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Success Story

Aquaculture pond water aeration system

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Introduction

Dissolved oxygen DO concentration is one of the most important water quality parameters affecting the quality of wastewater and aquaculture pond water. Various types of aeration systems have been developed over the years to maintain the desired level of DO concentration in the wastewater in an effort to improve the energy efficiency of the oxygen mass transfer process**.** In intensive aquaculture system increased fertilization, excessive feeding and high stocking density the natural aeration is insufficient and will be a limiting factor for production. Therefore, artificial aeration is very much essential for survival of intensively cultured aquatic flora and fauna. It is estimated that additional 500 kg of fish production can be achieved per kW of aeration. Aeration cost is the third largest cost in intensive aquaculture system after post larvae and feed cost representing about 15% of total production cost (Kumar *et al*., 2013). The selected aerator must be economically efficient and should be able to fulfill the requirement of oxygen supply in the pond water. Aerators contributes significant amount in the total production cost in intensive aquaculture. Mechanical Aeration enhances water quality and also improves the aqua-cultural yield. It also reduces the settlement of feed at the bottom of the pond. Dissolved oxygen (DO) is one of the most important water quality parameters affecting the quality of aquaculture water. Oxygen enters into the water body by absorption from the atmosphere or by plant photosynthesis. It is removed by respiration of organisms and decomposition of organic matter. The DO level of culture environment has direct influences on species growth fertility, survival rate, feed intake and digestion Drop in the DO level below the critical level can induce stress for aquacultural species. The growth of algae and bacteria also consume oxygen which also results in the reduction of DO level. The purpose of artificial aeration is to maintain the amount of oxygen level (DO) in aquaculture system within the permissible limit (6-8 mg/L). Aeration will also destroy the formation of any vertical temperature, salinity and chemical stratification by proper circulation and mixing of the pond water.

Aeration

The process of mixing air with water to increase the DO content in the pond water is known as aeration. The shortage of dissolved oxygen in water can be prevented by circulation of mechanical means, this is called as mechanical aeration. As mentioned initially, water aeration is the net movement of oxygen from atmosphere with higher pressure into the surface water. To keep the aquatic environment safely, the aeration equipment becomes the prior device, the aeration is significant to minimize the stress associated with oxygen concentration lower than 4 ppm. It functions to increase the area of contact between air and water, so that oxygen can enter into water surface. They also detailed that the aerator function is similar as the 'lung' to driving oxygen into water, stripping carbon dioxide out particularly for intensive aquaculture pond.

Principles of aeration

Aerating an aquaculture pond water basically involves transferring gaseous oxygen from the large reservoir in the atmosphere into the water of the pond, where DO concentrations have dropped to critical levels. Aerators help to mix pond water which can reduce thermal stratification and improve other water chemistry factors, most notably DO content. Finally, mixing by aeration can minimize organic matter accumulation that may increase BOD, reduce the density of algal blooms that can lead to oxygen depletion and fish health issues and shift the composition of algae blooms that may lead to flavor issues in finfish.

Types of pond aerator

Aeration is not new to aquaculture, but over the past few years interest in this process has been increased enormously. Various types of aerator systems have been developed over the years as an effort to improve energy efficiency of oxygen mass transfer process and to maintain the desired level of dissolved oxygen in wastewater. The types of aerator technique can be classified in three types (Thakre *et al*., 2008)

1. Surface or mechanical aeration method, which increase interfacial area by spraying water droplet into the air.
2. Diffuser aeration method, which release bubble beneath the surface of water.
3. Combine and turbine aeration method, which introduced larger air bubble into the water and reduce their sizes mechanically.

Paddle wheel Aerators

Paddle wheel aerators are the most broadly used method of aeration. These aerators consist

of an arrangement of paddles attached to a rotating drum or shaft. The pattern, length and shape of the paddles affect the aeration efficiency of the unit. They are considered as one of the most energy efficient device for increasing dissolved oxygen. They splash water into the air as the paddle wheel rotates. The splashed water comes in contact with air and falls back into the pond and thereby increasing the dissolved oxygen. Besides increasing the dissolved oxygen, they also increase both horizontal and vertical movement of pond water. The combined effect of strong circulation and aeration allows the formation of the important oxidized surface sediment layer.

Diffused-air aeration systems

Diffused-air aeration system use air compressors or blower to supply air and diffusers, porous pipe or other devices to release air bubbles into the water. Glass-bonded and silica stones are the most commonly used diffusers, however these diffusers constructed of porous plastic, synthetic perforated membranes and ceramic are also used. These are available in various shape and size such as rectangular or square stones, round or square disks or elongated tubes and pipes. The efficiency of diffused-air aeration systems is primarily a function of bubble size and diffuser depth. Diffusers that produce smaller bubbles, commonly known as fine-pore diffusers, are more efficient than diffusers that produce large or coarse bubbles. Because smaller bubbles have more surface area relative to their volume, which facilitates more efficient oxygen transfer. When the bubbles are released at a greater depth, these deeper release points allow more contact time for the bubbles to diffuse oxygen into the water column as they rise to the surface.

Propeller-Diffuser Aerators

Propeller-Diffuser Aerators also referred as Propeller-Aspirator Pumps consists of a submerged impeller-diffuser mounted on a rotating shaft contained within a hollow housing. The rotating shaft is connected to an electric motor that spins the shaft at speed up to 3,450 rpm. These are good circulators and aerators in pond but they designed more for deeper water (1-5 meter). When these are used in shallow ponds, they have a tendency to scour the basins where the water stream collides with the pond bottom, so consideration must be taken when it installed.

Vertical pump aerators

Vertical pump aerators also known as impeller aerators, consists of an electric motor with either a single or dual impeller attached to the motor shaft. These aerators are manufactured in size ranges from 1kW to over 100 kW, but those used for aquaculture are rarely larger than 3Kw.Typically, these entire unit is suspended just below the surface of the water by a float. The

float must have two anchor points to keep the unit in place and prevent rotation of the unit during operation.

Gravity Aerators

Gravity aerators are also known as waterfall aerators or cascades. These aerators utilize the energy released when water loses altitude to transfer oxygen. Gravity fall is the simplest way to aerate in flowing water aquaculture system if a sufficient gradient exists. Man-made gravity aerators consist of weirs, splashboards, lattices and screens. Transfer efficiencies of 1.2 - 2.3 kg O_2/kWh^{-1} are under possible standard conditions.

Aerator placement

Proper placement of aerator in ponds play a significant role in efficient mixing of water throughout ponds. If water mixing is important, aerators should be placed where they will improve pond water circulation patterns. For example, water circulation in large, rectangular ponds is optimized by placing paddle wheel aerators off the bank near the middle of the longer axis of the pond to direct currents across the short axis. Another factor that influences the efficiency of an aeration system is the placement of the aerators within the pond, relative to both the type of aerator used as well as the need for aeration. All aerators provide some level of water circulation within the pond. Depending on the type of aerator, this circulation can be primarily oriented horizontally or vertically to the pond surface. If the long axis of a pond is oriented along the direction of prevailing winds, locating aerators to take advantage of wind-driven currents will help to distribute oxygenated water and will improve circulation as well as transfer efficiency.

How much to aerate

In commercial fishponds, aeration is commonly about 1.5 to 2 hp/acre in each pond. For example, two 20-hp electric paddlewheel aerators may be used in a 20 to 30/ acre pond. Clearly, mechanical aeration at 1 to 2 hp/acre will not improve the dissolved oxygen concentration in the entire pond, but is used only to provide a small refuge of aerated water near the aerator. When dissolved oxygen concentrations are low, fish congregate in that area and remain there until oxygen conditions improve throughout the pond.

When to aerate

The need to aerate varies seasonally because water temperature affects the rates of respiration and photosynthesis. Problems with low dissolved oxygen concentrations are rare when water temperature is consistently below 15 °C. Problems are common when water temperature is above 27 °C. Local climates and unseasonable temperatures will, however, alter the need to aerate

ponds. Episodes of low dissolved oxygen concentration usually occur at night during the summer. Note, however, that the duration of aeration varies greatly among ponds on a given day. Some ponds may need no aeration, while others require continuous aeration throughout the day. The length of time aeration is used also depends on weather conditions. For example, during periods of warm, cloudy weather most ponds may need continuous aeration for several days.

Conclusion

Aeration will affect directly the dissolved oxygen level in the pond water and sediments. The result is improved soil conditions and improved water quality. Circulation, on the other hand, results in temperature destratification, uniform mixing of DO from surface to bottom, reduction of the thickness of the pond bottom sediment layer, improvement of water quality, and increase of the available habitat for aquatic animals. These benefits translate to healthier animals, larger animals, higher production, higher selling price, higher quality product, and increased profits.

References

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