

Green Mussel Biofilter System in Vannamei Shrimp Farming

Yushra¹, Andi Adam Malik¹, Sahabuddin¹, Muh. Iqbal Quraisyin¹

¹Program Studi Budidaya Perairan, Universitas Muhammadiyah Parepare
e-mail: yushra.kla08@gmail.com

Abstrak

Budidaya udang Vannamei (*Litopenaeus vannamei*) di Kabupaten Pinrang menghadapi berbagai tantangan, termasuk tingkat kematian yang tinggi, pertumbuhan yang lambat, dan serangan berbagai macam penyakit, yang sebagian besar disebabkan oleh kualitas air yang buruk. Penelitian ini bertujuan untuk menilai potensi penggunaan kerang hijau (*Perna viridis*) sebagai biofilter untuk meningkatkan kualitas air dan, pada gilirannya, meningkatkan produktivitas budidaya udang. Penelitian ini dilakukan di Kecamatan Suppa, dengan menggunakan kolam udang yang dikelola dengan sistem tradisional dan dilengkapi dengan reservoir air. Kerang hijau digunakan dalam sistem biofiltrasi untuk meningkatkan kualitas air. Hasil penelitian menunjukkan bahwa penggunaan kerang hijau dapat secara signifikan menurunkan konsentrasi logam berat, seperti merkuri (Hg), tembaga (Cu), kadmium (Cd), timbal (Pb), dan seng (Zn) dalam air kolam. Perbaikan kualitas air ini berkontribusi pada peningkatan produksi udang yang mencapai 582 kg/ha, sebuah peningkatan yang signifikan dibandingkan dengan tingkat produksi sebelumnya yaitu 250 kg/ha dan rata-rata nasional 500 kg/ha. Proses biofiltrasi oleh kerang hijau dapat mengurangi polutan dan menciptakan lingkungan yang lebih sehat untuk pertumbuhan udang. Temuan ini menunjukkan bahwa penggunaan kerang hijau sebagai biofilter dapat secara efektif meningkatkan kualitas air dan produktivitas budidaya udang Vannamei, serta memberikan solusi yang ramah lingkungan untuk meningkatkan hasil produksi dalam industri budidaya udang di daerah tersebut.

Kata kunci: *Budidaya Udang Vannamei; Kerang Hijau; Biofilter*

Abstract

Vannamei shrimp (*Litopenaeus vannamei*) farming in Pinrang Regency faces various challenges, including high mortality rates, slow growth, and attacks by various diseases, which are largely caused by poor water quality. This study aims to assess the potential of using green mussels (*Perna viridis*) as a biofilter to improve water quality and, in turn, enhance shrimp farming productivity. The research was conducted in Suppa District, using shrimp ponds managed with a traditional system and equipped with water reservoirs. Green mussels were used in the biofiltration system to improve water quality. The results showed that the use of green mussels significantly reduced

the concentration of heavy metals such as mercury (Hg), copper (Cu), cadmium (Cd), lead (Pb), and zinc (Zn) in the pond water. This improvement in water quality contributed to an increase in shrimp production to 582 kg/ha, a significant rise compared to the previous production level of 250 kg/ha and the national average of 500 kg/ha. The biofiltration process by green mussels helped reduce pollutants and created a healthier environment for shrimp growth. These findings suggest that using green mussels as a biofilter can effectively improve water quality and Vannamei shrimp farming productivity, while providing an environmentally friendly solution to enhance production yields in the shrimp farming industry in the region.

Keywords: *Vannamei Shrimp Farming; Green Mussels; Biofilter*

INTRODUCTION

The cultivation of Vannamei shrimp (*Litopenaeus vannamei*) has become one of the most dynamic sectors in fisheries, showing rapid growth and making a significant contribution to both local and national economies (Riniwati, 2016). Vannamei shrimp, originating from the coastal regions of the Latin American Pacific, has now become one of the main export commodities in various countries, including Indonesia (MSi, 2013). The growing global population, along with increasing demand for protein sources, has positioned Vannamei shrimp as one of the key solutions for food security (MSi & MSi, 2023). The continuous rise in global demand has driven the growth of this aquaculture sector, making it a strategic component in sustainable economic development.

Pinrang Regency, particularly Suppa District, is one of the regions in Indonesia known for its great potential for Vannamei shrimp farming. Its strategic geographical location, with excellent access to abundant seawater resources, creates ideal conditions for shrimp cultivation. This area is not only supported by favorable environmental conditions but also by the increasing availability of advanced farming technology. However, despite this great potential, shrimp farmers in Pinrang face significant challenges.

As global demand for Vannamei shrimp continues to rise, shrimp farmers in Pinrang Regency are under increasing pressure to maintain and improve their production. Although demand is growing, production trends show a decline due to various factors such as high shrimp mortality rates, slow growth, and the prevalence of various diseases (Tambunan et al., 2022). These factors not only reduce pond productivity but also threaten the survival of shrimp farming enterprises. Another issue affecting productivity is suboptimal water quality and environmental management, as good water quality is essential for ensuring the growth and health of Vannamei shrimp (Pasongli et al., 2016).

To address these challenges, innovations in water quality management are crucial. One approach that has been applied is water treatment methods involving natural biofilters, such as green mussels (*Perna viridis*) (Farizky et al., 2022). Green mussels are known for their effective biofiltration capabilities due to their ability to

accumulate heavy metals and pollutants from the water. Living as filter feeders, green mussels naturally filter food from the water, and in the process, they also filter harmful particles from their surroundings (Ali, 2017). Therefore, using green mussels as biofilters in water reservoirs integrated with shrimp ponds becomes a potential solution to improve water quality, reduce pollutants, and support more sustainable shrimp farming.

This research, therefore, aims to further explore the use of green mussels in improving the water quality of Vannamei shrimp ponds in Pinrang Regency. By reducing the concentration of heavy metals and other pollutants through this biofiltration method, it is hoped to support the sustainable success of Vannamei shrimp farming and increase pond productivity..

MATERIALS AND METHODS

This research was conducted in Suppa District, Pinrang Regency, using a sample shrimp pond equipped with a water reservoir and managed with a traditional system. Based on the sample requirements, a suitable location was selected, namely the pond owned by H. Latif, located in Wiring Tasi Village, with an area of 8,000 m² (Figure 1).

The inlet system of this pond uses an Alkon machine to pump seawater through a 10-inch PVC pipe. At the end of the pipe, there is a layer of palm fiber covered with a filtering cloth that serves as an initial filter to prevent the entry of other organisms. The pumped water is then channeled into a reservoir pond, which functions as a holding tank before being distributed into the shrimp pond. This reservoir is used as the location for spreading green mussels, which act as filters for heavy metals and other elements.

Water samples and observations were taken monthly throughout the cultivation process until harvest. Water samples were taken from three locations: the water source (seawater intake location), the reservoir or water storage area where the green mussels were spread, and the grow-out pond. Other water quality parameters were measured to assess their impact on production, and total production calculations were made to compare the production before and after the biofilter treatment.

The heavy metals measured in this study were mercury (Hg), copper (Cu), cadmium (Cd), lead (Pb), and zinc (Zn), based on their roles as trace elements (Takarina et al., 2013). The collected samples were then analyzed at the Chemical Oceanography Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University. Furthermore, the determination of seawater quality thresholds was based on Kep-51/KMNLH/2004.



Figure 1. Research Location and Overview of the Water Resource Transportation System from the Sea to the Reservoir and to the Grow-Out Pond

RESULTS AND DISCUSSION

The analysis of heavy metal content (Table 1) shows that the concentration of heavy metals at the seawater source location (Hg, Cu, Cd, Pb, Zn) overall exceeds the quality standard limits and falls into the category of light pollution (Kep-115/KMNLH/2003). This is assumed to be due to the water intake location still being within the coastal area, where the influence of anthropogenic waste is still high, and there is a river estuary near the waters. Water resource pollution is a phenomenon that has been widely studied and can be caused by natural processes (climate change, water-rock interaction, and geological factors) as well as human activities (agricultural practices and residential waste), and the presence of chemical compounds in the river estuary that accumulate from upstream to downstream (Nagaraju et al., 2016).

Table 1. Analysis Results of Heavy Metal Content in Seawater Samples.

Heavy Metal Element	Quality Standar Limit	Month:				Average	Category
		I	II	III	IV		
Hg (mg/l)	≤ 0,001	0,0001	N/A	0,0001	0,0006	0,0003	Contaminated
Cu (mg/l)	≤ 0,02	0,05	0,03	0,03	0,03	0,0350	Contaminated
Cd (mg/l)	≤ 0,001	0,003	0,001	0,001	0,003	0,0020	Contaminated
Pb (mg/l)	≤ 0,008	0,01	0,009	0,01	0,008	0,0093	Contaminated

Zn (mg/l)	≤ 0,05	0,05	0,055	0,064	0,06	0,0573	Contaminated
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Note: The data source comes from laboratory analysis conducted at the Chemical Oceanography Laboratory, Hasanuddin University.

Next, in the water reservoir pond (the location of the biofilter deployment), a reduction in the heavy metal content was observed (Table 2). Based on the Ministry of Environment regulation on the threshold limits of heavy metal content in waters, it was concluded that the heavy metal content in the water reservoir pond falls into the **non-contaminated** category. This reduction in heavy metal levels (Hg, Cu, Cd, Pb, Zn) is due to the biofiltration process carried out by the green mussel organisms that were spread in the pond. Green mussels are the best biological indicators for accumulating pollutants due to their sedentary nature (Vasanthi et al., 2012).

Table 2. Analysis Results of Water Reservoir Samples.

Heavy Metal Element	Quality Standard Limit	Month:				Average	Category
		I	II	III	IV		
Hg (mg/l)	≤ 0,001	0,000 0	N/A 0,01	0,000 0	0,000 1	0,0000	non-contaminated
Cu (mg/l)	≤ 0,02	0,02	2	0,01	0,02	0,0155	non-contaminated
Cd (mg/l)	≤ 0,001	0,001	N/A 0,00	N/A	0,001	0,0010	non-contaminated
Pb (mg/l)	≤ 0,008	0,008	6 0,04	0,009	0,009	0,0080	non-contaminated
Zn (mg/l)	≤ 0,05	0,05	4	0,052	0,05	0,0490	contaminated

Note: The data source comes from laboratory analysis conducted at the Chemical Oceanography Laboratory, Hasanuddin University.

Furthermore, the laboratory analysis of heavy metal content in the grow-out pond is shown in Table 3. The results indicate a decreasing trend in heavy metal content after the filtration process in the water reservoir pond. Based on the quality standards stipulated by the Ministry of Environment regulation (Kepmen LH), the heavy metal content in the grow-out pond falls into the **non-contaminated** category. The heavy metal levels were found to be below the established threshold limits.

Table 3. Analysis Results of Grow-Out Pond Samples.

Heavy Metal Element	Quality Standard Limit	Month:				Average	Category
		I	II	III	IV		
Hg (mg/l)	≤ 0,001	N/A	N/A	N/A	N/A	N/A	non-contaminated

Cu (mg/l)	≤ 0,02	0,01	N/A	0,01	0,01	0,0100	non-contaminated
Cd (mg/l)	≤ 0,001	N/A	N/A	N/A	N/A	N/A	non-contaminated
Pb (mg/l)	≤ 0,008	0,004	0,005	0,007	0,005	0,0053	non-contaminated
Zn (mg/l)	≤ 0,05	0,03	0,035	0,04	0,03	0,0338	non-contaminated

Note: The data source comes from laboratory analysis conducted at the Chemical Oceanography Laboratory, Hasanuddin University.

Based on the analysis of heavy metal content obtained from the three sampling locations, namely the Water Source (Table 1), Water Reservoir (Table 2), and Grow-Out Pond (Table 3), a decreasing trend in heavy metal concentrations is evident. This trend indicates that the significant reduction begins in the water reservoir pond, where green mussels (*Perna viridis*) are used as biofilters, and continues to the grow-out pond. The use of green mussels as biofilters in the water reservoir is effective in reducing heavy metal concentrations such as mercury (Hg), copper (Cu), cadmium (Cd), lead (Pb), and zinc (Zn) before the water is channeled to the grow-out pond. This reduction indicates that the biofiltration process by green mussels successfully accumulates and filters heavy metals from the water, as supported by previous research demonstrating the effectiveness of this organism in filtering pollutants from aquatic environments (Tantanasarit et al., 2013). The continuous reduction from the water reservoir to the grow-out pond also supports the theory that the integration of natural biofilters into aquaculture systems not only improves water quality but also promotes healthier and more productive shrimp growth (Ariadi et al., 2021).

Further measurements of water parameters were carried out to assess the suitability of the water quality used. The results of water quality observations (Table 4) generally fall into the suitable category for Vannamei shrimp farming activities based on Kep-115/KMNLH/2003. The obtained salinity was 33 ppm, the temperature was 30°C, and the pH was 8 ppm. These parameters are still within the limits set for shrimp farming activities. Thus, it can be concluded that water quality does not have a significant impact, as similar conditions were found in the 3 observation stations: the water source, the reservoir, and the grow-out pond.

Table 4. Results of Water Quality Measurements at the Research Locations.			
<i>Location</i>	<i>Parameters</i>		
	<i>Temperature (°C)</i>	<i>Salinity (ppm)</i>	<i>pH</i>
Seawater Source	30	33	8
Reservoir	29	33	7
Grow-out Pond	29	32	7

Data source: Direct field measurements.

Next, production analysis was conducted to obtain the production value, which was then compared with the production before the biofilter treatment with green mussels. The production from ponds using biofilter is presented in the Table 5.

Table 5. Pond Production Using Biofilter Ponds

Species	Stock	Mortality rate (%)	surviving stock	Weight (g/shrimp)	Size (shrimp/kg)	total production (kg)	pond area (m2)	Production (kg/Ha)
Vannamei shrimp	30000	3	29100	16	63	466	8000	582

Data source: Production data analysis

During the four-month maintenance process, the measured production parameters included the average weight per shrimp (g), the number of shrimp per kilogram, and the total production per hectare (kg/ha). The measurement results showed quite satisfactory outcomes. The average weight per shrimp reached 16 grams, with an average size of around 63 shrimp per kilogram. The total production reached 582 kg per hectare, which is a significant increase compared to the previous harvest, which only reached 250 kg per hectare.

This production also exceeded the national average of traditional pond production, which is around 500 kg per hectare (Global Seafood, 2023). Based on this data, it can be concluded that the application of biofilter ponds has a significant positive impact on increasing shrimp production. This is evident from the increase in production before and after the treatment, as well as when compared to the national average production.

CONCLUSIONS

This research shows that the use of green mussel (*Perna viridis*) biofilters in the Vannamei shrimp farming system in Pinrang Regency is effective in improving water quality and shrimp production. The analysis results show a significant reduction in heavy metal content, such as mercury (Hg), copper (Cu), cadmium (Cd), lead (Pb), and zinc (Zn), in the water reservoir pond after undergoing biofiltration by green mussels. This reduction directly impacts the health and growth of the shrimp, as evidenced by an increase in pond production from 250 kg/ha to 582 kg/ha. This increase not only surpasses the previous harvest results but also exceeds the national average of traditional pond production.

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REFERENCES

- Ali, N. A. (2017). *Analisis Kandungan Logam Berat Timbal (Pb) pada Kerang di Perairan Biringkassi Kabupaten Pangkep, Sulawesi Selatan*. <http://repositori.uin-alauddin.ac.id/4177/>
- Ariadi, H., Wafi, A., & Madusari, B. D. (2021). *Dinamika Oksigen Terlarut (Studi Kasus Pada Budidaya Udang)*. Penerbit Adab. [http://books.google.ie/books?id=U3Y-EAAAQBAJ&printsec=frontcover&dq=Dinamika+oksigen+terlarut+\(studi+kasus+pada+budidaya+udang\)&hl=&cd=1&source=gbp_api](http://books.google.ie/books?id=U3Y-EAAAQBAJ&printsec=frontcover&dq=Dinamika+oksigen+terlarut+(studi+kasus+pada+budidaya+udang)&hl=&cd=1&source=gbp_api)
- Boyd, C. E. (2019). *Water Quality*. Springer Nature. http://books.google.ie/books?id=h0mvDwAAQBAJ&printsec=frontcover&dq=Water+Quality,+boyd&hl=&cd=2&source=gbp_api
- Farizky, C. K., Fitriani, M., Hidayati, N. V., Rahardja, B. S., & Andriyono, S. (2022). STUDI BIOAKUMULASI LOGAM BERAT (Pb, Cd, DAN As) PADA RUMPUT LAUT (*Caulerpa racemosa*) DARI TAMBAK TRADISIONAL DI BRONDONG, LAMONGAN. *Jurnal Perikanan Unram*, 12(4), 722–733. <https://doi.org/10.29303/jp.v12i4.401>
- Global Seafood. (2023). L. vannamei trials in Indonesia improve productivity. *Global Seafood*. <https://www.globalseafood.org/advocate/l-vannamei-trials-in-indonesia-improve-productivity/>
- Hasan, M. R., & Chakrabarti, R. (2009). *Use of Algae and Aquatic Macrophytes as Feed in Small-scale Aquaculture*. http://books.google.ie/books?id=75qEyQEACAAJ&dq=Use+of+Algae+and+Aquatic+Macrophytes+as+Feed+in+Small-scale+Aquaculture.&hl=&cd=1&source=gbp_api
- Kep-115/KMNLH/2003, Tentang Pedoman Penentuan Status Mutu Air, Keputusan Menteri Negara Lingkungan Hidup Jakarta.
- MSi, I. H. M. K., & MSi, M. I. W. S. (2023). *Teknologi dan Manajemen Budidaya Udang Secara Berkelanjutan*. Nas Media Pustaka. http://books.google.ie/books?id=wmOqEAAAQBAJ&printsec=frontcover&dq=Teknologi+Dan+Manajemen+Budidaya+Udang&hl=&cd=1&source=gbp_api
- MSi, K. a. S. (2013). *Budi Daya Udang Vaname*. Gramedia Pustaka Utama. http://books.google.ie/books?id=vqNLDwAAQBAJ&printsec=frontcover&dq=Budi+Daya+Udang+Vaname&hl=&cd=3&source=gbp_api
- Nagaraju, A., Thejaswi, A., & Sreedhar, Y. (2016). Assessment of Groundwater Quality

- of Udayagiri area, Nellore District, Andhra Pradesh, South India Using Multivariate Statistical Techniques. *Earth Sciences Research Journal*, 20(4), 1. <https://doi.org/10.15446/esrj.v20n4.54555>
- Nurfadillah, N., Rusydi, I., & Hasfiandi, H. (2023). Study of trophic interactions of green mussels (*Perna viridis*) as bioremediation of waste for cultivation of windu shrimp (*Penaeus monodon*) in Gampong Alue Naga, Banda Aceh: application of IMTA system (Integrated Multi-Trophic Aquaculture). *IOP Conference Series Earth and Environmental Science*, 1221(1), 012047. <https://doi.org/10.1088/1755-1315/1221/1/012047>
- Odum, E. P. (2005). *Fundamentals Of Ecology*. http://books.google.ie/books?id=1IZ0ygAACAAJ&dq=Fundamentals+of+Ecology&hl=&cd=3&source=gbs_api
- Pasongli, H., Dirawan, G. D., & Suprpta. (2016). ZONASI KESESUAIAN TAMBAK UNTUK PENGEMBANGAN BUDIDAYA UDANG VANAME (*Penaeus vannamei*) PADA ASPEK KUALITAS AIR DI DESA TODOWONGI KECAMATAN JAILOLO KABUPATEN HALMAHERA BARAT. *JURNAL BIOEDUKASI*, 3(2). <https://doi.org/10.33387/bioedu.v3i2.70>
- Riniwati, H. (2016). Manajemen Sumberdaya Manusia: Aktivitas Utama dan Pengembangan SDM. In *UB Press eBooks*. <http://repository.um-palembang.ac.id/id/eprint/6593/>
- Takarina, N. D. T. D., Bengen, D. G., Sanusi, H. S., & Riani, E. (2013). Bioconcentration Factor of Copper (Cu), Lead (Pb), and Zinc (Zn) in *Anadara indica* Related to the Water Quality in Coastal Areas. *Makara Journal of Science*, 23–28. <https://doi.org/10.7454/mss.v17i1.2001>
- Tambunan, J. E., Rahmawati, A., Djamaludin, H., Dailami, M., & Anitasari, S. (2022). *Udang Vaname*. Universitas Brawijaya Press. http://books.google.ie/books?id=QLeeEAAAQBAJ&printsec=frontcover&dq=Udang+Vaname:+Dari+Hulu+ke+Hilir&hl=&cd=1&source=gbs_api
- Tantanasarit, C., Babel, S., Englande, A. J., & Meksumpun, S. (2013). Influence of size and density on filtration rate modeling and nutrient uptake by green mussel (*Perna viridis*). *Marine Pollution Bulletin*, 68(1–2), 38–45. <https://doi.org/10.1016/j.marpolbul.2012.12.027>
- Vasanthi, L. A., Revathi, P., Arulvasu, C., & Munuswamy, N. (2012). Biomarkers of metal toxicity and histology of *Perna viridis* from Ennore estuary, Chennai, south east coast of India. *Ecotoxicology and Environmental Safety*, 84, 92–98. <https://doi.org/10.1016/j.ecoenv.2012.06.025>