Int.J.Curr.Microbiol.App.Sci (2022) *11*(06): 353-358

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 11 Number 06 (2022)**
Journal homepage: http://www.ijcmas.com

Review Article

https://doi.org/10.20546/ijcmas.2022.1106.039

A Review on Aeration Process and Different Types of Aerators Used in Various Aquaculture Systems

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Keywords

Aerator, Aeration, DO, SAE, SOTR, aquaculture system, fish culture

Article Info

Received:
10 May 2022
Accepted:
02 June 2022
Available Online:
10 June 2022

A B S T R A C T

In any aquaculture plant maintaining dissolve oxygen (DO) level is essential for the better health and survival of the living organisms present in the water body specially fish. DO level can be maintained by aeration process. The general idea behind aeration is to bring the water into intimate contact with the air. Either the water may be discharged into free air or the air may be forced into water. Aeration process also removes light volatile organic compounds, dissolve gases and fix odor, taste etc. in case of drinking water. Some common Apparatus used includes: low cascades, multiple jet fountains throwing water to considerable heights, spray nozzles discharging above the surface of a reservoir, superimposed trays or shelves, submerged perforated pipes, and porous tubes and plates.There are two ways, standard oxygen transfer rate (SOTR) and standard aeration efficiency (SAE) of describing aerator performance. In selection of aerators for aeration in fish culture tank, durability and good standard aeration efficiency (SAE) value is too important moreover in case of aerators high standard oxygen transfer rate (SOTR) is important for the better growth of aquatic animals present in water. This article gives a review of different types of aerators used in aeration process based on various basis.

Introduction

In India fish farming plays a vital role in the rural economy of several states. In order to meet the demand of growing population, both inside and outside aquaculture practices have been taken seriously by the farmers of the country. In any fish farm, it is important to maintain the level of oxygen in the water keeping in view the health of the aquatic lives. The device which is used for the aeration process is known as aerator and there are several types of aerators available depending upon

the efficiency and area it is selected to be used. In fish culture, farmers generally follow traditional aeration process for their Small scale culture but when it comes about large scale fish culture farm, recirculating aquaculture system (RAS) and waste water treatment plants are needed where mechanical, highly efficient aerators are preferable, which offers accuracy and better performance in work.

In order to remove dissolved gases (such as CO_2) and oxidize dissolve metals such as iron, hydrogen sulfide and VOCs, (volatile organic chemicals) the process of aeration brings water and air in close contact with them. Aeration is often regarded as the first major step at the treatment plant. Aeration process in the fisheries or in the ponds, is useful in the early morning or in the midnight when the DO level is minimum. Moreover in cloudy weather the aeration process is considered very much necessary. Any oxygen adding methods into the water can be considered as a type of aeration.

Different types of aerators used in the aeration process

The blowers are the first stage in a diffused air system and adequate blower system design is required for efficient control of the Dissolve Oxygen (DO) concentration (Amand *et al.,* 2013).

Oxygen in ponds evolves from two sources-photosynthesis and diffusion from the air (Pederson *et al.,* 2013). In general, the amount of oxygen in pond water can be varying considerably from pond to pond and from time to time. Typically, however, oxygen concentrations are lowest at dawn and highest during late afternoon. The amount of oxygen water hold is dependent upon atmospheric pressure, salinity and temperature (Christ *et al.,* 2014).

According to Kepenyes *et al.,* (1982) in most pond culture operations, aeration offers the most immediate and practical solution to water quality problems encountered at higher stocking and feeding rates. The types of water aerator needed for application depends on efficiency, the chemical properties of the water and the reason for aeration. Surface aeration is a kind of aeration, defined as addition of gasses in liquid through free surface by increasing the partial pressure of gas (Drewnowski *et al.,* 2019). Various mechanical aerators such as vertical pumps, pumps sprayers, propeller aspirator pumps (PAP) and paddle wheels aerators are probably the most widely used surface aerators in the field of aquaculture for purpose of aeration (Kumar *et al.,* 2012). Oxygen transfer into pool depends on several factors such as discharge through pipe, number of opening and overall area of openings of aeration device. Shukla *et al.,* (2018) found in their study that the efficiency of transfer of oxygen decreases with increase in discharge and hence increase in velocity due to increased loss of head at the end of exit. However, with the increment in length of jet, the value of oxygen transfer efficiency (OTE) increases for all sets of aerators.

Furthermore, it was observed that value of oxygen transfer efficiency first upsurges with decrease in area of opening of aerator and then decreases abruptly. As said by Subramani *et al.,* (2012) the reduction in Biological oxygen demand (BOD) and Chemical oxygen demand (COD) will depend on the incoming quality and quantity of raw effluent and activated sludge.

Efficiency of aerator affected with the size of bubbles released (Navisa *et al.,* 2014). Cancino *et al.,* (2004) designed and developed a high efficiency centrifugal surface aerator for fishponds. Centrifugal aerators create enhanced conditions for dissolving gas into liquid phase, including bubble size, and bubble size distribution and duration of interaction with liquid. Centrifugal aerators combine several elements:

High turbulence swirling flow of liquid;

Orthogonal flow of liquid and gas;

Constant pressure inside the vessel;

Optimum flow velocity generating centrifugal forces

thereby extending diffusion rate within the vessel; and
Very small pores, through which gas permeates into the liquid and is sheared off into liquid phase, thereby forming small bubbles.

A cascade aerator consists of a series of steps that the water flows and usually, the rate of flow may vary between 20 to 100 m^3/h per m length of weir. (Akhlaque *et al.,* 2017). As said by Sabry *et al.,* (2010) a cascade aerator is one of the oldest and most common aerators which consists of a series of steps that the water flows over (similar to a flowing stream).. In the gravity aeration of wastewater, the aeration process brings wastewater and air into close contact by exposing drops or thin sheets of wastewater to the air (Hashimi *et al.,* 2018). In the study of Claude*et al.,* (1998) they verified that cascade aerators can be used to oxidize iron and to partially reduce dissolved gases.

Adel *et al.,* (2019) studied on speed of impeller and Dissolve Oxygen, They found that rotating speed has a remarkable effect on DO, as the rotational speed increases the time required to reach saturation decreases and consequently the oxygen mass transfer coefficient increases moreover they verified that as the aerator speed increases the standard aeration efficiency (SAE) increases, despite the increase in consumed power. According to Xing *et al.,* (2021) the increase in rotational speed of the impeller will increase the negative pressure at the center, the lifting force of the impeller on the water will increase, and the flow of water thrown by the blade to form a water jump will increase.

Paddle wheel aerator is found to be the best due to its low cost, low maintenance, ease in operation and high SOTR as well as SAE in intensive pond culture systems moreover it can be concluded that properly operated aeration system will help to mitigate the environmental hazard in the intensive culture and also reduction energy cost (Tanveer *et al.,* 2018). In a study by Roy *et al.,* (2015) found that standard oxygen transfer rate (SOTR) increases with the increase in rotational speed of paddle wheel aerator. Circulation of water during aeration moves oxygenated water away from the aerator to other parts of the pond, and it decreases thermal and chemical desertification. Water movement created by an aerator helps maintain high oxygen-transfer efficiency, because the freshly oxygenated water is propelled away from the aerator and replaced by water of lower DO concentration (Claude *et al.,* 1998)

According to Subramani *et al.,* (2012) The oxygen transfer in the aeration tank by the surface aerators may be increased by changing the suitable design of impeller. More over they found that for instance, pitched blade turbine (up flow) with six blades and a blade angle of 45° (pitch) will significantly increase the degree of surface aeration.

According to Vinatea *et al.,* (2007) paddle wheel aerators were shown to be more economic than the propeller-aspirator-pumps as regards to electricity costs in salinities between 0 and 10%; in salinities above 15% there is no difference between the number of aerators required per hectare for each model.

The study of Kossay *et al.,* (2006) says at a fixed airflow rate, increasing the level of water depth in water tank significantly increase each of oxygen transfer capacity, efficiency and the percentage of oxygen absorption in the system. Tamot *et al.,* (2011) did experiment on 3 different aerators and found Floating fountain is also effective for increasing dissolved oxygen level and the scenic beauty of the lake.

Bhuyar *et al.,* (2009) in their study concluded that aeration can be made more effective by optimizing various factors affecting it viz, speed of aerator, depth of immersion, blades angles *etc*. Moreover in their study the standard aeration efficiency of curved blade aerator was observed to be 2.95 kgO_2/kWh. It is easy to adopt most of new or existing methods of aeration that provide enough pressure in the system to create the required pressure differential. The venturi aerators utilize a vacuum principle rather than a pressure principle, the material being handled is never under high pressure in a concentrated form.

This reduces the possibility of caustic chemicals being sprayed into the air through cracks or breaks in the pipe. (Ahmet *et al.,* 1988). In a study by Zhu *et al.,* (2013) found that any particular sampling point, the Dissolved Oxygen (DO) provided by the aerator module with one air injector is always the highest and the oxygen transfer efficiency appeared to deteriorate as the number of air injectors increased in the system. Detailed studies on venturi aerator were carried by Bae *et al.,* (2021) and according to them the increase in pressure ratio reduces the negative pressure formed in a venturi nozzle's throat and causes a decrease in the air entrainment rate if there is no change in flow pattern.

It can be seen from the experimental results that the gas hold up and the standard oxygen mass transfer coefficient are related to the working conditions of the aerator, while the Sstandard oxygen mass transfer coefficient reflects the aeration performance of the aerator (Dai *et al.,* 2020).

In one study by Kumar *et al.,* (2013)found that a typical Indian Major Carp culture system in a small pond of less than 1000 m^3 volume circular steeped cascade aerator is most economical and they found that for larger ponds volume more than 5000 m^3 1-hp paddle wheel or 2-hp paddle wheel aerator is more economical.

Boyd *et al.,* (2020) carried out studies on the aeration requirement in pond and as said by them aeration requirement for a pond depends upon the pond oxygen demand, the minimum acceptable dissolved oxygen concentration, the water column photosynthesis and respiration rates, exchange of oxygen between air and water, dissolved oxygen in inflow and outflow of pond, and sediment respiration rate.

As said by Maloth *et al.,* (2020) the efficiency of aerator depends on the amount of area of contact between air and water, which is controlled primarily by the size of the water drop or air bubble. According to Patel *et al.,* (2020) aeration of water can be carried out by various processes like paddle wheel aerators (type of mechanical aerator) diffused air aeration etc. As said by them best way to transfer oxygen in water is fine bubble generation. In a study on jet aerators Deswal *et al.,* (2006) found that under similar conditions of experimentation multiple jets have higher oxygen mass transfer rates as compared to single jet aerators. Though different sources of energy can be used in the aeration process, but use of renewable source of energy can be a better solution for an eco-friendly environment. (Patel *et al.,* 2020).

Moucanu *et al.,* (2012) found that due to the higher aeration performances and lower energy consumption the use of the fine bubble diffusers is the most adequate solution for the refurbishment of the biological reactor from the Romanian wastewater treatment plants. Jayanthi *et al.,* (2021) studied on three different types of aerators and found that paddlewheel aerators performed better in terms of oxygen transfer and water circulation, than the other three types of aerators viz. Venturi jet, Scorpion jet and Wavesurge.

Taparhudee *et al.,* (2007) studied on both electricity operated and fuel operated aerator and they found the electric driven paddle-wheels had a lower average rotational speed and a less effective range than the diesel driven paddle-wheels at all depths moreover this resulted in greater accumulation of organic matter at the center and at the feeding area of the ponds than using the diesel engines.

In cloudy days dropping down of dissolve oxygen (DO) level in water is a very common problem faced by the fish growers and due to which they face an incomputable loss every year.

Aerator is the apparatus which can minimize the loss of fish farmers by maintaining the required DO level in water and in order to achieve the same, selection of suitable and efficient aerator is too important that adequate the mixing of air to water by saving power as well as the operating cost of the system. Also for high density fish population aeration is necessary for maintain the oxygen level.

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How to cite this article:

Kuldeep Deka, Dipika Bordoloi, Amar J. Khound, Manas J. Bharali and Racktackshree Chelleng. 2022. A Review on Aeration Process and Different Types of Aerators Used in Various Aquaculture Systems. *Int.J.Curr.Microbiol.App.Sci.* 11(06): 353-358. doi: https://doi.org/10.20546/ijcmas.2022.1106.039