

The water quality monitoring of vannamei shrimp (*Litopenaeus vannamei*) ponds in East Tanete Riattang District, Bone Regency, Indonesia

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ABSTRACT

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The monitoring of water quality is an essential process of shrimp production. This study aimed to evaluate the water quality based on physical, chemical, and biological parameters in a vannamei shrimp pond, which is managed by an intensive system in East Tanete Riattang District, Bone Regency. The sampling of parameters was conducted from March to April 2020 at the ponds in three villages, which include Waetuo (station A), Panyula (station B), and Toro (station C). The water quality was evaluated at each sampling site based on certain factors, such as dissolved oxygen (DO), temperature, salinity, pH, ammonia, and bacterial population. The results showed that the temperature, salinity, pH, DO, and bacterial populations ranged from 26 to 30 °C, 25 to 35 ppt, 5.5 to 7.0, 5.5 to 7.0 ppm, and 3.5×10^1 to 2.1×10^3 , respectively. According to the National Standard of Indonesia for shrimp culture, the range of these water quality parameters was suitable for vannamei shrimp life. Meanwhile, the level of ammonia was 1.7 to 1.8 ppm, which exceeded the normal range that supports the vannamei shrimp life-cycle.

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Introduction

White leg shrimp (*Litopenaeus vannamei*) is a significant commodity in Indonesia. Its culture is a rapidly-expanding business globally (Sivakumar, Harinath Reddy, and Surya Bhaskar Rao, 2020) due to the rapid growth, disease tolerance, and adaptability to high-density culture of this shrimp species (Liu *et al.*, 2020). Shrimp farming has become very important in Asia, with its countries producing more than 70 % of the world's shrimp commodities (Venkateswarlu *et al.*, 2019). Previous studies showed that the aquaculture of *L.vannamei* is one of the most important crustacean farming industries (Ni *et al.*, 2018). However, the sustainability of shrimp farming is highly dependent on the dynamic aspects of coastal water quality due to some interactions among shrimp

farmers in the coastal area for aquaculture activities (Kasnir *et al.*, 2014).

Water quality is an important aspect of the fish farming environment since the environment directly affects the farming activities of *L. vannamei*. It influences the propagation, development, and survival of aquatic animals. Vannamei shrimps are susceptible to stress, specifically when the environment is not favourable. Also, the reduction in water quality could stress the shrimp and cause diseases, which often leads to difficulties in rearing shrimp (Ritonga *et al.*, 2021). The assessment for

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good water quality is dependent on the species to be considered based on their safe levels (Sivakumar et al., 2020).

Vannamei shrimps need good water quality to optimize their growth and survival rate in aquaculture. Some parameters of water quality, such as salinity, pH, dissolve oxygen (DO), ammonia and temperature can have a direct and indirect impact on vannamei in a pond area. The level of DO consumption varies directly with feed input because of the waste biosynthesis and other organic materials (Ariadi et al., 2019). Water with a pH ranging from 7.5 to 9.0 is generally considered suitable for shrimp production. Ammonia may affect osmoregulatory capacity, the physiological state of the gills and hepatopancreas, increase the frequency of molting, reduce the growth of shrimp, and lead to high mortality rates (Lu et al., 2016). Temperature changes may affect growth, swimming, feeding, or lead to death in some cases (Huang et al., 2017; Xu et al., 2018).

The condition of the water present in the pond area of East Tanete Riattang District, Bone Regency, should be carefully monitored because this study results can be of significant use to farmers and the local government (Jarir et al., 2020). Presumably, the experiment has not been conducted in the area. This study aims to evaluate the water quality of vannamei shrimp (*L. vannamei*) pond along the coast of East Tanete Riattang District

Materials and Methods

Location and time of research

This study was conducted in the coastal area of East Tanete Riattang District, Bone Regency, South Sulawesi (Figure 1). It focused on three villages, namely Waetuo, Panyula, and Toro, which can be seen on the map below. Laboratory tests were conducted on various samples for two months at the Brackish Water Aquaculture Fishery Center Takalar, South Sulawesi, from March to April 2020.

Equipment and materials

Several equipment and materials were needed to perform the procedures in this study. The tools included throw nets (to take samples), sample bottles, plastic packing, and oxygen cylinders. Other materials used were questionnaires that had been prepared in relation to the basic requirements, samples of vannamei shrimp approximately one month of age and 2.6 g in weight, oxygen, as well as samples of shrimp rearing pond water.

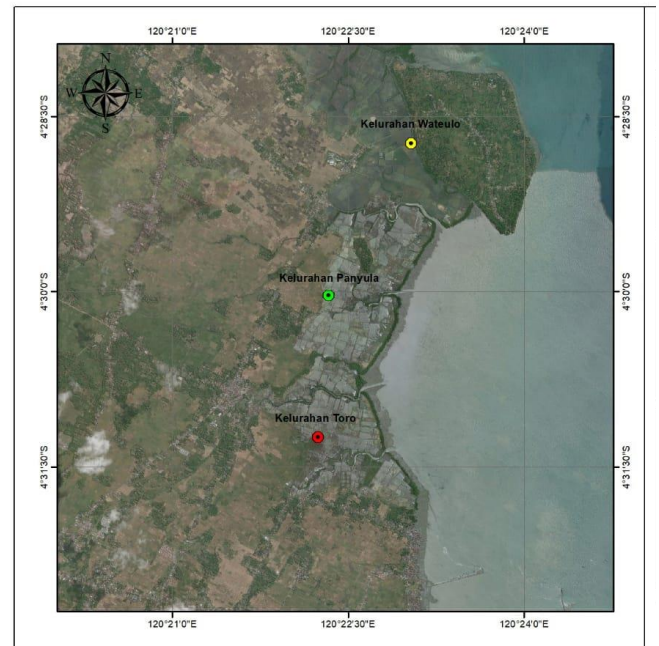


Figure 1. Study location

Water quality parameters

The water quality parameters included temperature, salinity, pH, DO, ammonia, and bacterial populations. The data on temperature, salinity, pH, and DO were obtained directly in the field weekly, while the ammonia levels (before water exchange) and bacterial population conditions were obtained in the Water Quality and Pathology Laboratory, at the Brackish Water Aquaculture Center Takalar.

Method of determination of pond samples under study

The samples were taken at random following the sampling provisions. According to data from the Marine and Fisheries Service of Bone Regency, the number of shrimp aquaculture ponds in East Tanete Riattang District is nine. The sample was taken based on the concept of (Neuman and Lawrence, 2000), which states that if the population is classified as a small category, which is less than 1000, then at least 30% of the total population is sampled. According to these factors, the number of ponds required to collect and contain the samples was set at 2-3. A proportional simple random sampling technique was conducted in each sub-district/village, which is one based on the size of the population to be represented (Nazir, 2003). This determination formula used to estimate the number of ponds required is given as

$$n_i = \frac{nk}{N} x n.$$

Where:

n_i : number of pond samples of each sub-district/village

nk: number of ponds in each sub-district/village
N: number of ponds from the entire population
n: number of ponds sampled.

Data analysis

The data obtained from the measurement of water quality parameters were analyzed descriptively by presenting in the form of tables and graphs.

Results

Description of vannamei shrimp farming activities

Shrimp farmers are known to apply intensive aquaculture. The description of the vannamei shrimp culture condition carried out in the three different locations is presented in [Table 1](#).

According to the table, Pond B was the largest pond, while Pond A had the highest stocking density. However, the highest ADG rate of shrimp occurred in pond C. The water change for each pond was different and the time intervals associated with water change in ponds A, B, and C were 3 days, 2 weeks, and 1 week, respectively. Additionally, the frequencies of water changes in ponds A, B, and C were 15%, 20%, and 20%, respectively. The frequencies of feeding ponds A, B, and C were four times, five times, and four times, respectively. The feed dose for the entire pond was 3% of the total biomass.

Table 1. Description of vannamei shrimp culture condition

Description of Cultivation Activities	Pond A	Pond B	Pond C
Land Area	1,500 m ²	1,700 m ²	1,300 m ²
Stocking Density	150 head/m ²	147 head/m ²	115 head/m ²
Change of Water Frequency	Every 3 days (15%)	Every 2 weeks (20%)	Every 1 week (20%)
Feeding Frequency	Four times	Five times	Four times
Feed Rate	3% of Body Weight	3% of Body Weight	3% of Body Weight
<i>Inlet and Outlet</i>	1 <i>inlet</i> and 1 <i>outlet</i>	1 <i>inlet</i> and 1 <i>outlet</i>	1 <i>inlet</i> and 1 <i>outlet</i>
ABW (<i>Average Body Weight</i>) (Sampling)	60 DOC = 7 - 8 g	45 DOC = 6 - 6.5 g	60 DOC = 6 - 7 g
ADG (<i>Average Daily Growth</i>)	0.3 g/day	0.25 g/day	0.32 g/day

Information:

Pond A = Toro Village

Pond B = Waetuo Village

Pond C = Panyula Village

Water quality parameters

Ammonia

The decomposition of organic (nitrogen) materials produced ammonia in water due to excretion and other metabolic activities of the microorganisms during the process ([Kordi and Tancung, 2007](#)). The results showed that the ammonia levels in ponds A, B, and C were 1.7 ppm, 1.8 ppm, and 1.7 ppm, respectively. The measurement of this parameter occurred before the transfer of water into the pond. Consequently, these statistics indicate that the ammonia levels of the pond are detrimental to the growth of vannamei shrimp.

Low pH water can result in decreased growth activity or a weak habitat, which leads to diseases and low survival rates ([Suwoyo, 2011](#)). The pH values of the three ponds are presented in [Figure 2](#).

According to the figure above, pH levels in ponds A, B, and C ranges from 6 - 6.3, 5.5 - 6, and 6 - 7, respectively. Each pond pH varies due to the various treatments of vannamei shrimp, ranging from 5.5 - 7, while the normal pH of shrimp ponds ranges from 6 - 9 ([Amri and Kanna, 2008](#)). Further studies show that the pH conditions of the ponds in East Tanete Rittang District are normal.

pH

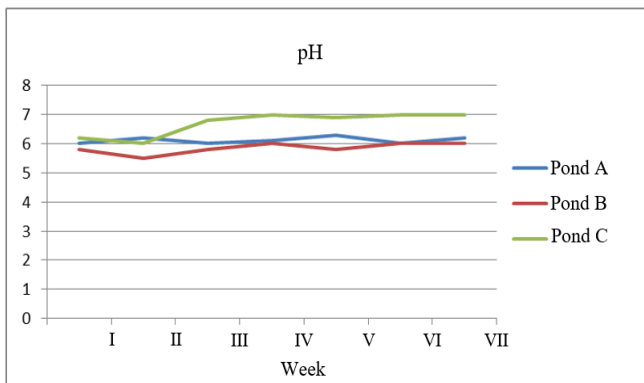


Figure 2 pH value in pond

DO

Oxygen is the most important parameter of water quality in aquaculture activities. The oxygen required must be dissolved in water for aquatic life to experience respiration (Kordi and Tancung, 2007). However, all microbial activities will reduce if the water contains insufficient DO. The role of oxygen in the ponds is not only for organism respiration but also for the oxidation of organic materials present at the bottom. The measurements of DO are presented in Figure 3.

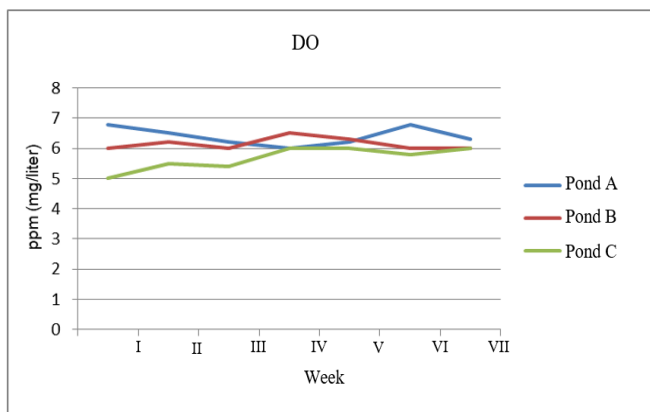


Figure 3 DO in pond

The measurement of DO in Tambak A, B, and C ranges from 6 - 6.8, 6 - 6.5, and 5 - 6 ppm, respectively. Further results show that they are in a good state for shrimp growth. The accepted range of DO, which supports shrimp growth, is 4 - 8 ppm (Farchan, 2006). The lack of DO can cause the shrimp to float above the water surface and experience stress that can lead to death. DO in vannamei shrimp aquaculture ponds in East Tanete Riattang District can be controlled by using windmills as an oxygen source. This must be conducted efficiently to avoid cost overruns.

Temperature

The temperature of water can affect the morphology, growth, behavior, reproduction, survival, and

metabolism of shrimp (Suwoyo, 2011). The temperature parameter values are presented in Figure 4.

The figure above shows that the temperature in Tambak A, B, and C ranges from 26 - 30 °C, 28 - 30 °C, and 27-30 °C, respectively. The overall temperature of the ponds ranges from 26 - 30°C and is still suitable for vannamei shrimp farming. The optimal temperature for shrimp growth is 26 - 32°C (Haliman and Adijaya, 2005).

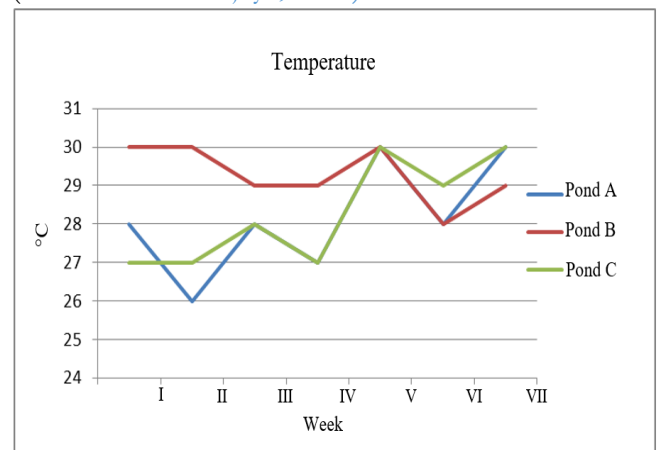


Figure 4 Temperature in pond

Salinity

Salinity is the concentration of the total ions present in water. It also describes the total solids in water after all iodides and bromides have been replaced by chlorides, all carbonates have been converted to oxides and all organic matter has been oxidized. Salinity is expressed in units of g/kg or promil (‰) (Effendi, 2003). Salinity plays an important role in water quality because it affects fish growth. Salinity affects the osmotic pressure of water, as they are both directly related (Kordi and Tancung, 2007). The organisms that reside in saltwater must be able to adapt to osmotic pressure and its environment, which requires much energy. However, this energy also requires oxygen, hence, a high salinity level will cause the dissolved oxygen to decrease, which could have detrimental effects to the organisms that are being preserved. The salinity parameter values are presented in Figure 5.

The measurements from the figure above show that the salinity of the ponds in East Tanete Riattang District ranged from 25-35 ppt and had increased in week 5. This occurred at that time because there was a dry season which increased evaporation. The high salinity of pond water is considered to be one of the major factors affecting the growth rate of vannamei shrimp during maintenance. However, (Farchan, 2006) stated that the ideal growth of vannamei

shrimp is at a salinity of 15-30 ppt, while the culture of *L.vannamei* has a wide range of salinity from 1 to 50‰(Rosas et al., 2001).

Bacterial population

This study focuses on the growth of pathogenic opportunistic bacteria in the form of *Vibrio* sp. in water. Bacteria is one of the microorganisms that exist in the environment and can be a major cause of diseases in vannamei shrimp farming. Bacterial species have been known to cause vibriosis diseases in penaeid shrimp. Furthermore, they are known to frequently attack cultivated animals, such as tiger prawns and other types of shrimp (Karunasagar et al., 1994), as well as several species of shellfish (Austin and Zhang, 2006). The results of the bacterial population in each pond can be seen in Table 2.



Figure 5 Salinity in pond

Table 2. Results of bacteria population in each pond

Pond	Bacterial	Population (CFU/ml)
Pond A	<i>Vibrio</i> sp.	5.5×10^2
Pond B	<i>Vibrio</i> sp.	3.5×10^1
Pond C	<i>Vibrio</i> sp.	2.1×10^3

The table above shows that each pond has a varied bacteria population, with Pond C having the largest and Pond B having the lowest. According to Tompo (2016), bacterial population is affected by dietary patterns, and food remains. They accumulate at the bottom of pond sediments but not in water media. Therefore, the population of *Vibrio* bacteria in the pond sediments increases and are not discarded. A shrimp farmer in East Tanete Riattang District changed the water in ponds A, B, and C every 3 days, 2 weeks, and 1 week, respectively, to reduce the bacterial population.

Discussion

Healthy environments are essential for the growth of aquatic organisms (Ferreira et al., 2011; Ma et al.,

2013). Each pond used in the study has a unique size and handling. Consequently, overcrowding could harm the entire culture system, which leads to failure because of massive waste (Rakhmanda et al., 2021). The results showed that Pond C produced the highest shrimp growth. The growth of *L.vannamei* is directly related to stocking density, water environment (Balakrishnan et al., 2011), and feed management (da Costa et al., 2016).

The ammonia content in the water should be less than 0.1 ppm. However, Farchan (2006) claims that ammonia content greater than 1 ppm is dangerous for shrimp growth. Cases such these may lead to stress on vannamei shrimps caused by microorganisms such as parasites (Buwono, 1993). The two forms of ammonia in water are NH_4^+ and NH_3 . The pH and NH_3 levels, as well as the toxicity of water, are directly related. This situation can lead to the accumulation of manure waste from leftover feed, shrimp carcasses, or other bodies at the bottom of pond in intensive aquaculture with high stocking density and very intensive feeding.

The measurement of pH is essential because Kordi and Tancung (2007) suggest that low pH will decrease DO, which leads to a decrease in oxygen consumption, an increase in respiratory activity, and a gradual loss of appetite. The organisms that are preserved will experience stress, and in extreme cases, death due to lack of oxygen. Stress is a major factor causing diseases in these organisms.

There may be cases of limited water quality equipment, hence, farmers usually practice liming after it rains to reduce soil acidity because they believe that the water in the maintenance medium will decrease pH. Farmers would rather calcify according to their estimates than carry out liming in doses. This is because they have not yet fully implemented the best aquaculture practice of vannamei shrimp culture in ponds.

The oxygen consumption level of shrimps with smaller weights is relatively higher than those with larger ones. The smaller organisms consume higher oxygen per unit of time and weight than the large ones because they require more energy for growth. Additionally, they have a higher metabolic rate than large organisms, hence, their level of oxygen consumption after meals is relatively higher because they need excess oxygen to oxidize nutrients to produce free energy.

The metabolism of a shrimp's body begins immediately if the temperature is above the optimum, resulting in an increased demand for dissolved oxygen. Shrimps experiencing

temperatures below 25°C will gradually lose appetite, leading to the addition of a wheel and further increase in costs. Shrimps become agitated when temperatures rise above 32°C (Farchan, 2006). Low temperatures of water can increase nitrite concentrations. Which can have an indirect effect on parasitic infections in organisms (Irianto, 2003).

Shrimp farmers in East Tanete Riattang District do not carry out any activities if they are unaware of the temperature level because they do not have accurate data by direct examination on the farm. They also do not know that there are treatments available to treat water quality problems, particularly temperature. To get a proper temperature range based on the quality of the water, the key is to pay attention to the depth of pond water (Sustianti et al., 2014) because it affects the water temperature. The temperature will increase if the water in the pond decreases (El-Sayed et al., 1996).

Vibrio sp. should be less than 10⁴ CFU/mL because it can lead to White Feces Disease (WFD) attacks (Supono et al., 2019). The *Vibrio harveyi* bacteria has a density of 10⁶ CFU/mL, which could cause 90% of shrimp mortality. The secondary infection of Vibriosis in *Penaeus monodon* occurs due to high stocking density, stress, unstable environment, and Virion particles. Recent studies show that *V. parahaemolyticus* can act as a primary pathogen to White Spot Disease (WSD), which belongs to the bacterial species called White Spot Syndrome Virus (WSSV). This pathogen can also increase with the onset of viral diseases (Ganesh et al., 2010).

Conclusions

According to the study results, the water quality parameters are still within the acceptable range that supports vannamei shrimp life. The results showed that these parameters including the temperature, salinity, pH, DO, and bacterial population had values ranging from 26 - 30°C, 25 - 35 ppt, 5.5 - 7, 5 - 6.8 ppm, and 3.5 × 10¹-2.1 × 10³ cells/mL, respectively. However, the ammonia levels in vannamei shrimp was higher than the normal threshold of 1.7-1.8 ppm.

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