

AKUAKULTURA



CARRYING CAPACITY OF VANNAME SHRIMP (Litopenaeus vannamei) PONDS IN THE ASPECT OF WATER QUALITY AT PURWOREJO VILLAGE, PASIR SAKTI SUBDISTRICT, EAST LAMPUNG DISTRICT

DAYA DUKUNG TAMBAK UDANG VANAME (Litopenaeus vannamei) PADA ASPEK KUALITAS AIR DI DESA PURWOREJO, KECAMATAN PASIR SAKTI, KABUPATEN LAMPUNG TIMUR

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Abstract

The carrying capacity of ponds in vaname shrimp farming is one of the factors supporting the productivity of aquaculture. The purpose of this study was to evaluate the carrying capacity of vaname shrimp ponds in the aspects of water quality to determine efforts to develop vaname shrimp farming based on the carrying capacity of the pond environment. This research was conducted in Purworejo Village, Pasir Sakti District, East Lampung Regency. The research parameters observed included physical, chemical, and biological parameters of water. The results obtained were temperature 29°C, salinity 18.7-19.3 ppt, pH 8.1-8.3, Dissolved Oxygen (DO) 6.0-6.6 mg/l, Total Ammonia Nitrogen (TAN) 0.023-0.083 mg/l, nitrite 0.086-0.149 mg/l, Total Organic Matter (TOM) 63.3-72.3 mg/l, alkalinity 143-165 mg/l, hardness 1860-1933 mg/l, plankton abundance 776 x 10³ - 1025 x 10³ cell/ml, *Total Vibrio Count* (TVC) 1.83 x $10^3 - 2.30 \times 10^3$. The conclusion obtained is that the physical and biological parameters of water quality are in optimal condition for vaname shrimp farming. In chemical parameters, the concentration of TOM exceeds the optimal limit, so it is necessary to do routine flushing and water changes.

Keywords: Pond Productivity, Pond Carrying Capacity, Water Quality, Vanname Shrimp

1. Introduction

Lampung is one of the regions with a long coastline and high potential for coastal commodities, so many people work as farmers. The main farm commodity is vaname shrimp (Aditama et al., 2024). The majority of farmers in Purworejo Village, Pasir Sakti District, use a semi-intensive farming system. Vaname shrimp farming can achieve maximum results if supported by

Abstract

The carrying capacity of ponds in vaname shrimp farming is one of the factors that support farming productivity. The purpose of this study was to evaluate the carrying capacity of vaname shrimp ponds in terms of water quality to determine efforts to develop vaname shrimp farming based on the carrying capacity of the pond environment. This study was conducted in Purworejo Village, Pasir Sakti Subdistrict, East Lampung Regency. The research parameters observed included physical, chemical, and biological water parameters. The results obtained were temperature 29°C, salinity 18.7-19.3 ppt, pH 8.1-8.3, Dissolved Oxygen (DO) 6.0-6.6 mg/l, Total Ammonia Nitrogen (TAN) 0.023-0.083 mg/l, nitrite 0.086-0.149 mg/l, Total Organic Matter (TOM) 63.3-72.3 mg/l, alkalinity 143-165 mg/l, hardness 1860-1933 mg/l, plankton abundance 776 x 103 - 1025 x 10³ cells/ml, *Total Vibrio Count* (TVC) 1.83 x 10³ - 2.30 x 10³. The conclusion is that the water quality in terms of physical and biological parameters is optimal for vaname shrimp farming. For chemical parameters, the TOM concentration exceeded the optimal limit, necessitating regular siphoning and water replacement.

Keywords: Pond Productivity, Pond Carrying Capacity, Water Quality, Vaname Shrimp

optimal pond carrying capacity. Pond carrying capacity is the level of ecological suitability that can accommodate the maximum capacity of a biomass or waste load in a farming ecosystem (Wafi *et al.*, 2021). Continuous shrimp farming activities can cause a decline in pond carrying capacity (Ariadi *et al.*, 2022). Ecological changes in the pond environment will affect the pond carrying capacity, which in turn will impact pond productivity. This situation is a consequence of the development of shrimp pond farming activities that are only profit-oriented without considering the pond carrying capacity.

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The problem faced is that the decline in pond carrying capacity can affect water quality in aquaculture ponds. Water quality greatly affects the cultivated biota. Water quality that meets aquaculture standards will support optimal growth. Conversely, poor water quality can cause stress, thereby inhibiting growth. Therefore, in aquaculture, it is important to maintain the carrying capacity of the environment to avoid crop failure (Farabi and Latuconsina, 2023). Information on pond carrying capacity in terms of water quality, especially in Purworejo Village, is not widely available. The purpose of this study is to evaluate the carrying capacity of vaname shrimp ponds in terms of water quality and, if there are suboptimal water quality parameters, additional treatments can be provided to support the sustainability of vaname shrimp farming in Purworejo Village, Pasir Sakti District, East Lampung Regency.

2. Materials and Methods

2.1. Time and Place

This study was conducted in November-December 2021. Water samples were collected from vaname shrimp ponds located in Purworejo Village, Pasir Sakti District, East Lampung Regency. Water samples were analyzed at the Mini Lab Central Proteina Prima (CPP) and the Integrated Laboratory and Technology Innovation Center (LTSIT) of the University of Lampung.

2.2. Water Quality Measurement

Water samples were collected every two weeks. Measurements of temperature, salinity, pH, and DO were taken *in situ* at 8:00 a.m. and 5:00 p.m. Western Indonesian Time, while measurements of water parameters such as Total Ammonia Nitrogen (TAN), nitrite, *Total Organic Matter (TOM)*, alkalinity, hardness, plankton abundance, and total vibrio were taken ex situ and then tested in the laboratory.

2.3. Data Analysis

Data were analyzed descriptively, quantitatively, and qualitatively. Data on physical, chemical, and biological water parameters were analyzed descriptively. The results obtained were compared with the optimal quality standards for vaname shrimp farming. Plankton abundance and *Total Vibrio Count* (TVC) data were analyzed quantitatively. Plankton abundance can be calculated using the following formula:

$$N = \frac{Oi}{Op} \times \frac{Vr}{Vo} \times \frac{1}{Vs} \times \frac{n}{p}$$

Explanation:

N : Number of individuals per liter

Oi : Sedwick Rafter cross-sectional area (mm²)

Op : Area of one field of view (mm²)
Vr : Volume of filtered water (ml)
Vo : Volume of water observed (ml)
Vs : Volume of filtered water (L)
N : Number of plankton found

The $\it Total \ Vibrio \ Count \ (TVC)$ can be calculated using the following formula:

$$N = \frac{C}{(1 \times n_1) + (0, 1 \times n_2) \times a}$$

Explanation:

N : Number of product colonies

c : Number of colonies on each plate counted
 n₁ : Number of plates in the first dilution counted
 n₂ : Number of cups in the second dilution that is counted

d: The first dilution that is counted

3. Results and Discussion

Water quality plays an important role for vaname shrimp because water serves as the shrimp's living medium. Management of pond water quality plays a role in determining the success of vaname shrimp farming. Suboptimal water quality can disrupt shrimp activity, one of which is causing stress, thereby reducing the shrimp's appetite. Water quality management is carried out to maintain the chemical and biological conditions in the cultivation medium so that it remains sterile and is not easily susceptible to disease (Maknun and Sumsanto, 2023). In this study, the water quality observed included physical, chemical, and biological parameters.

Table 1.Results of Water Quality Measurements in Vaname Shrimp Farming Ponds

Parameters	Farm			 Optimal Standard
	T1	T2	T3	- Optimai Standard
Temperature	29	29	29	28 - 32°C
(°C)				(Kurniaji et al., 2022)
Salinity (ppt)	19.3	19.3	18.7	15-37 ppt
				(Kurniaji et al., 2022)
pН	8.3	8.1	8.1	7 – 8.3
				(Kurniaji et al., 2022)
DO (mg/L)	6.6	6.1	6	3-7.5 mg/L
				(Putra et al., 2023)
TAN (mg/L)	0.023	0.083	0.074	<0.1 mg/L
				(Anggoro et al., 2024)
Nitrite (mg/L)	0.086	0.149	0.136	0.05-1 mg/L
				(Venkateswarlu et al.,
				2022)
TOM (mg/L)	72.3	63.3	68.7	55 mg/L
				(Halim et al., 2022)
Alkalinity	165	145	143	90-150 ppm
(ppm)				(Listriyana et al.,
				2023)
Hardness	1900	1933	1866	<3000 ppm
(ppm)	_			(Ramadina, 2021)
Plankton	776 x 10 ³	1025 x 10 ³	828×10^3	$10^4 - 12 \times 10^3$
abundance				(Halim et al., 2023)
(cells/mL)		_	_	
Total Vibrio	1.83×10^3	2.08×10^3	2.30×10^3	$10^4 - 10^6$
(CFU/mL)				(Lestari et al., 2018)

The results of water quality measurements consisting of physical, chemical, and biological parameters can be seen in Table 1. Based on the above data, the physical parameter observed is temperature. The temperature value obtained was 29°C, which is suitable for vaname shrimp. According to Kurniaji et al. (2022), the optimum temperature ranges from 28 to 32°C. If the temperature exceeds the optimum level, the metabolism in the shrimp's body will accelerate. Conversely, if the ambient temperature is lower than the optimum temperature, shrimp growth will decline, as indicated by a decrease in appetite (Supriatna et al., 2020). The temperature of pond water greatly affects biological, physical, and chemical processes in the water. In addition, water temperature greatly affects the morphological growth, behavior, metabolism, and reproduction of shrimp in ponds. The effect of temperature on shrimp farming is significant, as the higher the temperature in the water, the lower the concentration of dissolved oxygen (Utami et al., 2023).

The physical parameters observed in this study consisted of salinity, pH, dissolved oxygen (DO), total ammonia nitrogen (TAN), nitrite, total organic matter (TOM), alkalinity, and hardness. The salinity value in the vaname shrimp ponds at the research site ranged from 18.7 to 19.3 ppt, which is within the optimal range for vaname shrimp farming. This is in accordance with the statement by Kurniaji et al. (2022), that the salinity that supports vaname shrimp growth ranges from 15 to 37 ppt. Salinity plays an important role in water quality because it affects the growth of vaname shrimp. In addition, salinity also affects the molting process because it is closely related to the osmoregulation process in vaname shrimp. The higher the salinity, the greater the electrolyte concentration, and thus the higher the osmotic pressure- (Jayanti et al., 2022). Shrimp living at normal temperatures and salinity levels will facilitate the molting process. Molting, or the shedding of shrimp skin, is a process that allows the shrimp's body volume to increase (Se et al., 2023).

The observed pH value ranged from 8.1 to 8.3, indicating that this pH value is suitable for shrimp farming. According to Farabi and Latuconsina (2023), the relationship between pH and vaname shrimp life is in the range of 6.1-7.5 (moderate production), in the range of 7.6–8.0 (fairly good for shrimp farming), in the range of 8.1-8.7 (good for shrimp farming), and 8.8–9.5 (production begins to decline). Water with pH values that are too high or too low can cause stress in shrimp. This is characterized by changes in the shrimp's carapace, which becomes soft and causes a higher mortality rate in shrimp. The pH value of water can decrease due to respiration and the decomposition of organic substances. This decrease in pond water pH occurs due to the decomposition of organic materials by microorganisms, which releases CO(2) that can reduce oxygen concentration and water pH (Halim et al., 2022). If the pH is low, the dissolved oxygen content will decrease, resulting in reduced oxygen consumption, increased respiratory activity, and decreased appetite.

The dissolved oxygen values obtained in the ponds at the research site ranged from 6.0 to 6.6 mg/L, which is still suitable for supporting shrimp life. According to Putra et al. (2023), the optimal oxygen content for vaname shrimp farming ranges from 3 to 7.5 mg/L. Oxygen solubility in pond water will increase as the environmental carrying capacity decreases (Wafi et al., 2021). Dissolved oxygen affects the growth of vaname shrimp. If dissolved oxygen conditions are not optimal, it causes competition for oxygen consumption during photosynthesis, resulting in a decrease in dissolved oxygen concentration. In addition, suboptimal dissolved oxygen concentrations can also cause the death of vaname shrimp (Yanti et al., 2023). The sources of oxygen in ponds come from water exchange, the use of water wheels, and blowers. In the ponds at the research site, the source of oxygen came from the use of water wheels. The function of water wheels on dissolved oxygen is to stir, thereby accelerating the diffusion process and regulating the position of organic matter deposits or feed and feces residues (Suhendar et al., 2020).

The Total Ammonia Nitrogen (TAN) values obtained in this study ranged from 0.023 to 0.083 mg/L, which is within the optimal range because the total ammonia nitrogen content is <0.1 mg/L. This is in accordance with the statement by Anggoro et al. (2024), that a good ammonia level in pond water is below 0.1 mg/L. In pond T2, the TAN level obtained was higher than in the other ponds. This occurred because pond T2 was not regularly cleaned and the water was not changed. According to Arsad et al. (2017), irregular water replacement and siphoning can affect the accumulation of feces and feed residues at the bottom of the water, which is a factor that triggers ammonia levels. Ammonia entering the water can have a negative impact on shrimp farming activities. Ammonia in the aquatic environment can appear in the form of un-ionized ammonia (NH3)and ionized ammonia (NH4), but both can combine to form Total Ammonia Nitrogen (TAN) (Wahyuningsih and Gitarama, 2020). According to Suhendar et al. (2020), dissolved ammonia content can increase with longer cultivation periods. In addition, high stocking densities also increase the feed requirements of shrimp in ponds, which can lead to the accumulation of feed residues and feces. Ammonia in water that exceeds the limit is considered to cause stress in shrimp, resulting in a decrease in appetite.

The nitrite concentration values obtained ranged from 0.086 to 0.149 mg/L, indicating that these values are still within the optimal range for vaname shrimp farming. The optimal nitrite content in vaname shrimp farming waters is >0.05 mg/L, while >1 mg/L can be a limiting factor (Venkateswarlu *et al.*, 2019). Nitrite is an inorganic nitrogen compound formed as a result of

ammonia oxidation by *Nitrosomonas* bacteria. Therefore, nitrite concentration depends on the amount of ammonia. The higher the amount of ammonia, the higher the nitrite concentration in the water. Nitrite compounds in ponds need to be removed or reduced because they can be toxic to shrimp (Sambu *et al.*, 2021).

Total Organic Matter (TOM) indicates the total organic content in a body of water, consisting of dissolved, suspended, and colloidal organic matter (Abdillah et al., 2024). The measured TOM content ranged from 63.3 to 72.3 mg/L. This indicates that the total organic matter concentration in vaname shrimp ponds exceeds the optimal limit. According to Halim et al. (2022), the optimal limit for TOM concentration in vaname shrimp farming should not exceed 55 mg/L. The high TOM concentration in these ponds is caused by waste deposits at the bottom of the ponds, which originate from increased feeding, feces, and dead organisms in the water, such as mass plankton deaths and shrimp mortality. The amount and concentration of organic waste produced in intensive ponds are very high. In addition to cultivation waste, organic particles in ponds also come from chemical residues from the use of probiotics, liming, and fertilization in ponds. An increase in organic waste in ponds will cause the carrying capacity of the ponds to decline, as will the production of farmed shrimp. To reduce TOM levels in ponds, water changes and regular siphoning can be carried out (Ghufron et al., 2017).

Alkalinity is a water quality parameter that affects the abundance of mineral ions and calcium in pond water. The alkalinity values obtained in this study ranged from 143 to 165 ppm. According to Listriyana *et al.* (2023), the optimal alkalinity for vanamei cultivation ranges from 90 to 150 ppm. In pond T1, the alkalinity value exceeded the optimal limit, requiring water replacement. Excessively high alkalinity can cause hardness and inhibit the molting process in vaname shrimp. Alkalinity within the optimal range will help provide calcium for the osmotic needs of cells in the shrimp's body. Alkalinity functions as *a* natural pH *buffer* in ponds because it can maintain pH values despite fluctuations in water pH, whether from new water, rainwater, or the application of other materials (Yunarty *et al.*, 2022).

Hardness values in ponds are related to alkalinity levels. If alkalinity is high, hardness will also be high. The hardness results obtained in vaname shrimp ponds ranged from 1866 to 1933 ppm. This indicates that the hardness in these ponds is within the optimal range. According to Ramadina (2021), the highest level of hardness is 3000 ppm. The concentration of hardness in ponds is an accumulation of calcium ($Ca(^{2+})$ and magnesium ($Mg(^{2+})$ hardness. In addition, hardness also correlates with the abundance of mineral ions and the type of soil conditions in the environment surrounding the ponds. If the hardness concentration is high, it will form a crust that sticks to the gills (), making it difficult for shrimp to breathe and causing death. This hardness can cause toxicity through certain metal ions if left unchecked (Manullang *et al.*, 2023).

In this study, the biological parameters observed were plankton abundance and total vibrio. Plankton are organisms that float in the water body, so the frequency of water exchange in the cultivation pond will affect the types of plankton present in the vaname shrimp ponds. The availability of nutrients and changes in the nutrient ratio in a water body can cause changes in plankton abundance and species composition (Aisyah *et al.*, 2023). In the research ponds, the plankton abundance values obtained ranged from 10(⁴⁾to 12 x 10(³⁾cells/ml. The high plankton abundance was influenced by sufficient nutrient sources and the ability of plankton to utilize these nutrients. This is in line with the statement by Halim *et al.* (2023) that pond preparation affects the growth of phytoplankton in the pond.

Fertilization will cause the pond bottom to become fertile so that aquatic plants, especially blue algae, can grow well. Fertility will decrease as the maintenance period increases.

Vibrio is a group of opportunistic pathogenic bacteria commonly found in brackish water. Members of this bacterial group are characterized by their short rod shape, facultative aerobic nature, lack of capsule, gram-negative binary fission reproduction, flagella, lack of spores, and growth on Thiosulfate Citrate Bile Salt Sucrose (TCBS) media (Idami and Nasution, 2020). In this study, the total number of Vibrio obtained was 1.83 x^{10^3} – 2.30 x 10^3 CFU/mL, which is still safe for vaname shrimp farming activities. Bacterial isolates will be pathogenic to shrimp when their concentration is 104-107 CFU/mL and will affect shrimp survival after 24 - 48 hours (Lestari et al., 2018). High TVC indicates that water quality is not well maintained, which affects shrimp appetite, survival rate, and growth rate (Wafi et al., 2021). According to Amrullah et al. (2023), an increase in the number of Vibrio sp. bacteria in aquaculture is the main cause of disease in shrimp. In addition, environmental factors also influence the emergence of diseases caused by instability in pH, salinity, oxygen levels, temperature, ammonia, and organic materials, as these can cause stress and disease in shrimp.

4. Conclusion

Based on the results of research on the carrying capacity of vaname shrimp ponds in terms of water quality, it can be concluded that the physical parameters of the water are optimal for vaname shrimp farming. In terms of chemical parameters, the *Total Organic Matter* (TOM) value exceeds the optimum limit, so measures such as siphoning and routine water replacement are necessary. Regarding biological parameters, the abundance of plankton and total vibrio levels remain within safe conditions for vaname shrimp farming activities.

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