfer is not quite as good as others are.
• Some units have premature failure in the area of the extended shaft.

HORIZONTAL PROP UNITS (SAE estimated rates 1.5–2.5): These units operate similar to aspirators without the extended shaft nor do they suck air. You can position them to point in any direction and angle them similar to an aspirator.

+ Excellent for causing water movement.
+ Great for keeping ice off of ponds and preventing winter kills.
+ Can be mounted at variable water depths.
• Not the greatest in terms of oxygen transfer.

PUMPING OR CASCADING WATER: (SAE rates vary): If water already has to be moved through filters in tank systems you might as well splash it to take advantage of oxygen transfer from air/water contact.

Raceways have been designed to use gravity and at least 18" of fall between raceways to pick up oxygen as the water drops from one unit to the next. The best thing is the aeration is free.

PURE OXYGEN: Pure oxygen is typically added to high-density culture systems.

This can be accomplished via an oxygen generator as well as though purchasing oxygen in cylinders.

If the concentration of oxygen is close to the saturation level this is the best method to add more oxygen.

Typically the driving force to add oxygen in this type of system is pressure. All gases follow the law of partial pressure, which basically states that as pressure increases gases dissolve easier into solution. It is for this reason that adding air into a pressurized vessel is not a good idea.

Since air is 79% nitrogen, nitrogen supersaturation can result and cause fish stress or mortality analogous to humans getting the "bends."

When purchasing aeration the following criteria should be used:

● Minimal maintenance.
● Safety.
● Simple.
● Lead-time from supplier.
● Technical support and sizing CORRECT assistance. And
● Cost- both initial and electrical.

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Vertical pump agitator in a trout pond.

Group of diffusers held up off the bottom by one-gallon jugs. Air comes from a blower.

Bob Robinson photos