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Importance Of Dissolved Oxygen In Aquaculture Pond

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Introduction

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. Oxygen remains in water in dissolved form as dissolved oxygen (DO) Dissolved oxygen (DO) concentration is the most important and critical water quality parameter because of its direct effect on the feed consumption and metabolism of aquatic animals as well as indirect influence on the water quality. Aquatic animals and organisms in water require oxygen for respiration and other biological activities. One can expect that a decrease in the rate of the oxygen production by phytoplankton may have catastrophic consequences for life on earth, possibly resulting in mass extinction of organisms. Besides having capabilities to produce oxygen, planktonic community also depends on the oxygen availability and its confounding factors. Phytoplankton produces oxygen due to photosynthesis during the day, but consumes it through respiration during the night.

Oxygen consumption by plankton is a function of DO levels that depends on temperature. The DO of water increases with increasing atmospheric pressure while it decreases as the temperature and salinity increases. In warm water with increasing temperature, oxygen depletion may arise because of a simple physical property of water. The warmer the water, the less dissolved oxygen it can hold. Salinity is also an important factor in determining the amount of oxygen a body of water can hold; fresh water can absorb more oxygen than

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saltwater.

How Dissolved Oxygen (DO) is expressed ?

Dissolved oxygen concentration levels may be expressed as milligrams per liter (mg/L) or parts per million (ppm). Dissolved oxygen saturation is expressed as a percentage.

Source of DO in aquatic environment

There are three main sources of oxygen in the aquatic environment:

1. Direct diffusion from the atmosphere;
2. Wind and wave action; and
3. Photosynthesis.

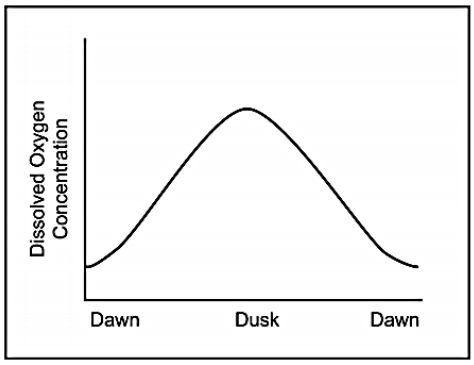

Figure 1: Dissolved oxygen concentration in ponds fluctuates on a 24-hour basis.

Source: Ruth Francis-Floyd, 2011

The most significant of these is photosynthesis by aquatic plants and phytoplankton. Photosynthesis produces oxygen during the day when sunlight falls on the plants in the water. The respiration of plants and animals, including fish, causes oxygen levels to fall at night. These regular changes in DO level that occur every 24 hours are called the diurnal oxygen cycle. (Ruth Francis-Floyd, 2011)

Optimum Level:

Smaller fish use more oxygen per unit weight than larger fish of the same species. Swingle (1969) found that warm water fish in ponds died after being exposed to less than 0.3 mg/L DO for a short period of time. A minimum of 1.0 mg/L is required to maintain life for many hours, while 1.5 mg/L is needed to support fish over several days. Warm-water species are often more tolerant of low D.O. concentrations. However, a DO level of 5 mg/L DO is regarded to be the bare minimum that must be maintained in order to achieve optimal fish growth in warm waters.

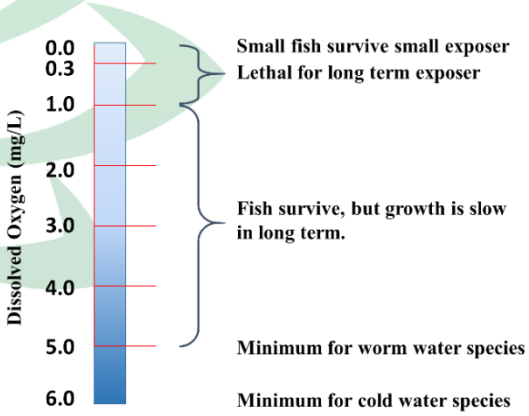

Figure 2: Modified After Swingle, 1969.

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Dissolved oxygen relation with water quality parameters:

Two water bodies that are both completely air-saturated may not always contain the same levels of dissolved oxygen. Temperature, pressure, and salinity all influence the quantity of dissolved oxygen (in mg/L). Dissolved oxygen has an inverse relationship with temperature and salinity, and a direct relationship with partial pressure over the water. Also DO drops when air pressure and humidity decrease.

Understanding Dissolved Oxygen and why does it is important in Aquaculture?

It's common knowledge that oxygen is essential to terrestrial life, but it also plays a key role in underwater ecosystems. Despite the fact that fish don't have lungs, they still require asmall amount of oxygen in order to breathe and carry out essential functions. They access the oxygen they need to survive via the water around them, in a form known as dissolved oxygen, or DO.

Whereas plants that float on the water's surface will release oxygen into the atmosphere, aquatic plants, kelp, and algae that exist at lower depths have adapted to use a miniscule amount of sunlight to conduct photosynthesis at greater depths. Oxygen is released into the water by these deep-water organisms. It is also diffused into the water from the atmosphere at the water's surface.

The total amount of oxygen in the ocean and other natural water sources is much less than the amount in the atmosphere and is typically measured in parts per million (ppm). Most fish require DO levels of just 5 ppm or greater in order to survive. That said, larger fish need more oxygen than smaller fish and DO levels can vary within a single aquatic environment based on the volume and type of plant and animal species present. For example, the suitable DO level for shrimp culture is 3 mg/l. However, values higher than 5 mg/l are recommended for intensive aquaculture practices.

Although 5 ppm does not seem like much, the effects of DO depletion can be severe. Fish that don't have adequate oxygen resources are more prone to disease and infection, are less efficient at converting food into energy, and experience stunted growth. If oxygen levels fall below a certain threshold, they will eventually die. Extremely high levels of DO usually result from

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photosynthesis by a large amount of plants. Substantial uncontrolled plant growth, especially algal bloom, is often the result of fertilizer runoff, and can also have an adverse effect on aquaculture.

Causes of Low DO in Water

There are many causes of low DO levels in water. In aquaculture, the most common cause of low DO is overstocking or overfeeding fish in an underwater enclosure or tank. Fish need oxygen to process the food they eat into fuel, so more fish and more food inevitably means that there's more oxygen being consumed on a daily basis. If oxygen isn't being adequately replenished at the water's surface or by photosynthesizing organisms, DO levels will tailspin. For this reason, many aquaculture facilities will introduce photosynthesizing aquatic organisms into a farming environment to help sustain adequate DO levels for larger fish populations.

Another common cause of depleted DO levels is zooplankton booms and phytoplankton crashes. Whereas phytoplankton is a photosynthesizing species that creates oxygen, zooplankton are respirating organisms that subsist largely on phytoplankton and are known to increase rapidly during phytoplankton blooms. By consuming phytoplankton and using DO to respirate and convert food into energy, an overpopulation of zooplankton can cause a depletion in the amount of DO available to other organisms in the same aquatic environment.

Phytoplankton crashes can be caused by other natural factors as well. For example, a sustained lack of sunlight and wind due to clouds or other obstructions can inhibit photosynthesis, killing off phytoplankton species and depleting DO levels.

DO levels can also be influenced by pH . Any changes to the pH value of water can affect how much DO the water can hold and transport. As you attempt to uncover the reason for changes in DO, take frequent pH readings to determine if the two metrics are connected.

The signs fish exhibit to low DO

- Loss of appetite
- Lethargy

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- Gasping near the surface
- Fish facing into current of inlet or aerator
- Death of larger fish, followed by smaller fish.

Effects of low DO

- Stress increased susceptibility to disease.
- Poor feed conversion efficiency.
- Poor growth.
- Death of fish and other pond organisms.

Monitoring DO Levels

Aquaculturists and fish owners should monitor DO levels on a routine basis using a portable or inline DO controllers, transmitters, or analyzers. By tracking changes in DO levels, you can identify when DO is getting dangerously low and make adjustments to your aquatic environment to increase the amount of oxygen present.

Increasing DO in Water

If your water quality monitor reveals low DO, there are varieties of things you can do to boost DO levels in your aquatic environment.

They include:In a situation of low DO following can be done to manage DO level:

- Aerating the water more frequently or aggressively using artificial aeration devices.
- Spraying water across the surface of your enclosure or tank to increase surface-level oxygen diffusion.
- Replacing the water in your environment with new water with a higher DO level.
- Introducing (controlled) photosynthesizing species into the environment to boost oxygen creation.
- Limiting feeding to reduce the amount of oxygen used.
- Removing dead organisms and plants that are being aerobically decomposed.

Pond design layout to increase DO in water naturally:

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In the design of pond layout, it is essential to consider maximal utilization of the natural environment to maintain higher dissolved oxygen content in pond water such as:

- Orientation of the long axis of the pond with the prevailing wind.
- Construction of larger pond to allow a greater contact of water surface with atmospheric air.
- Promote wind action on the pond in facilitating water movement and oxygen diffusion.
- Avoid planting of trees on dikes (Kungvankij et al. 1986)

Conclusion

Dissolved oxygen (DO) is one of the most important indicators of water quality in fish farming. It is essential for the survival of fish and other aquatic organisms. Oxygen dissolves in surface water due to the aerating action of winds. When dissolved oxygen becomes too low, fish and other aquatic organisms cannot survive. So farmers are suggested to maintain dissolved oxygen optimum levels (3-5 ppm).In cloudy days or winter season dissolved oxygen fall down due to lack of sunlight, in such cases farmers are advised to pump fresh water continuously or else use aerators as recommended by the fishery experts.

Reference

- Boyd, C.E., Watten, B.J., 1989. Aeration systems in aquaculture. Rev. Aquat. Sci. 1, 425–472.
- Boyd, C.E., Teichert-Coddington, D., 1992. Relationship between wind speed and reaeration in small aquaculture ponds. Aquac. Eng. 11, 121–131.
- Swingle, H.S. 1969. Methods of analysis for waters, organic matter and pond bottom soilsused in fisheries research. Auburn, USA, Auburn University.
- Kungvankij, P., Chua, T. E., Pudadera Jr, B. J., Corre, K. G., Borlongan, E., Tiro Jr, L. B., ... & Talean, G. A. (1986). Shrimp culture: pond design, operation and management.. http://www.fao.org/3/ac210e/AC210E09.htm

- Francis-Floyd, R. (2011). Dissolved oxygen for fish production. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS.http://agrilife.org/fisheries2/files/2013/09/Dissolved-Oxygen-for-Fish-Production1.pdf