Papers

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The oxygen content and dissolved oxygen consumption level of white shrimp *Litopenaeus vannamei* in the nanobubble cultivation system

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Abstract. Vaname shrimp is one of the most popular commodities, causing high demand. Success in aquaculture activities is related to the systemic and environmental conditions of cultivation. This study aims to determine the oxygen content and dissolved oxygen consumption level of vaname shrimp in nanobubble cultivation systems. This research was experimental using a completely randomized design factorial pattern. Consisting of two factors, factor A was the shrimp cultivated with nanobubbles and an aerator and factor B factor was the cultivation times of 0 days, 10 days, 20 days and 30 days. The parameters observed were oxygen content, oxygen consumption level and water quality including pH, ammonia, salinity, and temperature. Data analysis was conducted using Analysis Of Variance and continued with Duncan's Multiple Range test. The dissolved oxygen content in nanobubble treatment was 3.9 ppm to 10.8 ppm while the dissolved oxygen aerator treatment was 2.81 ppm to 4.65 ppm. The oxygen consumption rate was from 1.10 up to 6.84 mg/O_2/g/hour. The highest value in the aerator treatment was on the 30th day of the third and the lowest hour observation for the nanobubble treatment was on the 10th day of the 1st-hour observation. The results showed that the cultivation system with nanobubbles affected the oxygen content and oxygen consumption level of the vaname shrimp.

1. Introduction

Shrimp are a superior commodity that is an example of a non-oil and gas export that has a high price and a wide market share. The aquaculture sector is a prospective sector to be developed because it has great potential. Success in fishery cultivation activities is related to maintenance systems and the environmental condition of cultivation. Poor environmental conditions can be an obstacle to commodity growth and can lead to mass death. One of the parameters that determine the quality of water and environment in aquaculture is the level of Dissolved Oxygen (DO) in water [1].

Dissolved oxygen is required by the shrimp to process respiration. The need for oxygen in the water, if not met, will result in decreased levels of shrimp oxygen consumption and a decline in shrimp health conditions; even death [2]. Based on these observations, technology can improve water quality. One of the technology used to enhance the quality of water is nanobubble technology.

Nanobubbles are a bubble (<200 nm) in an oxygen-containing fluid [3]. According to [4], in a nanobubble system, oxygen in the water can be available for a long time, so then the waters' DO become stable. In addition to meeting the oxygen needed for the metabolism of aquaculture fish, nanobubbles are needed to decompose organic materials such as residual feed and fish feces, so then the quality of the water cultivation is better maintained. The purpose of this research is to learn about the effect of a cultivation system with nanobubbles present on oxygen content and the level of vaname shrimp oxygen consumption (*Litopenaeus vannamei*).

2. Material and methods

The materials used in this research were vaname shrimp sized 7 - 10 cm with a weight of 4 - 6 gr at 240 tail, pond water with a salinity of 18 - 20 ppt and chlorine. The tools used in this research consisted of a 51 cm x 38 cm x 35 cm berated container x 12, nanobubble machine, aerator, aeration hose, aeration stone, tub tank, filter tub, DO meter, pHmeter, spectrometer, thermometer, and a refractometer.

This research was conducted in the Education Laboratory of the Faculty of Fisheries and Marine in the University Airlangga from August to November 2017. The research method used in this research was experimental. The research design used was a Completely Randomized Design factorial pattern. The study consisted of 2 factors; the first factor was shrimp cultivation with nanobubbles and an aerator. The second factor was the cultivation time. For the preparation, the sequence included providing the cultivation container used in the research and then sterilizing the container, preparing the aerator to be used for the control, and filling the brackish water research containers with 20 liters of water each. The preparation of the circuit involved determining the position of the container with the used tandon and the installation of the nanobubble devices connected to the treatment series. The optimization of the nanobubble system was done to balance the circulation of the water conducted in the series and the researcher also conducted preliminary research to be certain that they would obtain good research results. The nanobubble generator had a flow rate of 2 - 16 L / min while the aerator used was 4 L / min.

The dissolved DO measurements used the appropriate DO meter tools [5]. The ammonia measurement was done using a spectrometer [6]. The salinity measurement used a refractometer device [7]. The temperature measurement was taken using a thermometer [8]. The pH measurement used a pH meter [9]. The level of oxygen consumption was related to the individual's ability to absorb oxygen to support its life processes. The level of oxygen consumption is related to respiration and the metabolic processes of the organisms. Oxygen consumption was calculated based on the formula [10] as follows:

$$TKO = \{ (DO\ start - DO\ end)/W \times t \} \times V$$

Information:
TKO = Oxygen Consumption Rate (mg / O_2 / gr body / hour)
DO start = dissolved oxygen at the beginning of observation (mg / L)
DO end = Dissolved oxygen at the end of observation (mg / L)
W = weight of test shrimp (gr)
V = Water volume (L)
t = Observation period (hours)

3. Results

The water quality parameters of the cultivation of nanobubble-treated vaname shrimp and the aerator treatment fluctuated. The results of the measurement of the dissolved oxygen content of the vaname shrimp showed there to be significant differences between the nanobubble and aerator treatments ($p < 0.05$). Dissolved oxygen in the nanobubble treatment was 3.9 ppm until it reached 10.8 ppm while the dissolved oxygen aerator treatment was 2.81 ppm to 7.85 ppm. The results from the average dissolved oxygen content have been shown in Table 1. The graph of the average dissolved oxygen content can be seen in Figure 1.

Table 1. Average dissolved oxygen content.

Measurement Time	DO value (mg/L) ± SD	
	Nanobubble	Aerator
Day0	10.80^{u} ± 0.07616	7.85^{st} ± 0.05679
Day2	8.25^{t} ± 0.09883	7.55^{r} ± 0.07500
Day4	7.92^{s} ± 0.06801	7.45^{q} ± 0.06898
Day6	7.75^{r} ± 0.09465	7.14^{p} ± 0.08042
Day8	7.43^{q} ± 0.07932	7.08^{n} ± 0.10595
Day10	7.26^{p} ± 0.07853	6.90^{l} ± 0.11916
Day12	7.10^{o} ± 0.14000	6.82^{k} ± 0.26420
Day14	7.02^{m} ± 0.11899	6.65^{i} ± 0.07528
Day16	6.98^{l} ± 0.14201	6.25^{g} ± 0.21672
Day18	6.80^{k} ± 0.05944	5.68^{f} ± 0.07136
Day20	6.75^{j} ± 0.13598	5.57^{f} ± 0.04967
Day22	6.45^{h} ± 0.05795	4.02^{d} ± 0.06831
Day24	6.30^{g} ± 0.09979	3.96^{B} ± 0.07890
Day26	4.16^{e} ± 0.09605	2.90^{A} ± 0.10145
Day28	4.25^{c} ± 0.09345	2.85^{a} ± 0.05439
Day30	3.90^{b} ± 0.07182	2.81^{a} ± 0.04243

Discription: Different superscripts in different columns and rows show significant differences ($p < 0.05$)

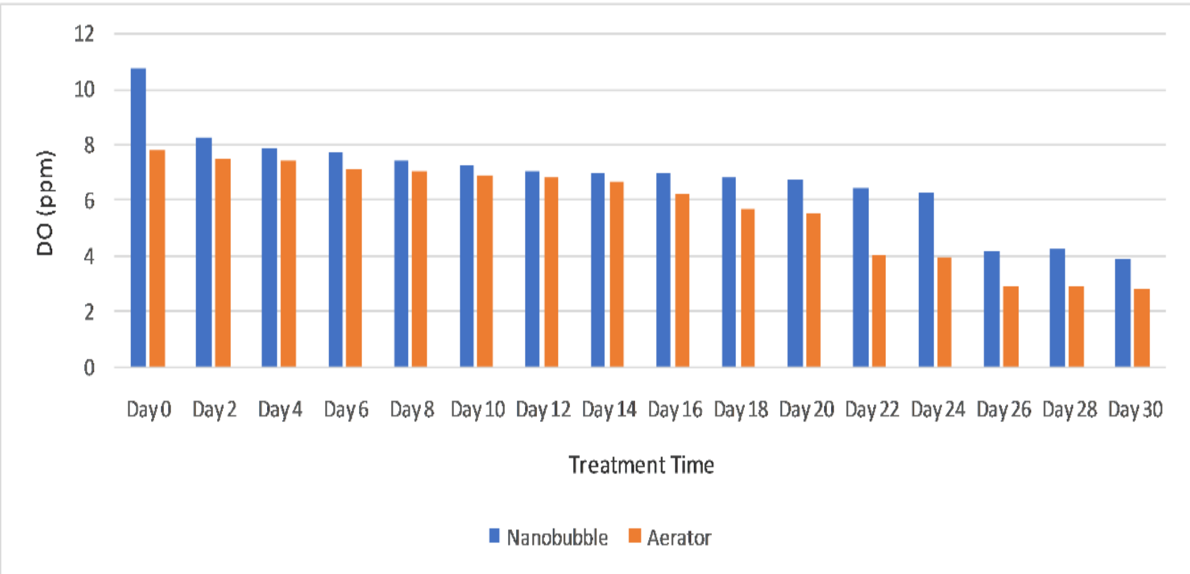

Figure 1. Graph of dissolved oxygen content.

Table 2. Results from the dissolved oxygen consumption level of the vaname shrimp

Measurement time		Treatment ($mg/O_2/g/h$)	
		Nanobubble (A1)	Aerator (A2)
	1 h (a1)	$2.56^{ghijkl} \pm 0.53$	$2.96^{efghij} \pm 1.14$
Day 0	2 h (a2)	$3.61^{cdefg} \pm 1.82$	$4.42^{cde} \pm 0.79$
	3 h (a3)	$4.61^{bcd} \pm 0.96$	$5.20^{bc} \pm 1.47$
	1 h (b1)	$1.10^{l} \pm 0.06$	$2.84^{fghij} \pm 0.67$
Day 10	2 h (b2)	$1.49^{jkl} \pm 0.57$	$3.03^{defghi} \pm 1.73$
	3 h (b3)	$2.68^{ghijk} \pm 0.52$	$3.56^{defgh} \pm 0.61$
	1 h (c1)	$1.54^{ijkl} \pm 0.32$	$3.89^{cdefg} \pm 0.85$
Day 20	2 h (c2)	$1.42^{jkl} \pm 0.25$	$4.40^{cde} \pm 0.78$
	3 h (c3)	$2.29^{hijkl} \pm 1.12$	$4.32^{cdef} \pm 0.75$
	1 h (d1)	$1.44^{jkl} \pm 0.46$	$5.85^{ab} \pm 0.44$
Day 30	2 h (d2)	$1.18^{kl} \pm 0.13$	$5.96^{ab} \pm 0.87$
	3 h (d3)	$2.23^{hijkl} \pm 1.18$	$6.84^{a} \pm 1.29$

The results of the vanity dissolved levels of vaname shrimp can be seen in Table 2. The graph of the average dissolved oxygen consumption level of vaname shrimp can be seen in Figure 2. The results of the measurement of the vaname shrimp's oxygen consumption level showed there to be significant differences between the nanobubble and aerator treatment ($p < 0.05$). The average yield of the vaname shrimp's oxygen consumption level during the treatment showed that the highest oxygen consumption level value in the aerator treatment on the 30th day was not significantly different when compared to the aerator treatment, taking day 30 to days 1 and 2 into account, but it was different from the 0, 10, 20, and 30 day nanobubble treatments respectively. The lowest consumption rate value in the nanobubble treatment of 10th day - 1 hour did not differ significantly with the nanobubble treatment of day 0 1 hour, 10th day - 2 hours, 20th day 1 hour 2 hours and 3 hours, and 30th day 1 hour, 2 hours and 3 hours, but the real difference was in the nanobubble treatment day 0 - 2 hours, 3 hours, day 10 - 3 hours, and the aerators day 0 - 10, 20, and 30 days.

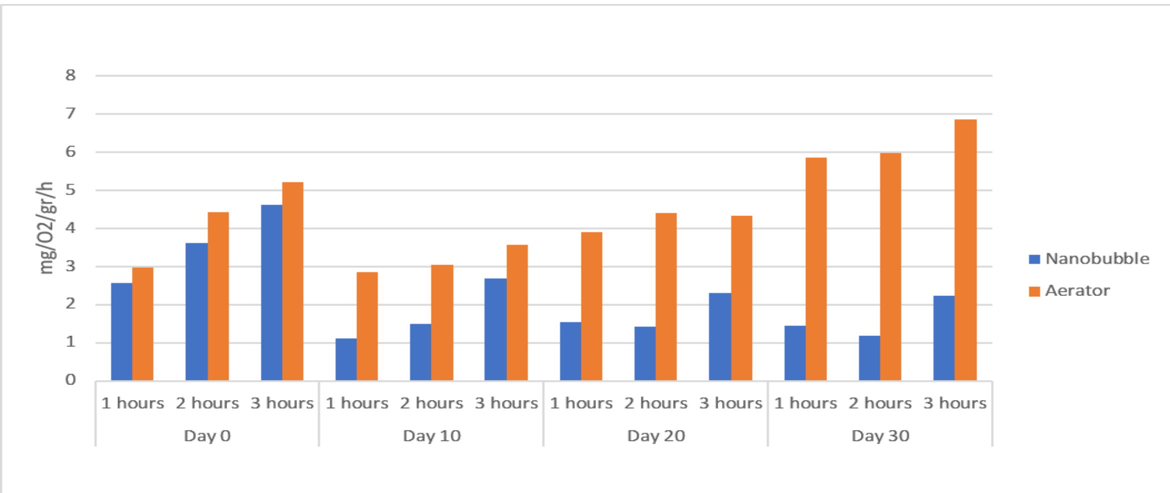

Figure 2. Graph of the dissolved oxygen consumption level of the vaname shrimp.

The average value of the nanobubble cultivated oxygen level was lower than the rate of the oxygen consumption cultivation supplied by the aerator. The dissolved oxygen consumption level of the vaname shrimp cultivation with the nanobubbles increased and decreased in each measurement hour. In the treatment cultivation with the aerator, there was experienced an average increase in each hour of measurement. The level of the vaname shrimp's oxygen consumption after being cultivated with the nanobubble and aerator decreased in the early hours of observation and increased in the next hour. This occured until the end of the cultivation period on the 30th day while the shrimp vaname in the treatment with the aerator increased their oxygen consumption until the 30th day.

4. Discussion

The dissolved oxygen content in the nanobubble treatment was higher than in the aerator maintenance medium. This is because a nano-sized bubble can last longer in the cultivation media, so the dissolved oxygen content will be stable in the water and last longer. A nanobubble is a bubble (<200 nm) in an oxygen-containing fluid [3]. According to [4], in a nanobubble system, the oxygen in the waters can be available for a long time, so then the DO of the water becomes stable. According to [11], the concentration of the dissolved DO in a good pond for vaname shrimp culture is 3.5 to 7.5 mg / l. Although the aerator concentration of DO treatment is within normal limits, the DO concentration is lower.

The level of oxygen consumption is related to the ability of the individuals to absorb oxygen to support their life processes. The factors affecting the rate of oxygen consumption include temperature, body size and activity [12]. The level of the vaname shrimp's oxygen consumption in the treatment with nanobubbles was within the normal range of 1.1 to 4.61 mg / O_2 / g / hr. According to [13], the level of vaname shrimp oxygen consumption at 25 ppt salinity and 30^0C temperature is 1.63 - 4.80 mg / L / h. Low dissolved oxygen consumption level values are because oxygen in the form of nanobubbles can last longer in the water, and so are more easily absorbed by the shrimp. The hemosit in the shrimp when on the treatment of high nanobubbles showed that oxygen transport throughout the body became easier and so it can be used to support shrimp activity. This is following the opinion of [4], who stated that the nanobubble system produces oxygen that can be dissolved over a period long time to meet the needs of both the organisms and the decomposition of organic material.

The oxygen consumption level of the vaname shrimp with the aerator treatment increased from what it was on the 10^{th} to 30^{th} days of maintenance. Shrimp take up more oxygen in the water to support its activities; this is because ammonia and nitrite are present bad cultivation containers that are unsuited to vaname shrimp cultivation. The unavailability of sufficient oxygen in the water causes high ammonia. Low oxygen is only sufficient for ammonia formation, so then the process of ammonia oxidation into nitrite and nitrate (nitrification) does not run perfectly [14]. According to [15], the higher the ammonia and nitrite levels in the water, the higher the content of the organic matter in the water as well. High organic matter causes an accumulation of organic matter in the water which results in a decrease in water quality. According to [1], poor environmental conditions can become obstacles to commodity growth and results in mass death. In addition to poor water quality, the increase in the oxygen consumption of white shrimp is due to the increased metabolic rate of the shrimp when it comes to producing the energy needed to survive poor environmental conditions; the oxygen demand thus increases. According to [2], an increased metabolic rate means increased oxygen demand by the bodily tissues.

5. Conclusion

The use of nanobubble technology can increase the oxygen content in the water, thus affecting the oxygen consumption level of vaname shrimp *Litopenaeus vannamei*.

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