The Percentage Of Oxygen Absorption By Vannamei Shrimp (*Litopenaeus vannamei*) Which Is Supported By The Paddlewheel

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Abstract

A dynamic model was used to obtain optimal value or amount in the application of paddlewheel. Stella 9.1.4 software programing was employed to find relationships among parameters. The aims of this reasearch was to determine the percentage of oxygen uptake by vannamei shrimp (Litopenaeus vannamei) which is supported by 1 paddlewheel. The result showed that the optimal number of paddlewheel was 1 paddlewheel with Standart Aeration Efficiency was 1,31 kgO_2/kWh. The percentage of oxygen absorption on vannamei shrimp until final cultivation was 24% during the cultivation, the percentage of oxygen absorption on vannamei shrimp had increased. In this research, total oxygen demand was 567 ppm, shrimp production was 1054,88 kg, the amount of feed was 2278,1 kg with a pond area was 600 m^2, stocking density was 133 PL/m^2 during a cultivation period of 98 days.

Keyword : Paddlewheel, Oxygen, Vannamei shrimp (*Litopenaeus vannamei*)

1. Introduction

Vannamei shrimp (*Litopenaeus vannamei*) was officially introduced to the farming community in 2001 after the decline in tiger shrimp (*Penaeus monodon*) production due to various problems encountered in the production process, both technical and non technical (Kaligis, 2010). Vannamei shrimp (*L. vannamei*) from America was the first to enter Indonesia in may 2002 with the import of 2000 vannamei shrimp (*L. vannamei*) seed and 5 million post larvae from Hawaii and Taiwan then 300.000 from Latin America (Ruswahyuni *et al*., 2010).

The problem in the intensive system is by increasing the density of Vannamei shrimp (*L. vannamei*), followed by increasing the number of oxygen consumption and how to overcome the lack of oxygen in the ponds at a high density of Vannamei shrimp (*L. vannamei*) in intensive pond. Lack of oxygen concentration is recognized as a cause of stress, decreased appetite, slow growth, susceptible to disease, and mortality in shrimp or fish (Boyd, 2000). Respiratory activity decreases and is susceptible to disease when oxygen is too low (Velazco *et al*., 2010).

Paddlewheel can be used to add the concentration of dissolved oxygen in the pond and can prevent aquatic biota of death during the period of low oxygen (Boyd, 1982). Kurniawan *et al*. (2014) said that the number of paddlewheel with Standart Aeration Efficiency was 1.31 kgO_2/kWh to be used in vannamei shrimp ponds with a pond area of 600 m^2 and stocking density was 133 PL/m^2. The objective of this research was to determine the percentage of oxygen absorption by vannamei shrimp (*Litopenaeus vannamei*) which is supported by 1 paddlewheel and a dynamic model was used to obtain optimal value or amount in the application of paddlewheel.

2. Materials And Methods

These data were taken in intensive shrimp vannamei ponds at BBAP Situbondo, East Java. The research was carried out for 98 days and used 1 pond with the specification as shown in Table 1:

Table 1. Specification of intensive ponds

No	Variable	Unit	Value
1	Pond size	m^2	600
2	Stocking density	PL/m^2	133
3	Starting of aeration	hours	24
4	Time of cultivation	days	98
5	Water depth	m	120

Material used in this research was an intensive pond, Whiteleg shrimp sample, the feed supply. The equipments used are paddlewheel, thermometer, sampling net, daily feed log book and plastic bucket for biomass calculation. Water quality was measured with 4 parameters i.e.: dissolved oxygen, temperature, salinity, and pH. The purpose of the measurement was to determine the fluctuations during 24 hours and to calculated the optimizing number of paddlewheel in the ponds.

Data analysis

Quantitative analysis approach:

The vannamei shrimp (*L. vannamei*) respiration rate (mg O_2 shrimp^{-1} h^{-1}) as a function of temperature, salinity, and wet body weight (Table 2) (Vinatea *et al*. 2011). In the calculation, 1 m^3 of water per square meter of area was considered, and the respiratory rate was multiplied by the number of shrimp in each hypothetical stocking density and then divided by 1000 to find the oxygen consumption values (mg O_2 L^{-1} h^{-1}).

Table 2. Individual respiratory rate (mg O_2 Shrimp^{-1} h^{-1}) of *L. vannamei* as a function of temperature, salinity, and wet weight (Vinatea *et al*., 2011)

Salinity (ppt)	Temp. (C)	5 gr (ppm)	10 gr (ppm)	15 gr (ppm)	20 gr (ppm)
37	20	0,8	1,91	3,2	4,6
	25	1,22	1,84	2,35	2,79
	30	1,73	3,19	4,55	5,86
25	20	0,81	1,88	3,08	4,37
	25	1,23	2,5	3,78	5,08
	30	1,63	3,22	4,8	6,36
13	20	1,01	2,22	3,52	4,88
	25	1,25	2,53	3,83	5,13
	30	1,61	3,28	4,96	6,65
1	20	0,86	1,66	2,42	3,18
	25	1,19	2,55	3,98	5,45
	30	1,91	4,25	6,77	9,42

Calculation at night where, the paddlewheel was the main oxygen supplier. So, the paddlewheel transfers oxygen by 50% from SAE (*Standart Aerator Efficiency*). And then, miltiplied by 12 hours during the night. So, the formula for determining the percentage of shrimp ability to absorb oxygen is:

$$\frac{Vannamei\ shrimp\ respiration}{Actual\ oxygen\ transfer} x100\%$$

Dynamic system approach:

Model development was done using dynamic system approach. Dynamic system modelling was based on conceptual representation of relation among different system components (Bullgao *et al*., 2013). For this reason, STELLA^{TM} software was used in this research.

The conceptual model was made and than be translated into dynamic system modelling (Stella^{TM}) through stock and flow maps. Stages in the construction of models (Jianguo, 1991) (Figure 1).

3. Results And Methods

Water quality result was observed during 24 hours in order to determine the fluctuations Table. 3

Table 3. Water quality during 24 hours

Time	O_2 (ppm)	pH	Temperature (^{0}C)	Salinity (ppt)
01.00	1,7	6,7	29,8	38
03.00	1,7	6,66	29,8	38
05.00	1,5	6,65	29,5	38
07.00	3	6,71	31,3	38
09.00	4,5	6,82	30,9	38
11.00	5,8	7	31	39
13.00	7,2	7,05	31,8	39
15.00	5,5	6,89	32	39
17.00	3,7	6,9	31,8	38
19.00	2,8	6,82	30,7	38
21.00	2,2	6,75	30,2	38
23.00	2	6,7	29,7	38

The highest oxygen concentration was observed at 13.00 (7,2 ppm) and subsequently decreased to the lowest concentration at 05.00 (1,5 ppm) than subsequently increased until 13.00 continuously during 24 hours. pH concentration showed no significant difference a range between 6,65 of 05.00 am to 7,05 of 13.00. Temperature value was no significantly different a range between 29,5^{0}C at 05.00 am to 32^{0}C at 15.00 and didn't show significant fluctuation. Salinity concentration showed no significantly different a range between 38 to 39 ppt.

Table 4. The result of vannamei shrimp (*L. vannamei*) oxygen consumption rate (mg O^2 L^{-1} h^{-1})

Days	Density (shrimp)	Temperature (^{0}C)	Salinity (ppt)	Weight 5 gr (PPM/h)	Weight 10 gr (PPM/h)	Weight 15 gr (PPM/h)
1 - 20	80000	30	37	138,4	255,2	364
21 - 30	80000	30	37	138,4	255,2	364
31 - 40	80000	30	37	138,4	255,2	364
41 - 50	80000	30	37	138,4	255,2	364
51 - 60	76000	30	37	131,48	242,44	345,8
61 - 70	76000	30	37	131,48	242,44	345,8
71 - 80	76000	30	37	131,48	242,44	345,8
81 - 90	76000	30	37	131,48	242,44	345,8
91 - 98	76000	30	37	131,48	242,44	345,8

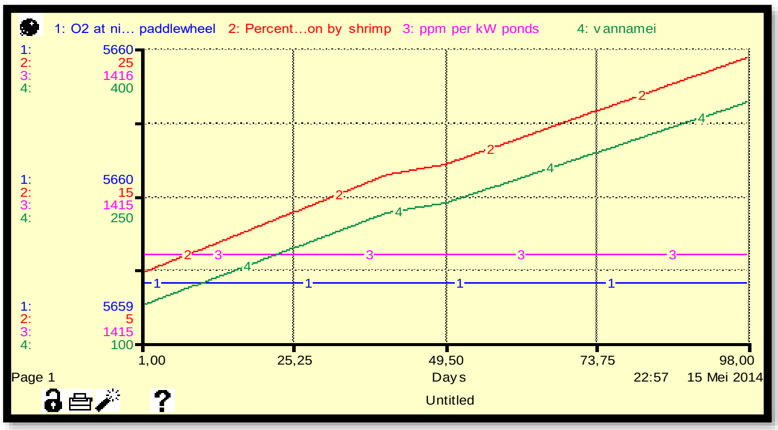

Figure 1. The model of vannamei shrimp (*L. vannamei*) oxygen consumption rate (mg $O^2L^{-1}h^{-1}$) ((1) Oxygen demand, (2) Phytoplankton, (3) vannamei shrimp (4,5) oxygen consumption of organic matter)

Figure 2 showed that to increase of the oxygen consumption from 1 to 25 days of cultivation an increase (138.4 until 196.80 mg O^2 L^{-1} h^{-1}), 25 to 50 days of cultivation an increase (196.80 until 244.04 mg O^2 L^{-1} h^{-1}), 50 to 74 days of cultivation an increase (244.04 until 294.12 mg O^2 L^{-1} h^{-1}), 74 to 98 days of cultivation an increase (294.12 until 345.80 mg O^2 L^{-1} h^{-1}). The percentage of oxygen absorption ability was showed by a Model Dinamic System (Figure 3).

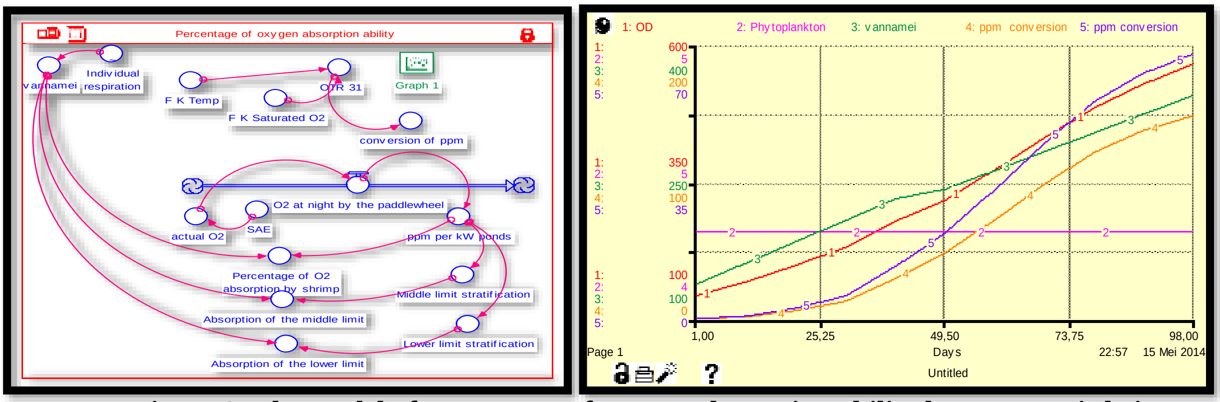

Figure 2. The model of percentage of oxygen absorption ability by vannamei shrimp (*L vannamei*). (Causality and Causality Graph)

The above model showed that increased percentage of oxygen absorption from the beginning to the end of cultivation (Graph No 2). This happens, along with the increasing respiration rate of vannamei shrimp (*L vannamei*) (Graph No 4) which is influenced by increasing the body weight of vannamei shrimp (*L vannamei*). The percentage of oxygen absorption at day 1 to 25 was 9.78 to 13.87%, at days 25 to 50 was 13.87 to 17.21%, at days 50 to 74 was 17.21 to 20.83%, and at days 74 to 98 was 20.83 to 24.44%.The respiration of vannamei shrimp (*L vannamei*) at day 1 to 25 was 138.40 to 196.20 ppm aerator, at days 25 to 50 was 196.20 to 243.51 ppm, at days 50 to 74 was 243.51 to 294.65 ppm, days 74 to 98 was 294.65 to 345.80 ppm.

4. Discussion

The result of the fluctuation of water quality was different during 24 hours for intensive production of *L. vannamei* (Table 3). The result obtained was the highest oxygen concentration was observed at 13.00 (7,2 ppm) and subsequently decreased to the lowest concentration at 05.00 (1,5 ppm). It is suspected that phytoplankton play an important role in increasing oxygen during the day by photosynthesis. The highest level of oxygen in a pond appeared during the daytime when the phytoplankton was producing oxygen through photosynthesis (Conte and Cubbage, 2001). Boyd (2000) said that oxygen levels can be higher for 24 hours, but the response of cultuivated spesies appears to be highlighted by the low oxygen concentration at night.

Highest pH concentration was observed 13.00 (7,05) and subsequently decreased to the lowest concentration at 05.00 (6,65). Phytoplankton use CO_2 during the daytime, the pH would increased and at night phytoplankton and all organisms release CO2 resulting in pH will decrease (Boyd, 1989). The result of temperature measurements in the field for 24 hours was normal (29^0C – 32^0C) because it is in accordance with the water quality standard in BSN (2012) was $28{,}5^0$C – $31{,}5^0$C. And 28^0C – 31^0C (Farchan, 2007).

The result of temperature measurement in the field for 24 hours was normal, namely 29.1 – 32^0C. Water temperature was very closely related to the concentration of dissolved oxygen and the rate of oxygen consumption in water (Kurniawan *et al*., 2014). Kordi and tancung (2005) said that temperature also affects metabolic activity, therefore the spread of organisms both in the ocean and in freshwater waters was limited by the temperature of these waters. Salinity was the content of dissolved salts in water and is often expressed in parts per thousand (Tucker, 1991). The result of in situ measurement for 24 hours was mederate, ranging from 38 – 39 ppt. According to Boyd (1989) the salinity range in vannamei shrimp (*L. vannamei*) culture was 15 – 25 ppt.

Intensivication of aquaculture in general has caused higher oxygen demand in the culture unit and, consequently, in the number of aerator needed to fulfill satisfactorily the organism demands (Boyd, 1998). Until now intensive cultivation system have been limited not only because of the high cost of feed formulations but also for their use due to poor pond environments (Naranjo *et al*., 2012). Vannamei shrimp *(L. vannamei)* can grow large quickly if connected with good environmental factors (Reyna, 2001). Kurniawan *et al*., (2014) said that the number of paddlewheel with Standart Aeration Efficiency was 1.31 kgO_2/kWh to be used in vannamei shrimp ponds with a pond area of 600 m^2 and stocking density was 133 PL/m^2. All gas can be dissolved in the water, the amount of partial pressure of all dissolved gases is known as total gas pressure (Lekang, 2007).

In this research, we found the percentage of oxygen absorption by vannamei shrimp (*L. vannamei*) was right by using a dynamic system model. Analysis of oxygen uptake by vannamei shrimp (*L. vannamei*), based on actual oxygen transfer which results in 1415 ppm and vannamei shrimp (*L. vannamei*) respiration from beginning to the end of the cultivation.

From the series of model above (Figure. 2) states that is a linear relationship between vannamei shrimp (*L vannamei*) respiration rate and percentage of oxygen absorption by vannamei shrimp (*L vannamei*). The above model showed that increased percentage of oxygen absorption from the beginning to the end of cultivation (Graph No 2). This happens, along with the increasing respiration rate of vannamei shrimp (*L vannamei*) (Graph No 4) which was influenced by increasing the body weight of vannamei shrimp (*L vannamei*).

Paddlewheel was often used because paddlewheel provide better efficiency and comfort in it's operation and maintenance of the paddlewheel (Rao and Kumar, 2007 in Bhuyar *et al*., 2009). The efficiency of a paddlewheel can affect the amount of oxygen transferred to meet the oxygen requirements of shrimp. (Kurniawan *et al*., 2014).

5. Conclusions

The conclusion of the result showed that the percentage of oxygen absorption by vannamei shrimp (*L. vannamei*) was 24% in 600 m^2 pond area and stocking density of 133 vannamei PL/m^2 by used 1 paddlewheel.

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