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# Application of Nano Cells on Water Quality in the Vannamei Shrimp (*Litopenaeus vannamei*) Post-Larvae Culture

**Rimal Hamal[1*], Andi Yusuf[1], Mulyati[1], Suryati[1], Nursyahran[2]**

[1]Aquaculture Department, Pangkep State Polytechnic of Agriculture, Pangkajene and Islands
[2]Department of Aquaculture, Institute of Maritime Technology and Business Balik Diwa, Makassar
***Corresponding Author:** rimalhamal00@gmail.com

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**ABSTRACT**

The vannamei shrimp farming has several advantages, as this species is known for its disease resistance, short cultivation period, and relatively low feed conversion ratio (FCR). These benefits make vannamei shrimp highly desirable and one of the most commonly farmed shrimp species. However, challenges in shrimp farming still arise, particularly concerning declining environmental quality, which can lead to disease outbreaks. These diseases hinder the growth and development of the cultured shrimp. Nano cell application serves as an enzyme that enhances the efficiency of vitamins and enzymes in the shrimp's body. This study aimed to examine the effect of nano cell application on the water quality of the vannamei shrimp post-larvae culture. The research was conducted from May to June at the Marine Fish Hatchery Laboratory, Pangkep State Polytechnic of Agriculture, Pangkajene and Islands. The study used a completely randomized design (CRD) with four treatments and three replications: **A** (0 ml dose), **B** (5 ml dose), **C** (10 ml dose), **D** (15 ml dose). The observed parameters included water quality indicators such as temperature, dissolved oxygen (DO), pH, salinity, ammonia, and nitrite levels. The results showed that the application of nano cells influenced water quality parameters, demonstrating its potential impact on maintaining optimal water conditions in the vannamei shrimp culture.

## INTRODUCTION

Nanoenzyme particles are described as protein-like structures that cluster with dimensions of 10- 100nm, offering stability, biocompatibility, conductivity, and sensitivity (**Xing *et al.,* 2022**). These particles exhibit various characteristics that enhance the performance of enzyme-based sensors by increasing surface area (**Eivazzadeh-Keihan *et al.,* 2022**). An increase in temperature can enhance nanoenzyme activity due to increased kinetic energy, which accelerates the interaction between the nanoenzyme and the substrate. However, beyond the optimal temperature, the activity may decrease due to structural denaturation or nanoparticle aggregation (**Gao L *et al.,* 2007**)

The application of Nano Cell technology in the cultivation of the vannamei shrimp (*Litopenaeus vannamei*) is an innovative approach aimed at improving water quality and, in turn, increasing the survival rate of post-larvae shrimp. Optimal water quality is crucial in shrimp farming, as unsuitable physical and chemical water parameters can cause stress, reduce growth, and increase mortality rates (**Saputra *et al.*, 2021**).

Nano Cell technology, which is based on the use of nanoparticles, has the potential to improve water quality through several mechanisms. One of these is the enhancement of dissolved oxygen concentration in water. Studies show that the use of nanobubbles can significantly increase dissolved oxygen levels compared to conventional methods, thereby supporting the metabolism and growth of post-larvae shrimp (**Ariadi e*t al.*, 2022**).

Additionally, Nano Cell technology can help regulate ammonia and nitrite concentrations in water. Ammonia and nitrite are toxic compounds that can negatively impact shrimp health. Effective water quality management, including technologies such as nanobubbles, can maintain these compounds within safe limits, reducing stress and mortality risks in shrimp (**Tahe & Suwoyo, 2011**).

The implementation of Nano Cell technology also contributes to the stability of other physicochemical water parameters, such as pH and temperature, which are essential for creating an optimal environment for shrimp growth. By maintaining stable and standard-compliant water quality, the survival rate of vannamei shrimp post-larvae can be significantly improved (**Farchan, 2006**).

Although research on the specific application of Nano Cell technology in shrimp farming is still developing, preliminary evidence suggests that this technology holds great potential for enhancing the efficiency and sustainability of the vannamei shrimp production. However, further studies are needed to understand its working mechanisms, optimal dosage, and potential side effects when applied on a commercial scale.

## MATERIALS AND METHODS

### Materials and methods

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## RESULTS

The observed water quality parameter results during the study are presented in Table (1).

**Table 1.** Average values of water quality parameters

| Water quality parameters | Treatment | | | | References |
|---|---|---|---|---|---|
| | A | B | C | D | |
| Temperature °C | 28,2-29,7 | 28,1-29,7 | 28,1-29,8 | 28,1-29,7 | 26-32 |
| pH | 7,5-8,6 | 7,5- 8,5 | 7,5-8,6 | 7,5-8,6 | 6-9 |
| DO (ppm) | 3,58-3,60 | 4,05-4,08 | 4,40-4,29 | 4,25-4,47 | > 4 mg/L |
| Salinity (ppt) | 15 | 15 | 15 | 15 | 10-35 ppt |
| Ammonia | 4 | 2,8 | 1,6 | 0,6 | 0,095 mg/L |
| Nitrite | 1,6 | 0,55 | 0,43 | 0,3 | 0,06 MG/L |

**A. Temperature**

The temperature observations each week during the study can be seen in Fig. (1).

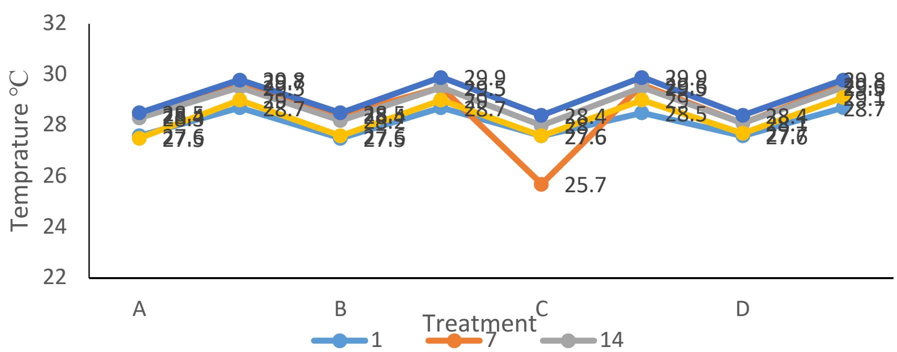


**Fig. 1.** Weekly temperature measurements

Based on Table (1) presented above, the average temperature range during the study for each treatment was relatively similar, ranging from 28.1 to 29.7°C, which is still within the optimal range for the vannamei shrimp. There is a measurement of both morning and afternoon temperatures, as shown in the first week, all treatments were relatively the same, still within the optimal temperature range for the vannamei shrimp. Based on the results of the paired T-test comparison between morning and afternoon temperature measurements, it was found that there was no significant effect on the treatments.

**B. Acidity level (pH)**

The pH measurements were taken weekly throughout the study can be seen in Fig. (2).

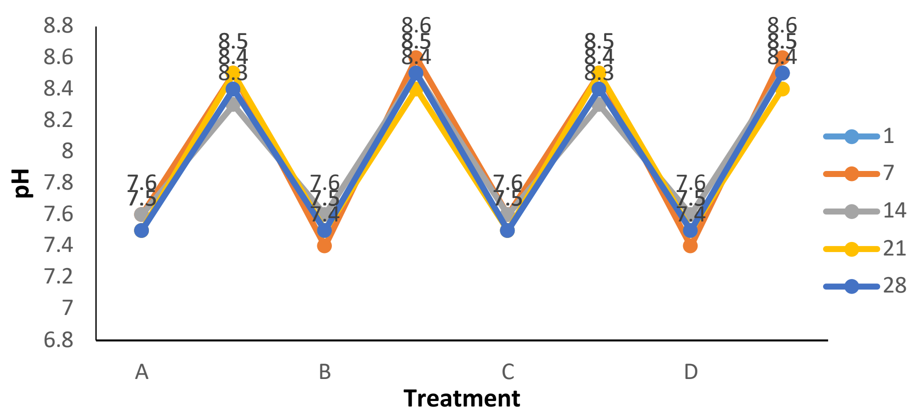


**Fig. 2.** Measurement of acidity level (pH)

The observed pH levels in all treatments during the study ranged from 7.5 to 8.6, which is still suitable for the needs of the vannamei shrimp. The changes between the morning and afternoon measurements are shown in Fig. (2). Based on the results of the paired T-test comparison between morning and afternoon pH measurements, it was found that there was no significant effect on the treatments.

**C. DO (Dissolved oxygen)**

The dissolved oxygen (DO) measurements taken weekly throughout the study can be seen in Fig. (3).

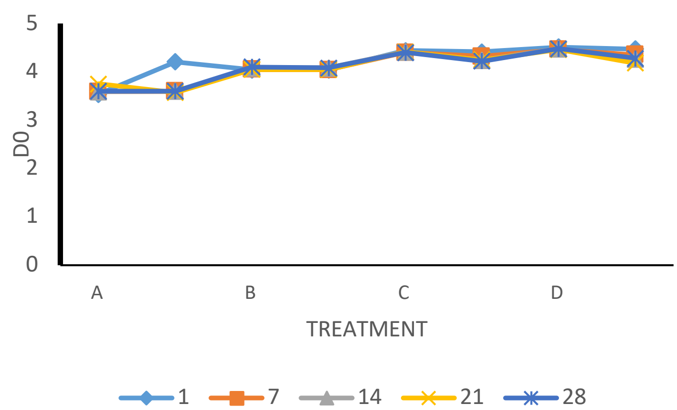


**Fig. 3.** Weekly dissolved oxygen (DO) measurements

Dissolved oxygen (DO) in treatments B, C, and D increased, while in the treatment without aeration (A), it decreased. These results indicate that treatments with aeration have a greater effect on increasing dissolved oxygen levels compared to treatments without aeration. There is a change between the morning and afternoon DO measurements. Based on the paired T-test, which compares the morning and afternoon DO measurements, it was found that there was a significant effect on the treatments. This indicates that DO levels have an impact on the survival of shrimp.

**D. Salinity**

The weekly salinity measurements during the study can be seen in Fig. (4).

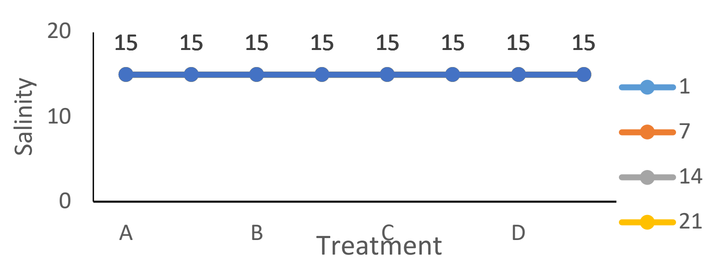


**Fig. 4.** Weekly salinity measurements

Based on Fig. (4), the salinity measurements for all treatments during the study were within the range of 15ppt, which is still within the optimal range. The results of the paired T-test comparison between morning and afternoon measurements showed no significant effect on the treatments. These results indicate that salinity is related to shrimp appetite, growth, and survival.

### E. Ammonia

The weekly ammonia measurement results during the study can be seen in Fig. (5).

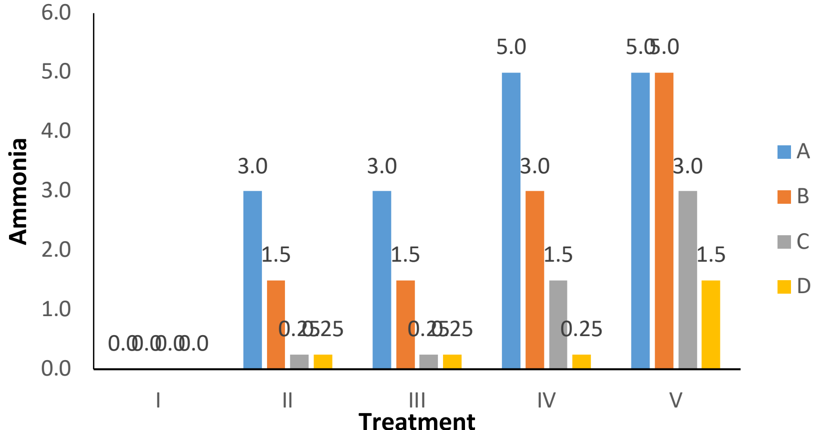


**Fig. 5.** Weekly ammonia observation results

Based on the ammonia measurements in Fig. (5), the ammonia levels in each treatment with the application of Nano Cell in shrimp showed an increase across all treatments. Treatments A, B, C, and D exhibited a drastic rise from week II to week V (at the end of the rearing period). This increase is suspected to be caused by the accumulation of uneaten feed and shrimp waste, leading to elevated ammonia levels. The toxicity of water quality variables does not act independently, meaning that even if ammonia levels exceed the survival threshold, as long as other parameters remain within optimal levels, it will not be lethal to the shrimp.

### F. Nitrite

The weekly nitrite measurement results during the study can be seen in Fig. (6).

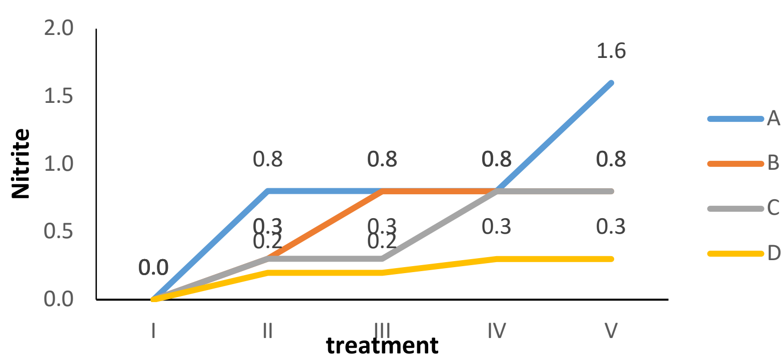


**Fig. 6.** Weekly nitrite observation results

Based on the nitrite measurements shown in Fig. (6), the nitrite levels in each treatment with the application of Nano Cell in the vannamei shrimp showed an increase. As seen in Fig. (6), treatments A, B, and C experienced a drastic rise in nitrite levels from the second week until the end of the rearing period, whereas treatment D showed an increase starting in the fourth week. Observations throughout the rearing period indicate that treatment D, which involved the administration of Nano Cell at a dose of 15ml, had the lowest nitrite concentration, with an average value of 0.02mg/ L. Treatment D also exhibited the highest survival rate among all treatments.

## DISCUSSION

### Water quality

The optimal temperature supporting the life of the vannamei shrimp ranges from 27.2 to 32°C (**Yudiati *et al.,* 2010**). This statement is consistent with the temperature value found in the study, which is greater than 27°C (**SNI, 2016**).

The highest survival and larval development index values were found at 30 and 35°C and at 25 and 30ups. Other salinities analyzed in this trial delayed growth and decreased survival in the larvae of this shrimp type, although the effect was different to the three temperatures of the trial. Results differ from those reported by other authors (**Pina, *et al.,* 2005, 2006**), where a salinity of 34 to 35ups is said to be optimal for the development and survival success of *L. vannamei* white shrimp larvae. The studies conducted on *Penaeus semisulcatus* and *Penaeus merguiensis* (**Kumlu *et al.,* 2005; Zacharia *et al.,* 2022**), as well as *Penaeus penicillatus*, *Metapenaeus affinis* and *Parapenaeopsis stylifera* (**Niza *et al.,* 2000**), showed that the best temperature and salinity interval for survival and development since nauplius eclosion is between 29-33°C and 30-35ups.

The observed pH values fall within the optimal range for vannamei shrimp farming, with a tolerance range of 6.5–9.0 (**Wyban & Sweeny, 1991**). For the grow-out phase of vannamei shrimp, the optimal pH level is between 7.5 and 8.5 (**SNI, 2016**). Low pH levels can cause shrimp to become fragile and their shells to soften due to the inability to form new exoskeletons, whereas excessively high pH levels can increase ammonia (NH3) concentrations, which indirectly endanger shrimp survival (**Purnomo, 1988**). At a certain pH, the surface charge of nanoparticles can change, affecting the electrostatic repulsion between particles. If the repulsive forces weaken (usually at a pH near the isoelectric point), the particles tend to aggregate and lose their stability (**Honary & Zahir, 2013**).

Water pH levels of 4.6–6.0 and 9.8–11.0 can disrupt shrimp metabolism (**Wardoyo, 1998**). Wickins (**1976**) also stated that a pH of 6.4 could result in a 60% reduction in shrimp growth rate. Shrimp mortality occurs at pH levels of 4.0 and 11.0

(**Wardoyo, 1998**). An increase in water pH above 10 can cause shrimp mortality, while a decrease in pH below 5 can lead to slow shrimp growth (**Yuliana, 2018**).

Mechanical aeration can enhance oxygen solubility in water by pumping air into it (**Boyd *et al*., 2017**). This process helps counteract the decline in dissolved oxygen caused by oxygen consumption from nano cells, which aid in converting waste and uneaten feed into non-toxic products **(Salmin, 2005)**, as well as fish respiration **(Boyd *et al*., 2017)**.

Dissolved oxygen levels in water ranging from 3.81– 4.43mg/ L or 5.44– 6.33mg/ L are still safe for aquaculture, as they remain above the oxygen threshold of >5 mg/L or 3.57mg/ L (**Fatma *et al.,* 2021**). The minimum dissolved oxygen requirement for the vannamei shrimp grow-out is >4 mg/L (**SNI, 2016**). Conversely, if oxygen availability in the water is insufficient, shrimp will experience stress, leading to a decline in survival rates. A continuous dissolved oxygen concentration of 1– 5mg/ L can disrupt growth, whereas levels between 5mg/ L and saturation are highly beneficial for growth (**Boyd, 1995; Kordi, 2010**). The application of nanocellulose as a bioadsorbent in water treatment systems has significant potential in reducing organic matter and various pollutants (**Gopakumar *et al*., 2018; Zhou *et al*., 2018**). The reduction in BOD and COD concentrations through nanocellulose adsorption contributes to the increase of dissolved oxygen (DO) in water (**Trache *et al*., 2020**), which in turn supports ecological balance in aquatic environments.

According to Kordi (**2007**), the ideal salinity range for the vannamei shrimp farming during the growth phase is between 10– 30ppt, with an optimal range of 15–25ppt. Optimal salinity is crucial for the survival of aquatic animals, as their environment is directly influenced by water conditions. Outside the optimal range, the animals must expend significant energy for osmoregulation in addition to other physiological processes. The optimal salinity level is within the range of 10– 30ppt (**Supono, 2019**), while the recommended salinity for the vannamei shrimp grow-out is between 26– 32ppt (**SNI, 2016**). Salinity significantly affects shrimp appetite, growth, and survival rates. (**Nababan *et al.,* 2015**). **Lante *et al.* (2015)** stated that shrimp growth at a salinity of 31–32ppt is slower compared to a salinity range of 17– 25ppt. This is because more energy is allocated for muscle formation, while less energy is used for osmoregulation. This statement aligns with **Arsad *et al.* (2017)**, who noted that high salinity in the rearing environment can disrupt shrimp growth due to impaired osmoregulation. The regulation of osmoregulation affects shrimp metabolism, which in turn influences energy production. **Halima *et al.* (2022)** stated that under low ammonia conditions, shrimp growth and survival rates improve. **Adiwijaya *et al.* (2003)** suggested that the optimal nitrite range for the vannamei shrimp farming is 0.01– 0.05mg/ L, while the optimal total organic matter concentration should be less than 55mg/ L. According to **Clifford (1994)**, the optimal nitrate concentration for the vannamei shrimp ranges from 0.4 to 0.8mg/ L.

## CONCLUSION

The water quality parameters for each treatment were as follows: temperature ranged from **28.1–29.7°C**, pH levels from **7.5–8.6**, dissolved oxygen (DO) from **3.58–4.47 ppm**, and salinity at **15 ppt**. These values fall within the tolerance limits for the vannamei shrimp survival. The lowest ammonia and nitrite levels were recorded in **Treatment D (15ml dose)**, with an average ammonia concentration of **0.6mg/ L** and an average nitrite concentration of **0.3mg/ L**.

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