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Submission date: 04-Jul-2021 02:44PM (UTC+0700)

Submission ID: 1615475905

File name: Susanto_2021_IOP_Conf._Ser._Earth_Environ._Sci._715_012063.pdf (639.04K)

Word count: 2436

Character count: 11978

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To cite this article: A Susanto *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **715** 012063

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The Development Design of Venturi Type Protein Skimmer for Mariculture Land Base System

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Abstract. The sustainability of mariculture activities is very dependent on how water is managed. One of the important qualities of water is dissolved oxygen which can be dissolved from the diffusion of air bubbles released by the diffuser. The use of conventional aeration (stone aeration diffuser) has problems due to the macro size of the air bubbles. One solution is to use venturi which produces microbubbles. Therefore, this research aimed to analyze the skimmer design using venturi and the resulting dissolved oxygen values. As a comparison, this study also observed dissolved oxygen from the stone aeration diffuser. This research was conducted without using test organisms. The results showed that venturi can create fine air bubbles. The dissolved oxygen value in the skimmer system using the venturi was higher than the stone aeration diffuser.

1. Introduction

The rational use of recirculating equipment is the key to improving the efficiency of water resource utilization in aquaculture. The coupling and connection among various types of equipment provide the foundation for ensuring stable water quality and healthy growth of culturing aquatic products [1]. The use of aeration is very important to supply the dissolved oxygen (DO) in the waters, especially in intensive aquaculture systems including marine species [2]. If the DO level is too low, the aquatic life may not survive and the system may have odor problems as well [3].

Water aeration is commonly being used to improve DO concentration in aquaculture to increase water quality. Many different types of aerators are used for a variety of diverse needs and processes. Venturi system is one of them is admired aeration process which highly efficient and required less than 20% pressure difference to pledge suction for sufficient supplementations of DO makes a sustainable environment-friendly system of mass production [4]. The venturi aeration system is



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capable of producing micro-bubbles to increase the concentration of dissolved oxygen in the water to promote the growth of aquatic life, including marine organisms [5].

The various environmental parameters have a significant effect on the development and survival rate of marine fish in aquaculture. Temperature, ammonia, dissolved oxygen (DO), pH, and salinity influence the physiological condition of fish. However, culturing marine fish with natural food has several advantages. The waste from food and feces from fish causes high dissolved organic waste in seawater. Recirculating aquaculture systems (RAS) need to maintain water quality culture duration. One of the important parts in RAS for marine fish is the skimmer [6]. The venturi skimmer is an effective type of skimmer that is used for skimming the water to remove dissolved organic waste [6, 7]. However, the optimum design of a venturi type of skimmer needs to be improved. The purpose of this study is to explore the effect of venturi skimmer to the quality of seawater. We developed a suitable design of venturi type of skimmer to maintain seawater quality including ammonia, DO, pH, salinity, and temperature level. In the preliminary stage of our research, we analyze the DO level generated by the venturi skimmer and conventional aeration (stone aeration diffuser).

2. Methods

This research used a laboratory experiment. The engineering design process was conducted to determine the system process of a venturi protein skimmer. Previous patent documents and scientific publications were compared to analyze the optimum development design for the skimmer. The laboratory experiment was accompanied during September 2020 in the Aquaculture Laboratory, University of Sultan Ageng Tirtayasa. The experiment was conducted to measure the technical performance of the skimmer to maintain seawater quality in the aquarium. We compared the effect of skimmer and stone aeration diffuser to the water quality parameters, especially dissolved oxygen (DO). Skimmer and stone aeration diffusers were turned on for 10, 30, and 60 minutes, then observed changes in DO every 15 minutes for 60 minutes.

3. Result

3.1 Skimmer design

The skimmer developed consists of three components, namely the venturi tube, water pump, and skimmer tube (Figure 1). The venturi tube is the initial place for water and air to enter the skimmer system. An air intake regulator is also added to the end of the air hose connected to the venturi tube. Furthermore, we made modifications with the needle wheel in the water pump to mix water and air. So that the resulting fine air bubbles (Figure 2). The water pump and the skimmer tube are connected using a hose. The water inlet in the skimmer tube is made higher than the outlet. The skimmer tube is equipped with a dirty foam reservoir and a wastewater outlet. The clean water outlet of the skimmer tube is equipped with a regulator to maintain the water pressure in the skimmer tube.

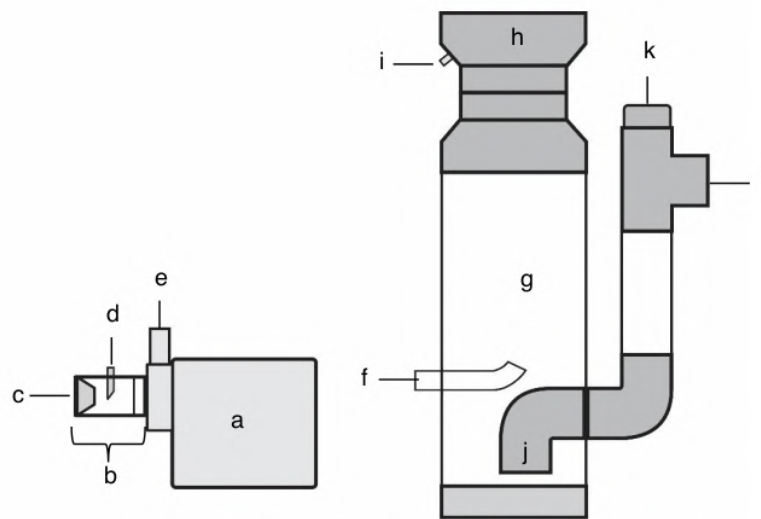


Figure 1. Skimmer (Sketch by Herjayanto). a: water pump, b: venturi tube, c: inlet water, d: inlet air, e: outlet water from the pump to skimmer tube, f: inlet water, g: skimmer tube, h: dirty foam shelter, i: wastewater outlet, j: outlet from skimmer tube, k: the water regulator comes out of the skimmer tube, l: clean water outlet.



Figure 2. Air bubbles were generated from the venturi and water pump with a modified needle wheel shape (arrow) (Photograph by Herjayanto).

3.2 Dissolved oxygen

The dissolved oxygen value at the time the skimmer and stone aeration diffuser was turned on for 10 minutes showed that the initial DO value of the skimmer was 6.25 mg/l, which was higher than that of aeration, which was 4.55 mg/l. The DO value continued to drop to 3.60 mg/l on the skimmer and 3.35 on aeration (Figure 3).

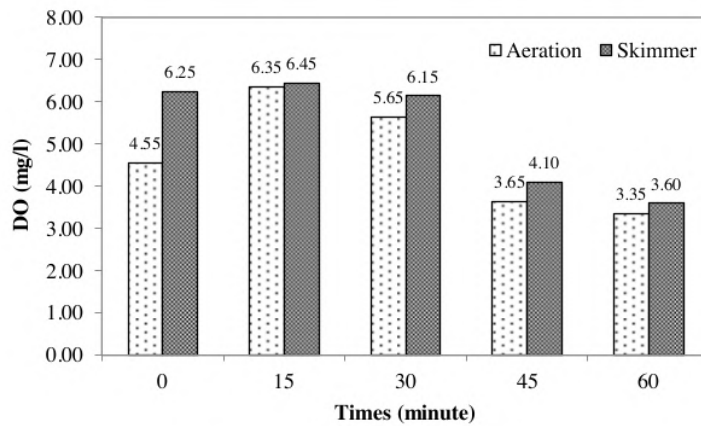


Figure 3. Number of DO after ten minutes of treatment

The length of time that the skimmer and stone aeration diffuser was turned on for 30 minutes showed that the initial DO value of the skimmer was 6.35 mg/l, which was higher than that of aeration, which was 4.95 mg/l. The DO value continued to drop to 4.20 mg/l on the skimmer and 4.05 for aeration (Figure 4).

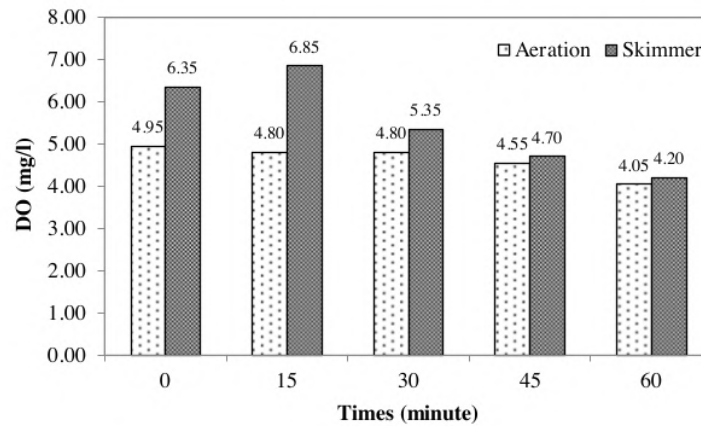


Figure 4. Number of DO after 30 minutes of treatment

When the skimmer and stone aeration diffuser was turned on for 60 minutes, it showed that the initial DO value of the skimmer was 6.15 mg/l, which was higher than that of aeration, which was 4.80 mg/l. The DO value continued to drop to 5.00 mg/l on the skimmer and 4.85 on the aeration (Figure 5).

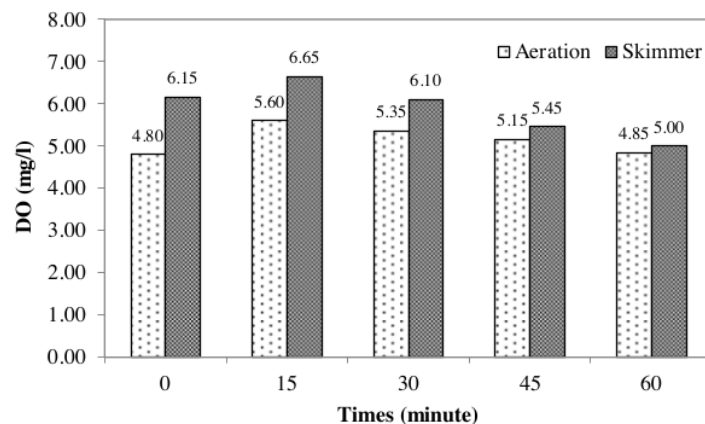


Figure 5. Number of DO after 60 minutes of treatment

4. Discussions

The use of a conventional aeration system (stone aeration diffuser) has long been used to supply dissolved oxygen in aquaculture activities [1], namely freshwater culture, brackish water culture, and mariculture. However, the stone aeration diffuser has a weakness in the size of macro air bubbles [5]. The larger the size of the air bubbles, the faster they will come to the surface of the water and then burst. This results in the lack of time the air bubbles diffuse in the water into dissolved oxygen [5, 6]. In principle, the dissolved oxygen comes from air diffusion which comes from air bubbles that are ejected from the stone aeration diffuser. This principle is different from the Venturi system in this study. Venturi uses the principle of water pressure to make air into the venturi tube. Therefore, the inlet water mouth of the venturi tube is made to resemble a funnel. At the end of the funnel, there is a small pipe through which air enters. The position of the small pipe is in the middle of the tube. Furthermore, air and water will be mixed through the pump with a modified needle wheel shape. The resulting water bubbles are finer (microbubbles) which are then flowed into the skimmer tube [8]. The microbubbles will be in the water longer [6]. Water will be shot into the tube causing foam at the top of the tube. If the water is dirty, the foam will appear more and brown-black. This condition indicates that the skimmer can remove organic waste in water [7].

Clean water with a fine bubble size will come out through the outlet which is located near the bottom of the skimmer tube. These fine bubbles caused the initial DO value in the aquarium using a skimmer higher (6.15-6.35 mg / L) than the DO value in the aeration system (4.55-4.95 mg / L) in all treatments (Figures 3, 4, and 5). The final DO value on the skimmer which is higher than that of aeration is thought to be due to the fine air bubbles from the venturi system which can last longer in the aquarium as a source of DO. Besides, the longer the skimmer was turned on (60 minutes), the more air bubbles in the aquarium resulted in a higher DO value at the end of the observation. This can be seen in the final DO value of the skimmer which was turned on for 60 minutes, namely 5.00 mg / L (Figure 5), which was higher than the final DO value of the skimmer which was turned on for 30 minutes (4.20 mg / L) (Figure 4) and 3.60 mg / L on the skimmer which was turned on for 10 minutes (Figure 3). Based on these descriptions, further research is needed to obtain the optimum time to operate the skimmer which is associated with energy use efficiency. Also, it is necessary to use test fish to determine the optimum density of fish that can be maintained using the skimmer.

Acknowledgment

This research is supported by the University of Sultan Ageng Tirtayasa through an institutional excellent research grant with grant number B/137/UN.43.9/PT.01.03/2020.

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