

Analysis of Water Quality Parameters with Plankton Community Structure in Vannamei Shrimp Ponds

Kartika Primasari*, Agus Widodo

Politeknik Kelautan Dan Perikanan Sidoarjo

Correspondence Email: primasari.kartika@gmail.com*

Abstract

This study aimed to analyze water quality parameters in relation to the plankton community structure in vannamei shrimp ponds. Observations were conducted from Day of Culture (DOC) 1 to DOC 30 at two pond locations, B6 and B7, focusing on daily measurements of water quality and plankton abundance. Data were analyzed descriptively. The results indicated that water quality parameters generally met optimal standards for vannamei shrimp cultivation, despite natural fluctuations influenced by weather and farming activities. Plankton analysis revealed that both ponds were dominated by the Chlorophyta group, especially *Chlorella* sp., which reached a maximum abundance of 2,560,000 individuals in pond B6 and 272,500 in pond B7. Biodiversity indices showed stable diversity and low species dominance, indicating a balanced ecosystem. The dominance of *Chlorella* sp. contributed to the green coloration of pond water and served dual ecological functions: as a natural feed and a photosynthetic agent. Its presence is also beneficial due to its nutritional content, including polysaccharides and vitamin C, which can enhance shrimp immunity. This study confirms the critical role of water quality and plankton composition in maintaining pond productivity and shrimp health in intensive aquaculture systems.

Keywords: water quality, plankton structure, *chlorella* sp., vannamei shrimp.

INTRODUCTION

Vannamei shrimp (*Litopenaeus vannamei*) is a leading aquaculture commodity cultivated in Indonesia. This shrimp was first introduced in Indonesia in 2001 based on the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 41/2001 as an effort to increase Indonesia's shrimp production, replacing tiger shrimp (*Penaeus monodon*), which was experiencing a decline in quality. Currently, vannamei shrimp has spread across Indonesia and is cultivated by fish farmers and shrimp pond operators (Babu et al., 2014).

The intensive cultivation system refers to shrimp farming with a high stocking density ranging from 100 to 300 individuals/m², equipped with plastic mulch covering all parts of the pond, paddlewheels, water pumps, aerators, high stocking rates, and 100% pellet feed (Hidayat et al., 2019). Vannamei shrimp farming technology continues to develop, with the

emergence of intensive and super-intensive technologies reaching stocking densities of 100 to 400 individuals/m² (Nababan et al., 2015).

One of the main problems in the grow-out phase of vannamei shrimp is production failure caused by environmental conditions such as water quality that does not meet the standards required for cultivation during the maintenance period. One technique to overcome this issue is through proper water quality management to ensure it remains within the standards for shrimp farming, thereby increasing pond productivity.

Plankton are organisms that include phytoplankton and zooplankton. Phytoplankton in aquatic environments can perform photosynthesis, producing organic matter, oxygen, and nutrients for higher organisms, thereby increasing the primary productivity of the waters (Heinle et al., 2021). Zooplankton serve as primary consumers that connect phytoplankton with small and large carnivores, influencing the complexity of the aquatic food chain. The distribution patterns and community structure of zooplankton in a body of water can be used as biological indicators to determine changes in the aquatic environment (Suherman, 2005 in Iswanto, 2015).

Plankton is one of the key indicators of environmental quality. Plankton acts as a natural feed for fish and shrimp larvae, serving as a source of energy and growth (Xu et al., 2016). In vannamei shrimp ponds, plankton functions as natural feed and as an ecological parameter that can reflect the environmental conditions of the cultivation area. Changes in the plankton structure in aquaculture environments can serve as indicators of water quality changes. One of the harmful impacts of deteriorating water quality in vannamei shrimp ponds is algal blooming. Algal blooms in aquaculture environments can affect water quality, biodiversity, plankton structure, and reduce the ecological function of the aquatic ecosystem (Amorim & Moura, 2020).

Water quality factors affect the growth of vannamei shrimp. Water quality that meets the necessary requirements supports the growth of vannamei shrimp, whereas deteriorating water quality can lead to increased stress levels and decreased shrimp appetite (Vieira-Girão et al., 2015; Ariadi et al., 2020). Furthermore, changes in water quality impact the community, composition, species, and abundance of plankton in vannamei shrimp ponds (Djunaidah et al., 2017; Sirait et al., 2018). The presence of plankton in aquatic environments is highly important because it is related to water quality indicators and the availability of natural feed that can be utilized by vannamei shrimp cultivated under semi-intensive, intensive, and super-intensive systems. The availability of natural feed (plankton) determines the productivity level of the pond. Field parameters include temperature, brightness, dissolved oxygen, and water color. Water quality parameters analyzed in the laboratory include salinity, pH, alkalinity, TOM, phosphate, nitrite, nitrate, ammonia, and plankton.

METHOD

In this research activity, the author participated in all activities conducted at the shrimp pond as well as in the laboratory for plankton examination. The observation of water quality parameters and plankton was carried out from DOC (Days of Culture) 1 to DOC 30. Observations were conducted daily. The application of probiotics in the pond was carried out once every two weeks. The data observed in this activity included: values of water quality parameters and plankton. After the data were collected, they were classified into two groups: quantitative data and qualitative data. Subsequently, the technical data were processed using descriptive analysis, which involved presenting the data according to the information obtained in the field.

RESULT AND DISCUSSION

The results of the study showed that the water quality for vannamei shrimp cultivation, overall, met the requirements for vannamei shrimp farming based on the average values. The observed water quality parameters fluctuated during the study due to natural environmental conditions and farming activities. Natural factors such as weather significantly influenced water quality fluctuations, while farming activities potentially caused fluctuations due to the increase of organic and inorganic waste originating from feed residues, feces, and shrimp excretion.

Based on the results of the study, the temperature on DOC 30–40 in ponds B6 and B7 at night showed a decreasing trend as the shrimp aged. This was due to cloudy weather during the cultivation period. Relatively high temperature fluctuations occurred because heat remained from sunlight during the day. On DOC 30–40, the temperature decreased because the weather during observation was cloudy and tended to rain. However, this temperature decrease remained within the optimal range of 27–31°C. This is consistent with Kharisma and Manan (2012), who stated that the optimal temperature required by vannamei shrimp ranges from 28–32°C, as this range allows for optimal shrimp metabolism, survival, and growth. If extreme fluctuations occur, it may reduce shrimp appetite, thereby inhibiting shrimp growth (Putra and Manna, 2014).

The diversity index reflects the level of organism diversity in an ecosystem. The diversity index obtained during the observation was 0.91 in pond 1 and 1.38 in pond 2. The biological index values in ponds 1 and 2 were stable (0.91–1.38) and are categorized as good for shrimp cultivation. The availability of organic matter and the adaptability of each plankton species to the existing environment are among the factors influencing the plankton diversity index in an aquatic system (Sari et al., 2017).

The evenness index reflects the distribution level of organisms in an ecosystem. The evenness index in pond 1 was 0.39 and in pond 2 was 0.54, indicating a low evenness value ($E > 0.6$). The variation in the plankton evenness index in aquatic systems is influenced by several factors, including water quality, nutrient availability, and the varying ability of individuals or species to utilize those nutrients. The plankton dominance index in pond 1 was 0.62 and in pond 2 was 0.40. In general, the dominance index results from both ponds were stable and fell into the category of no dominant species ($0 < D \leq 0.5$). Overall, the Simpson dominance index values in both ponds were low and indicated no species dominance ($0 < D \leq 0.5$).

According to Suryadi and Kelana (2017), a dominance value approaching one indicates that one genus dominates over others in a community, while a value approaching zero indicates that no genus extremely dominates over others. The low dominance index was due to the even distribution of plankton species.

Abundance reflects the size of a population or species in terms of the number of individuals, showing how large or small the population is (Kramadibrata, 2017). Plankton abundance is greatly affected by migration, which is the movement of plankton from one place to another. Migration can occur not only due to population density but also as a result of environmental physical conditions such as changes in temperature and water currents.

In general, the number of individuals in all observed ponds belonged to five classes: Chlorophyceae, Cyanophyceae, Bacillariophyceae, Dinophyceae, and Protozoa. Observations showed that the highest plankton abundance was in pond B6, with the highest composition being *Chlorella* sp. The plankton composition in pond 1 had a total of 2,560,000 individuals, with *Chlorella* sp. being the most frequently found species, while in pond 2, *Chlorella* sp. also dominated with 272,500 individuals.

The high number of *Chlorella* sp. was because it is a type of microalgae with potential as an immunostimulant to enhance the immune system of vannamei shrimp against disease infections. This is related to the polysaccharide and vitamin C content in *Chlorella* sp. Pond water dominated by *Chlorella* sp. tends to be dark green in color. The water color gradient in the pond indicates an increase in *Chlorella* sp. cell concentration.

CONCLUSION

The observation results showed that the highest plankton abundance was found in pond B6, with the highest composition belonging to the Chlorophyta group. The total number of plankton individuals in pond B6 was 2,560,000, with *Chlorella* sp. being the most frequently encountered species. Meanwhile, the highest abundance percentage in pond B7 also belonged to the Chlorophyta group, with a total of 272,500 individuals, dominated by *Chlorella* sp. The dominance of *Chlorella* sp. caused the pond water to appear light green, and *Chlorella* sp. can function as both natural feed and a photosynthetic organism. The color gradient of the pond water indicates an increase in *Chlorella* sp. cell density.

REFERENCES

- Amorim, C. A., & Moura, A. do N. (2020). Ecological impacts of freshwater algal blooms on water quality, plankton biodiversity, structure, and ecosystem functioning. *Science of the Total Environment*, 758. <https://doi.org/10.1016/j.scitotenv.2020.143605>
- Ariadi, H., Wafi, A., & Supriatna. (2020). Hubungan kualitas air dengan nilai FCR pada budidaya intensif udang vanname (Litopenaeus vannamei). *Samakia: Jurnal Ilmu Perikanan*, 11(1), 44–50. <https://doi.org/10.35316/jsapi.v11i1.653>
- Arifin, Zainal. (2020). Metodologi Penelitian Pendidikan. *Jurnal Media Pendidikan, Kependidikan dan Sosial Kemasyarakatan*, 1(1).
- Babu, D., Ravuru, J.N. Mude. (2014). Effect of Density on Growth and of Litopenaeus vannamei of Brackish Water Culture System in Summer Season with Artificial in Prakasam District, India. *American international Journal of Research in Formal, Applied, & Natural Sciences*, 5(1), 10-13.
- Dugassa, H., Gaetan, D. G. (2018). Biology of White Leg Shrimp, *Penaeus vannamei*: Review. *World Journal of Fish and Marine Science*, 0(2), 5- 17.
- Erlangga, E. (2012). *Budidaya Udang Vannamei Secara Intensive*. Tangerang: Pustaka Agro Mandiri.
- Elfinulfajri, F. (2009). Struktur komunitas fitoplankton serta keterkaitannya dengan perairan di lingkungan tambak udang intensif. *Jurnal Bionature*, 13(2), 108–115.
- Ghufron, M., M. Lamid., P.D.W. Sari., dan H. suprpto. (2017). Teknik Pembesaran Udang Vaname (*Litopenaeus vannamei*) Pada Tambak Pendampingan PT Central Proteina Prima Tbk. di Desa Randulatah, Kecamatan Paiton, Probolinggo, Jawa Timur. *Journal of Aquaculture and Fish Health*, 7(2).
- Harijono, T., M.Z. Arifin., M. Abrori., dan L.BR. Ritonga. (2019). *Teknik Budidaya Ikan Air Payau*. Jakarta: AMAFRAD Press.
- Hidayat, M. (2013). Keanekaragaman Plankton Di Waduk Keuliling Kecamatan Kuta Cot Glie Kabupaten Aceh Besar. *Jurnal Biotik*, 1(2), 67–136.
- Heinle, M. J., Kolchar, R. M., Flandez, A. V., Clardy, T. R., Thomas, B. K., Hikmawan, Nababan, E., Putra I., dan Rusliadi. (2015). Pemeliharaan udang vaname (*vannamei*) dengan persentase pemberian pakan. *Jurnal Ilmiah Perikanan dan Kelautan*, 3(2).

- Purnamasari, I., D. Purnama, dan M.A.F. Utami. (2017). Pertumbuhan Udang Vannamei (*Litopenaeus vannamei*) di Tambak Intensif. *Jurnal Enggano*, 2(1), 58-67.
- Puspita, I.L. (2013). Pengaruh Growth Asset dan Intrinsic Value Terhadap Harga Saham pada Perusahaan Food and Beverage di Bursa Efek Indonesia. *Jurnal Riset dan Akuntansi*, 2 (2), 05-112.
- Qiptiyah, M., Halidah., M. A. Rakhman. (2008). Struktur Komunitas Plankton di Perairan Mangrove dan Perairan Terbuka di Kabupaten Sinjai, Sulawesi Utara. *Jurnal Penelitian Hutan dan Konservasi Alam*, 2(2), 137-143.
- Rijali, Ahmad. (2018). Analisis Data Kualitatif. *Jurnal Alhadharah*, 17(33).
- Sirait, M., Rahmatia, F., & Pattullo, P. (2018). Komparasi indeks keanekaragaman dan indeks dominansi fitoplankton di Sungai Ciliwung Jakarta. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 11(1), 75. <https://doi.org/10.21107/jk.v11i1.3338>
- Sitanggang, L.P., dan L. Amanda. (2019). *Analisa Kualitas Air Alkalinitas dan Kesadahan (Hardness) Pada Pembesaran Udang Putih (Litopenaeus vannamei) di Laboratorium Animal Health Service Binaan PT Central Proteina Prima Tbk*. Medan
- Supriatna., M. Mahmudi., M. Musa dan Kusriani. (2020). Hubungan pH dengan Parameter Kualitas Air pada Tambak Intensif Udang Vannamei (*Litopenaeus Vannamei*). *Journal of Fisheries and Marine Research*, 4(3), 368-374.
- Supono. (2017). *Teknologi Produksi Udang. Edisi Pertama*. Yogyakarta : Plantaxia.
- Supono. (2017). *Teknologi Produksi Udang*. Yogyakarta : Plantaxia.
- Suwoyo, H. (2018). *Manajemen Udang Vannamei (Litopenaeus vannamei) dengan Teknologi Ekstensif Plus*. Maros. Balai Riset Perikanan Budidaya Air Payau Dan Penyuluhan Perikanan.
- Sugiyono. (2013). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta.
- SNI. (2006). *Produksi Udang Vannamei (Litopenaeus vannamei) Di Tambak Dengan Teknologi Intensif*. (SNI 07-7246-2006). Jakarta: Badan Nasional Sertifikasi Profesi (BNSP).
- Thoha, H. (2004). Kelimpahan Plankton di Perairan Bangka-Belitung dan Laut Cina Selatan, Sumatera, Mei-Juni 2002. *Makara Sains*, 8(3), 96-102.
- T. I., Prihartato, P. K., Abdulkader, K. A., & Qurban, M. A. (2021). Spatial and temporal variability in the phytoplankton community of the Western Arabian Gulf and its regulation by physicochemical factors and zooplankton. *Regional Studies in Marine Science*, 47, 101982. <https://doi.org/10.1016/j.rsma.2021.101982>
- Usman, M. S., J. D. Kusen. dan J. R. S. L. Rimper. (2013). Struktur Komunitas Plankton di Perairan Pulau Bangka Kabupaten Minahasa Utara. *Jurnal Pesisir dan Laut Tropis*, 3(1), 51-57
- Witoko, P. Purbosari, N. Noor, M.N. Hartono, D.P. Barades, E. dan Bokau, R.J. (2018). *Budidaya Udang Vannamei (Litopenaeus vannamei)*.
- Wandansari, N.D. (2013). Perlakuan Akuntansi Atas PPH Pasal 21 Pada PT. Artha Prima Finance Kotamobagu. *Jurnal EMBA*, 1(3), 558 - 566.
- Winarni, S. (2011). *Penyempurnaan Penyajian Materi Pengukuran Plankton pada BMN Hidrobiologi*. Bogor: Universitas Terbuka.
- Wulandari, D. (2009). *Keterikatan antara Fitoplankton dengan Parameter Fisika Kimia di Estuari Sungai Brantas (Porong) Jawa Timur*. Bogor: Institut Pertanian Bogor.
- Xu, H., Yong, J., & Xu, G. (2016). Bioassessment of water quality status using a potential bioindicator based on functional groups of planktonic ciliates in marine ecosystems. *Marine Pollution Bulletin*, 110(1), 409-414. <https://doi.org/10.1016/j.marpolbul.2016.06.033>

- Yazwar. (2008). *Keanekaragaman Plankton dan Keterkaitannya dengan Kualitas Air di Parapat Danau Toba*. Medan: Sekolah Padsa Sarjana Universitas Sumatera Utara.
- Zaqiyah. (2015). *Pengamatan Kelimpahan Plankton Di Tambak Udang Vannamei Sistem Intensif PT SURYA WINDU KARTIKA, Desa Bomo, Kecamatan Rogogampi, Banyuwangi*. Surabaya: Universitas Airlangga.