Aeration, Filtration and Disinfection in Mariculture

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Aeration

Among various water quality parameters for a successful aquaculture practice, Dissolved oxygen content in the water is one of the most important parameters, as the oxygen is a vital for all the organisms living in the water and having an aerobic type of respiration. The purpose of aeration is to increase the concentration of oxygen in the water. In scientific aquaculture practices, this is more critical because, often the rate of consumption of oxygen is much higher than the natural rate of replenishment of oxygen in the water through diffusion from atmosphere and photosynthesis of aquatic plants. Oxygen is one environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. Oxygen affects the solubility and availability of many nutrients. Low levels of dissolved oxygen can cause changes in oxidation state of substances from the oxidized to the reduced form. Lack of dissolved oxygen can be directly harmful to culture organisms or cause a substantial increase in the level of toxic metabolites. It is therefore important to continuously maintain dissolved oxygen at optimum levels of above 3.5 ppm.

Dissolved oxygen is measured either in mg per litre (mgl^{-1}) or parts per million (ppm) with 0 ppm representing total oxygen depletion and 15 ppm representing the maximum or saturation. The solubility of oxygen is influenced by several factors. The solubility of oxygen decreases as the temperature increases; decreases exponentially with increase in salinity; decreases with lower atmospheric pressure and higher humidity and increases with depth. Water temperature is the main limiting factor in aquaculture farms. Oxygen from atmosphere enters the water naturally through air/water interface. This process is enhanced by wind action which creates a mild turbulence at the water surface.

Need for artificial aeration in culture system

- Rise in atmospheric temperature causes an increase in the rate of biological degradation of organic matter and subsequent depletion of oxygen concentration in water.
- Prolonged cloudy conditions causes reduction in the photosynthetic activity by green plants in ponds results in reduction in oxygen concentration.

- Increased stocking rate of animals in semi intensive and intensive farming practices requires greater amount of oxygen for respiration for all aquatic organisms results in depletion of oxygen concentration in water.
- Aeration in ponds helps in mixing and circulation of pond water. Mixing and circulation is more critical in scientific farming which also helps in feed distribution and waste disposal.

Aerators

Aerators are mechanical devices which increases the dissolved oxygen content of the water. Aerators utilizes the energy input to increases the surface area of water available for oxygen transfer andmix water with oxygen to ensure the liquid medium with of oxygen concentration is brought in contact with oxygen or air.

Oxygen Transfer Process

Three steps are involved in the transfer process of oxygen into water

a. Transfer of oxygen in the gas to gas liquid interface

b. Transfer across the gas liquid interface

c. Transfer of oxygen away from the interface into the liquid

Types of aerators

Different types of aerators used in aquaculture are

1. *Gravity aerator*: In gravity aerators, the water falls under gravity and air is mixed into it from the surrounding atmosphere. They can man made or natural.
2. *Surface aerator*: this type of aerators are commonly used on ponds and can also be used in large tanks, cages etc. They are used to break up or agitate the surface of water so that oxygen transfer takes place. There are different designs of surface type aerators available. Paddle wheel aerators and spray type surface aerators are commercial type surface aerators.
3. *Diffuser aerator*: Diffuser aerators inject air or oxygen into a body of water in the form of bubbles. Oxygen is transferred from the bubbles to the water by diffusion across the liquid film.
4. *Turbine aerator*: Turbine aerator consists of a propeller submerged in the water to be aerated. Circulation of water by Rotation of propeller causes greater aeration to occur at the surface. The main disadvantage of using this type of aerator is that propellers can cause damage to the fishes.

Aeration in aquaculture ponds

Steps to maintain optimum levels of Dissolved oxygen would be to support major factors that increase DO and put into check the factors that decrease DO. Photosynthesis plays a major role in oxygen production; respiration of all living organisms in the pond is the major factor involved in oxygen consumption. Oxygen concentration in pond water exhibits a diurnal pattern, with the maximum occurring during the peak of photosynthesis in the afternoon and the minimum occurring at dawn due to night time respiration. The magnitude of DO fluctuation is small and occurs around the level of saturated DO when plankton density is low and increases asplankton density increases. Supplemental aeration is generally provided during night time when DO increases to levels below 4.0 ppm. Photosynthesis of phytoplankton is the major contributor of DO during the day and diffusion accounts for increases when DO is below saturation at night. Diffusion at night can be

tremendously facilitated with the use of aerators, which exposes more water surface to equilibrate with atmospheric oxygen. Through reverse diffusion, anaerator operated during the day will tend to remove supersaturated DO. The net effectis a milder diurnal fluctuations of DO similar to the conditions of low phytoplankton density. Such conditions are favorable for semi-intensive culture of prawn and shrimp. Photosynthetic oxygen production is also significantly reduced when large scale depletion of plankton population occurs. Under these conditions, flushing out decaying plankton, providing for additional aerators and a erating for additional hours may be necessary to maintain DO at optimum levels. When plankton density is high, the penetration of sunlight through water gets reduced, thereby reducing photosynthetic oxygen production in the bottom ofthe water column. High plankton density often results from high nutrient loads and other these conditions, large quantities of feed and faecal wastes are found on the pond bottom. This causes an increase in bacterial population and metabolic activity in the bottom sediments leading to high oxygen demand in the bottom sediment. Limited light penetration and increased DO consumption in the bottom may cause significantly lower DO compared to the top layer of the water column. If this causes DO to deplete to lower than critical levels, disastrous effects on the bottom living organisms may happen. Limited light penetration (low secchi disc reading) can also cause differencesin the temperature of the top and bottom layer. Temperature stratification usually occurs during calm and warm afternoons.

Filtration

Removal of particles from a water flow in important in aquaculture. Suspended solids, dissolved solids and organic matter were removed from water by filtration of water through suitable media.

Types of filtration

1. Mechanical filtration

In aquaculture, mechanical filtration is used primarily for the separation of solids and liquids. A mechanical filter is a filter that is set into the water flow to collect the particles and larger objects and allow water to pass through. Mechanical filters uses differences in particle size of the solution (or mixture) components to extract one part form the other. The simplest type comprises a static screen, a grating or perforated plate. They are usually simple in operation and relatively easy to maintain.

In sand filters, water is allowed to flow through a layer of sand with particles of varying sizes and depth. The layer is not dense, but contains a number of channels and holes created between the particles that constitute filter medium. When water is passes through the filter medium, particles larger than a certain size will be trapped in the medium.

Various types of mechanical filters are (i) stationary screen (ii) rotary screen (iii) vibratory screen

2. Gravitational filtration

Gravitational filtration utilizes the force of gravity to separate particles from fluid. Density difference of the suspended particles and water is used in this type of filtration. A simple example of gravity filtration is sedimentation. Sedimentation is a process of allowing particulate materials having density greater than that of suspending liquid to settle out under gravitational forces. The settling process of the suspended particles can be increased by aggregating the suspended particles by addition of certain chemicals (coagulation) or by adding chemicals to produce insoluble compounds with suspended particles (precipitation).

3. Biological filtration

Concentration of ammonia in culture water is reduced by biological filtration process. Biological filters are devices to culture microorganism that will perform the given task of reducing the ammonia concentration when water with high ammonia level floes through them. In water both Ammonia (NH_3) and ammonium ion (NH_4^+) are present and their sum is known as Total Ammonia Nitrogen (TAN) and their proportions vary with pH. Ammonia (NH_3) is toxic to fish and their presence in water is important in aquaculture practices.

Biological filters (biofilters) are used to maintain water quality in recirculating or closed aquaculture systems. Biofilters are also used to improve water quality before water is discharged from a facility. Biological filers are formed as a component of the main filtration system which ensures water quality in an aquaculture farm. However it is very important in recirculating aquaculture or aquarium system.

In biological filters, bacteria are used to convert ammonia in various steps. (i) Conversion of ammonium to Nitrite (ii) conversion of Nitrite to Nitrate and (iii) Conversion of nitrate to molecular nitrogen. The first two steps, known as nitrification, are performed by specific bacteria which oxidize ammonia. The autotrophic bacteria, *Nitrosomonas* bacteria utilize ammonia as a food source and produce nitrite. This nitrite is further converted to nitrate by *Nitrobacter*. These bacteria grow and colonize on the filter medium of biological filter. Both nitrifying bacteria will grow and colonize the biofilter as long as there is food available. The efficiency of the nitrification process depends on the optimum growth of bacteria on the biofilter medium. One of the main factors affecting bacterial growth is the amount ammonia in the water. Other factors regulate are temperature, oxygen concentration, pH, salinity, organic substances and toxic substances.

Disinfection

Water drawn from coastal waters, estuaries and rivers used for various aquaculture activities often forms an efficient means for the introduction and spread of infectious diseases in the system. So it is very essential to have a pathogen-free water source for success in aquaculture. For aquaculture, the supply water to the farm or hatchery is disinfected by various methods. Disinfection of wastewater before discharging is necessary to avoid the pathogen contamination in the environment. Disinfection can be described as the reduction of microorganisms such as bacteria, viruses, fungi and parasites to a desired concentration. The aim of disinfection of water in fish farming is toreduce the risk of transfer of infectious dieses from water to the fishto an acceptable level.

There are several methods for disinfecting water. Disinfectants can be grouped as chemical and non chemical agents. A four group classification for disinfectants is (i) chemical agents (ii) physical agents (iii) mechanical agents and (iv) radiation. Even though various methods can be used for disinfecting water, the quality of the water to be disinfected is of major importance. Pure inlet water is much simpler to disinfect than the outlet water because latter contains more particles. Turbid water and water with a high content of organic substances such as reuse water are also more difficult to disinfect and therefore not commonly disinfected. For disinfection of water supplies to aquaculture facilities, UV light and ozone are commonly used. When starting disinfection, one must be aware of the production of disinfection bye products which might be harmful for fishes and humans. Disinfection can be performed in different situations in aquaculture. Water equipment, buildings and effluents can all be disinfected.

Ultraviolet Light

UV light is electromagnetic radiation with a wavelength of 1-40nm located at lower end of the visible spectrum and beyond. The ability of UV light to inactive and destroy microorganisms varies with both wavelength and the microorganisms to be inactivated. The most effective wave length for disinfection is 250 – 270nm. UV light damages the genetic materials in the microorganisms which results in their inactivation and death. The efficiency of UV light depends on various factors like lamp intensity, age of the lamp, cleanliness of the lamp surface, distance between the lamp and organisms to be inactivated, duration of UV exposure and purity of water. UV lamps need to be replaced regularly, atleast once in a year. UV light transmission through water depends on the turbidity of water, lower in turbid water.

UV lights can be placed in the water flow which is the usual method or above water flow. The dose required to kill pathogenic microorganisms depends on the organism. Most of the common bacteria requires a lower dose while viruses, which are more difficult to disinfect, needs stronger exposure intensity and duration.

Ozone

Ozone is a very strong oxidizing agent, highly toxic to all forms of life. Ozone, is a colourless gas which is very unstable and will quickly be broken down to O_2. Ozone inactivates the microorganisms by damaging cell membranes and nucleic acids, breaking long chain molecules into simpler forms. Another advantageous effect of using Ozone in aquaculture systems is that by oxidation it reduces the amount of NH_3, NO_2, biological oxygen demand. When using ozone as a disinfectant, it is recommended that particles be removed from water before the ozone is added, otherwise much of ozone will be used to oxidize the particles. When adding ozone to water, special injection system has to be used to ensure good gas water mixing. The ozone needs to given sufficient time to function and oxidize microorganisms. For effective inactivation of pathogens, ozone can be applied in a high dose for a shorter duration and vice versa. Overdosing must be avoided because this may kill the fish. Most pathogens are killed by an ozone dose of 0.1-1.0mg/L and contact time of 1-10 min, but this varies with the organisms.

The water quality parameters like concentration of dissolved organics, particular organics, inorganic ions, pH and temperature will have large impact on the residual ozone concentration after a given time. Because of these variations, it is important to add enough ozone to obtain a satisfactory residual concentration to achieve disinfection.

One of the major problems with ozone disinfection is that it is highly toxic to fishes and humans. Ozone is toxic to fishes even at lower concentrations as it oxidizes gill tissue of fishes. Therefore after disinfection, any residual ozone present in water should be removed or destroyed. An adequate retention time ensures that most of the ozone has reacted and the product is mainly oxygen gas. Being a very strong oxidizing agent, it will oxidize all materials which comes in contact. Ozone will destroy most of the plastic for some extent. Ozone will oxidize metals causing significant corrosion problems.

Chlorine

Chlorine is a very effective disinfectant for water and the most common method used for disinfection of water. It is normally obtained by adding liquid sodium hypochlorite to water, or solid calcium hypochlorite mixed into the water or pure chlorine gas. All these compounds are strong oxidizing agents and have the ability to break down organic molecules.

For effective disinfection using chlorine, specific contact time is required which include time for dissociation in water, time for diffusion through cell wall and time to inactivate selected enzymes. Presence of residual chlorine after disinfection is critical for fishes and overdoing must be avoided. Water containing chlorine is very toxic to fishes. When disinfecting tanks or other equipments with chlorine, it is important that sufficient clean water is used to wash away the chlorine residues produced. There for when using chlorine as a disinfectant, a method for dechlorination must be included.