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INCORPORATION OF GREEN MUSSELS AS BIOFILTERS TO AUGMENT THE GROWTH OF VANNAMEI SHRIMP IN POLYCULTURE SYSTEMS

Integrasi Kerang Hijau Sebagai Biofilter Untuk Meningkatkan Pertumbuhan Udang Vannamei di Budidaya Polikultur

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ABSTRACT

Vannamei shrimp, with its several advantages, is an essential export item for Indonesia. Polyculture technique has demonstrated efficacy in augmenting the growth and efficiency of shrimp production, with output consistently rising. In a polyculture system, green mussels function as biofilters and may assimilate organic materials. This study aims to elucidate the impact of green mussel biofilters on the development of Vannamei shrimp inside a polyculture system. This study was executed over a span of 21 days utilizing a Completely Randomized Design (CRD), incorporating three treatments with three replications, which included varying quantities of green mussels (10, 20, and 30 people) with 10 milkfish, 10 Vannamei shrimp, and 250 g of seaweed. The parameters measured were lead (Pb) concentrations in water, soil, and shrimp, along with the absolute lengths of the cephalothorax, abdomen, and overall length of the shrimp. The findings demonstrated that 20 green mussels were the optimal choice for the growth of Vannamei shrimp, despite the absence of statistically significant differences. In the treatment with 30 green mussels, the lead concentration dropped to 0.06 mg/L in water and 0.62 mg/L in soil, however the minimum lead concentration in shrimp was seen in the treatment with 10 green mussels (0.12 mg/kg).

Key words: Vannamei Shrimp, Green Mussels, Biofilter, Polyculture, Lead Content

ABSTRAK

Dengan banyak manfaatnya, udang Vannamei adalah komoditas unggulan Indonesia yang sangat penting untuk ekspor. Teknologi polikultur terbukti meningkatkan pertumbuhan dan efisiensi produksi udang, dan produksinya terus meningkat. Dalam sistem polikultur, kerang hijau berfungsi sebagai biofilter dan dapat menyerap bahan organik. Tujuan dari penelitian ini adalah untuk mengetahui bagaimana peran biofilter kerang hijau mempengaruhi pertumbuhan udang vannamei dalam sistem polikultur. Penelitian ini, yang dilakukan selama 21 hari sesuai dengan Rancangan Acak Lengkap (RAL), mencakup tiga perlakuan dengan tiga ulangan yang menggunakan jumlah kerang hijau yang berbeda (10, 20, dan 30 ekor) dikombinasikan dengan

10 bandeng, 10 udang vannamei, dan 250 g rumput laut. Kandungan timbal (Pb) pada air, tanah, dan udang serta panjang mutlak cephalothorax, abdomen, dan panjang total udang adalah beberapa parameter yang diamati. Hasil menunjukkan bahwa 20 ekor kerang hijau adalah pilihan terbaik untuk pertumbuhan udang vannamei, meskipun tidak ada perbedaan signifikan secara statistik. Pada perlakuan 30 ekor kerang hijau, kandungan timbal turun dengan 0,06 mg/L pada air dan 0,62 mg/L pada tanah, sedangkan pada perlakuan 10 ekor kerang hijau, kandungan timbal terendah adalah 0,12 mg/kg

Kata Kunci: Udang Vannamei, Kerang Hijau, Biofilter, Polikultur, Kandungan Timbal (Pb)

INTRODUCTION

Vannamei shrimp, also known as Litopenaeus vannamei, is one of the most sought-after fish species in Indonesia. Vannamei shrimp cultivation has become one of Indonesia's main fishery export commodities since it was introduced in the early 2000s (Arsad *et al*., 2017). In addition to having many advantages, vannamei shrimp also has many problems. These include problems with disease, water quality, and feed efficiency, as well as rapid growth and resistance to the environment (Makmur *et al.*, 2018).

One interesting alternative to be developed to overcome this problem is a polyculture system using tarpaulin ponds (Septian *et al.*, 2020). The vannamei shrimp polyculture system has been successfully combined with other commodities, such as milkfish (*Chanos chanos*) and seaweed (*Gracilaria* sp.), according to several studies (Abreu *et al*., 2019). One of the biggest obstacles to the growth of vannamei shrimp is the decline in water quality. This is due to the high organic matter found in leftover feed and shrimp feces (Palayukan *et al.*, 2016).

Biofilter technology is a solution to this problem (Putra *et al.*, 2016). Seaweed and shellfish are examples of organisms that are often used as biofilters. As filter animals, monkeys can assimilate Particulate Organic Matter (POM), such as phytoplankton, in the aquaculture pond environment. Mussels can also filter other materials, such as fish or shrimp feces.

To support their growth, mussels utilize Dissolved Inorganic Nitrogen (DIN) indirectly through phytoplankton assimilation (Hold & Edwards, 2014). Therefore, the use of mussels as biofilters helps maintain water quality and increase the efficiency of vannamei shrimp growth. The use of this technology can increase the results of polyculture system cultivation.

This study aims to study the growth rate of vannamei shrimp cultivated through the polyculture method, with various densities of mussels as biofilters. The purpose of this study was to find the most suitable number of mussels and vannamei shrimp to achieve optimal cultivation results. It is hoped that the findings of this study will make a significant contribution to developing a more sustainable vannamei shrimp cultivation system in Indonesia.

RESEARCH METHODS

Time and Place

This research was conducted for 21 days, starting from 27th June to 18th July, 2024, located in the traditional ponds of Ujungpangkah District, Gresik Regency.

Research Method

The research method used in this research was a Completely Randomized Design (CRD), where the experiment was carried out 3 times with 3 different treatments, so that a total of 9 experimental units were carried out, as in Table 1.

Table 1. Treatment in Research

Treatment	Details
A	10 milkfish, 10 vannamei shrimp, 250 g seaweed, 20 green mussels
B	10 milkfish, 10 vannamei shrimp, 250 g seaweed, 30 green mussels
C	10 milkfish, 10 vannamei shrimp, 250 g seaweed, 40 green mussels

From table 1 it can be seen that samples will be taken randomly from each treatment. For shrimp and green mussels, 3 samples were taken each, while seaweed was taken as much as 10 grams at the beginning of the measurement. All variables will be processed and evaluated using analysis of variance (ANOVA), this method is used to see the extent to which the data has an effect, either significantly or not using the IBM SPSS Statistics 20 application, if the results show a significant effect, then it will be continued with the Tukey test with a confidence level of 95%.

Research Parameters

Vannamei Shrimp Growth

The growth of vannamei shrimp measured was the absolute length of the Cephalothorax, the absolute length of the abdomen, and the absolute total length. The absolute length was calculated using the formula of Jaelani *et al.* (2021), as follows;

$$H = Ht - H0$$

Information:
H : Absolute length (cm)
Ht : Final length of research (cm)
H0 : Initial length of research (cm)

Lead (Pb) Content

Lead (Pb) level testing was conducted on water and soil of cultivation as well as on vannamei shrimp. Testing was conducted at the Brawijaya University Laboratory.

RESULT

Absolute Length of Cephalothorax

The absolute length of the cephalothorax during the 21-day maintenance period obtained results as shown in Figure 1.

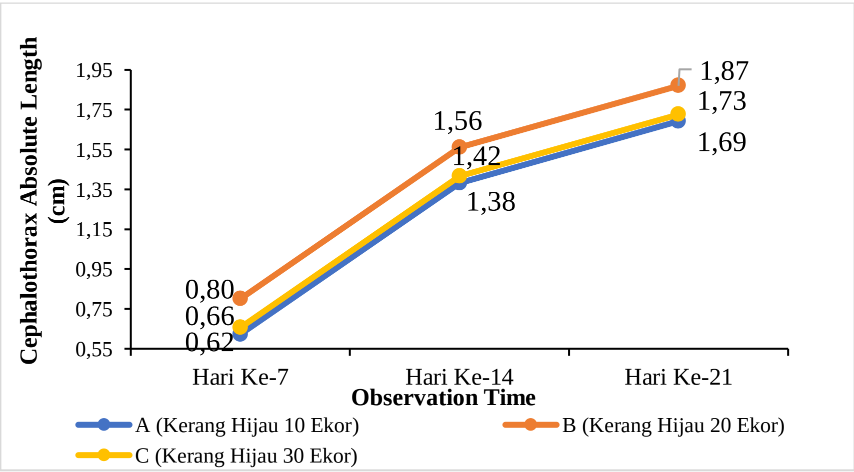

Figure 1. Absolute Length *of Cephalothorax*

The absolute length growth of the Cephalothorax was highest in treatment B (20 mussels), which was 1.87 cm. Meanwhile, the results of the ANOVA statistical test and continued with the Tukey test obtained the results as in Table 2.

Table 2. *Tukey* Advanced Test Notation for Absolute Length of Shrimp Cephalothorax Vanamei (*Litopenaeus Vannamei*)

Treatment	**Absolute Length (cm)**		
	Day 7	Day 14	Day 21
A (10 Green Mussels)	0.62±0.19 [a]	1.38±0.19 [a]	1.69±0.17 [a]
B (20 Green Mussels)	0.80±0.19 [a]	1.56±0.19 [a]	1.87±0.19 [a]
C (30 Green Mussels)	0.66±0.18 [a]	1.42±0.19 [a]	1.73±0.16 [a]

Based on the results of the Tukey Test, it states that there is no significant influence from all treatments (A, B, C), because the p value > 0.05.

Absolute Abdominal Length

The results of the absolute abdominal length during 21 days of maintenance can be seen in Figure 2.

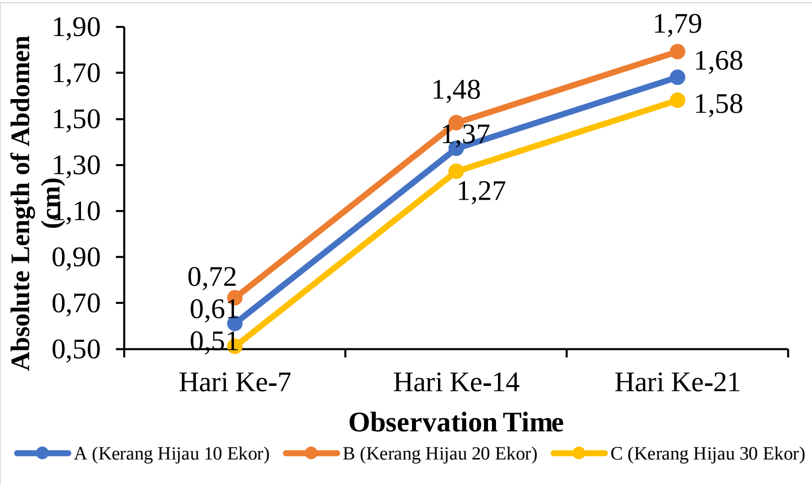

Figure 2. Absolute Length of the Abdomen

The absolute abdominal length value increased along with the increasing observation time, from Day 7 to Day 21 with the highest result being in treatment B (20 mussels). The results of the Tukey test notation on the absolute abdominal length can be seen in Table 3.

Table 3 . Tukey Advanced Test Notation Absolute Length of Shrimp Abdomen Vanamei (*Litopenaeus Vannamei*)

Treatment	**Absolute Length of Abdomen (cm)**		
	Day 7	Day 14	Day 21
A (10 Green Mussels)	0.61±0.31 [a]	1.37±0.33 [a]	1.68±0.31 [a]
B (20 Green Mussels)	0.72±0.36 [a]	1.48±0.33 [a]	1.79±0.35 [a]
C (30 Green Mussels)	0.51±-.33 [a]	1.27±0.39 [a]	1.58±0.34 [a]

Based on the table above, it can be interpreted that the Sig. (P-Value) value for all observation times (days 7, 14, and 21) is 0.808. Because the p value> 0.05, it shows that there is no statistically significant effect on the absolute length of the vannamei shrimp abdomen between treatments (A, B, and C).

Total Absolute Length

The total absolute length of vannamei shrimp during maintenance obtained results as in Figure 3.

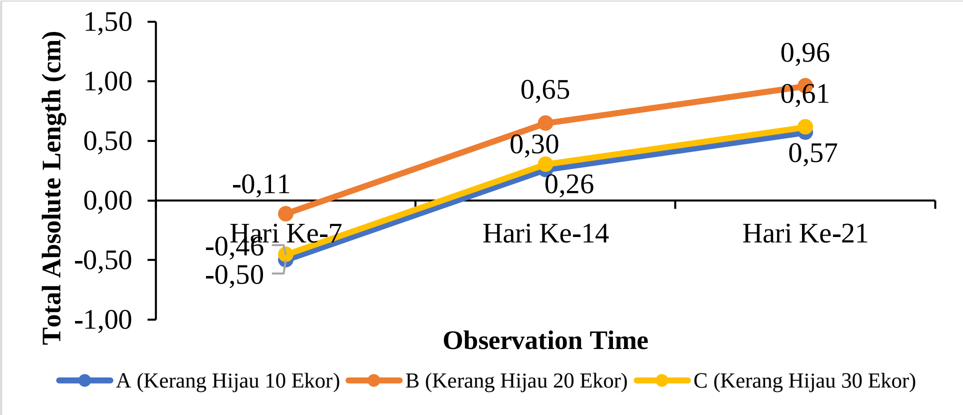

Figure 3. Total Absolute Length Growth

Of the three treatments, treatment B (20 Green Mussels) showed the best total absolute value on day 21 (0.96) compared to treatment A (0.57) and treatment (0.61) on the same day. The results of the statistical test on the total absolute length can be seen in Table 4.

Table 4. Tukey Advanced Test Notation Absolute Length of Shrimp Total Vanamei (*Litopenaeus vannamei*)

Treatment	Total Absolute Length (cm)		
	Day 7	Day 14	Day 21
A (10 Green Mussels)	-0.5±0.44 [a]	0.26±0.47 [a]	0.57±0.48 [a]
B (20 Green Mussels)	-0.11±0.43 [a]	0.65±0.47 [a]	0.96±0.41 [a]
C (30 Green Mussels)	-0.46±0.44 [a]	0.30±0.45 [a]	0.61±0.49 [a]

The statistical results above show that there is no significant effect of all treatments (A, B, C) on the growth of the total absolute length of vannamaei shrimp because the p value> 0.05.

Lead (Pb) Content of Water and Cultivation Soil

The results of testing the lead (Pb) content in water and soil of the cultivation media can be seen in Figure 4 (Water) and Figure 5 (Soil).

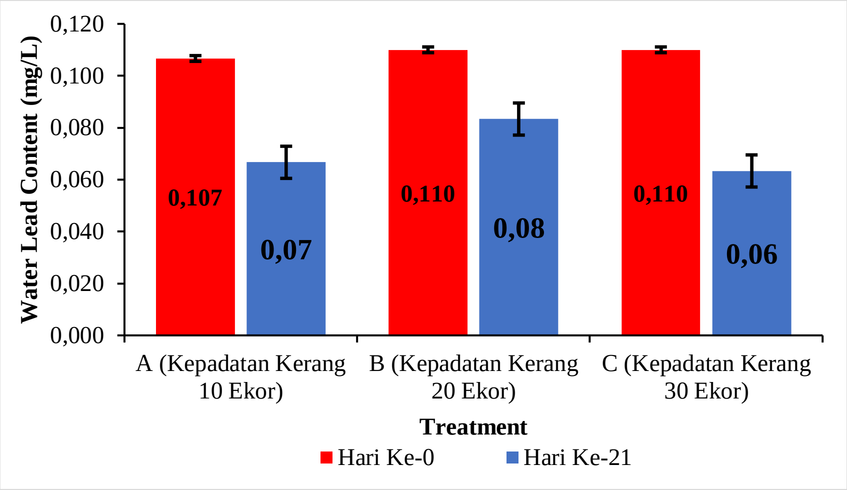

Figure 4. Results of Pb Content in Aquaculture Water

The Pb content in the culture water showed a decrease during the cultivation period, the results obtained were the lowest lead content in water in treatment C (30 mussels), namely 0.06 mg/L.

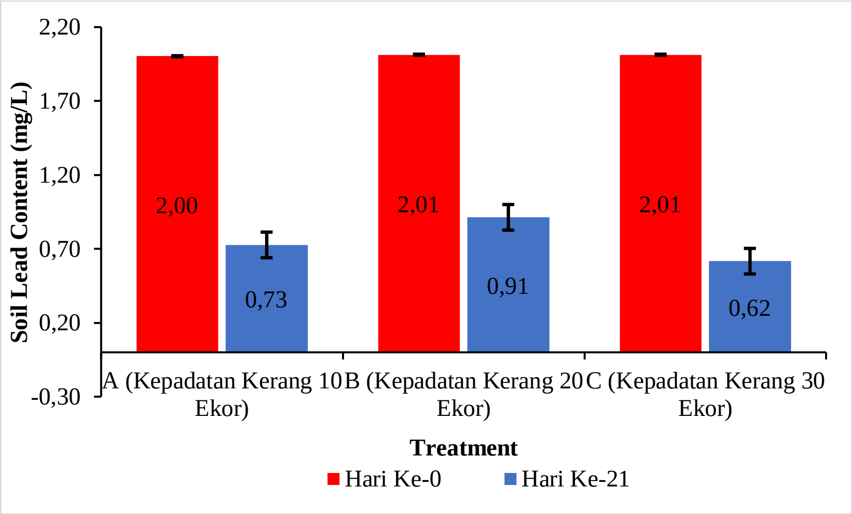

Figure 5. Results of Pb Content in Cultivated Soil

The lead content in the soil also decreased during the cultivation period, the lowest lead content in the soil was obtained in treatment C (30 mussels), which was 0.62 mg/L.

Lead Content (PB) of Vanamei Shrimp

The lead content in vannamei shrimp meat can be seen in the graph in Figure 6.

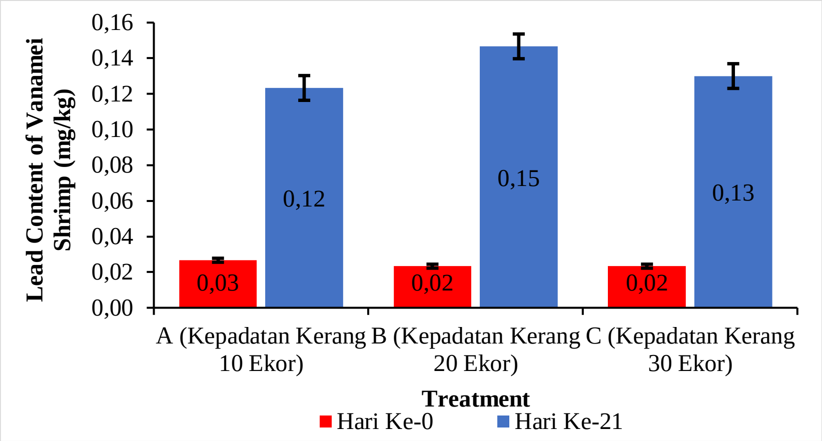

Figure 6. Lead Content of Shrimp Vannamei

The lead content in vannamei shrimp was found to be higher compared to water and soil. The lowest lead content was found in treatment A (10 shellfish) which was 0.12 mg/kg.

DISCUSSION

The growth of vannamei shrimp can be seen from the growth of the cephalothorax (Dhewantara *et al*., 2022). The absolute length of the Cephalothorax (cm) increased with increasing observation time, from the 7th day to the 21st day. For each observation time, the absolute length value of the Cephalothorax (cm) was positively correlated with the increase in green mussels given. Samocha *et al.* (2013), stated that the length of the shrimp cephalothorax is an important parameter in shrimp growth. The final results of the study showed that the length of the cephalothorax of vannamei shrimp kept for 90 days ranged from 25.4 ± 2.6 mm at the beginning of maintenance and reached 47.2 ± 3.1 mm at the end of the maintenance period. The length of the shrimp cephalothorax increased significantly with increasing maintenance time, this is because vannamei shrimp need time to adapt to the new environment. Factors that affect the length of the vannamei shrimp cephalothorax include age, sex, stocking density, water quality, and feed given. Based on the results of the Tukey Test that has been carried out, it can be concluded that there is no significant effect on the absolute length of the vannamei shrimp cephalothorax between treatments (A, B, and C) because the p value is > 0.05. The absence of a significant effect is due to several influencing factors, one of which is the range of green mussel density (10-30 tails) which is still within the equivalent biofiltration capacity for the volume of water used. In addition, in this polyculture cultivation, biofiltration does not only depend on green mussels, but there is also a contribution from seaweed which also has the ability to absorb dissolved nutrients (Retnosari *et al*., 2019). In addition, the influence of food availability, variations in body size, and limited space for oxygen acquisition also affect the growth of the cephalothorax (Estriyani, 2013).

Abdominal length is also one of the determinants of shrimp growth, especially to determine its economic value (Trijoko *et al*., 2013). The absolute length of the abdomen increases with increasing observation time, from Day 7 to Day 21 with the highest results in treatment B (20 shellfish). This is in line with a study conducted by Parenrengi *et al*. (2009), it was stated that the absolute length of the abdomen of vannamei shrimp increases with age, where at the age of 30 days the average absolute length of the abdomen is 6.3 cm, then increases to 9.6 cm at the age of 90 days, this indicates a positive correlation between the length of the abdomen and the maintenance period. In addition to the maintenance period, natural feed is a factor that influences abdominal growth, such as in the study of Putri *et al.* (2013), which stated that natural feed provides higher abdominal length results. From the results of the statistical tests that have been carried out, it shows that there is no statistically significant difference in the absolute length of the abdomen of vannamei shrimp between treatments (A, B, and C) at each observation time. This means that the provision of green mussels in different amounts (10, 20, and 30 tails) did not have a significant effect on the growth of the absolute length of the abdomen of vannamei shrimp in this study. Optimal shrimp growth can be influenced by several factors such as the amount of feed given, fertilization, aeration given and the survival of the cultivated shrimp (Pratama, 2019).

The best absolute total length of vannamei shrimp was obtained in treatment B (20 mussels), which was 0.9 cm on the 21st day of maintenance. These results indicate that giving 20 green mussels per unit is the optimal amount to produce optimal total length compared to other treatments. However, the statistical results did not show a significant effect between the three treatments on the total length of vannamei shrimp. This can be explained through the concept of ecological balance in an integrated system. Martinez (2020) stated that in a multi-trophic cultivation system, there is a "sweet spot" or optimal point where interactions between organisms reach maximum efficiency. The density of 20 mussels likely represents the optimal balance point between biofiltration capacity and organic waste load in the system. At this density, the filtration process runs effectively without creating excessive competition between individual mussels, resulting in environmental conditions that are more supportive of shrimp growth. The slow growth of absolute shrimp length can be influenced by competition for space and high energy use in the cultivation medium (Gotama *et al*., 2024).

The results of the test of the content of heavy metal lead (Pb) in water and soil of shrimp cultivation media showed results slightly exceeding the standard quality threshold by Decree of the Minister of Environment Number 51 of 2004 concerning Sea Water Quality Standards, namely 0.5 mg/L. Although both exceed the optimal metal content standard, Pb in water and soil of the cultivation media decreased at the end of the cultivation period when compared to the beginning of cultivation. Lead in water and soil had the highest reduction results in treatment C (30 mussels) 0.06 mg/L (water) and 0.62 mg/L (soil). The accumulation of lead in water is naturally smaller compared to soil and shrimp meat (Lestari *et al.*, 2018). This shows that the more mussels in cultivation managed to reduce lead content. This could be due to the biofilter working optimally. Organic materials such as lead are additional food sources for green mussels (Retnosari *et al.*, 2019). Green mussels will absorb particles dissolved in water as food through the mantle cavity, this is done because green mussels are filter feeders (Marwan *et al*., 2015). The presence of green mussels helps reduce heavy metal content in vannamei shrimp cultivation media (Rejeki *et al*., 2020).

The lead content in vannamei shrimp was found to be higher than the lead content in soil and water. Darmono (2008), stated that the accumulation of lead in shrimp meat is higher when compared to the concentration of lead in water, this is because aquatic organisms are able to accumulate lead in their bodies at higher levels than in water, because the metal interacts with body tissue over a certain period of time (Semuli, 2015). However, the lead content in vannamei shrimp is still within the threshold according to SNI 7387 of 2009, which is 0.5 mg/kg.

CONCLUSION

For vannamei shrimp cultivation, mussels help their growth. With 20 mussels, the cephalothorax length was 1.87 cm, the abdomen length was 1.79 cm, and the total length was 0.96 cm. These results indicate that mussels can help shrimp growth, although there was no statistically significant effect ($p > 0.05$). In addition, in the treatment with 30 mussels, the lead (Pb) content in water and soil was the lowest, although still above the established standard (water: 0.06 mg/L; soil: 0.62 mg/L). In the treatment with 10 mussels, the Pb content of vannamei shrimp was the lowest (0.12 mg/kg). The results show the role of mussels as biofilters in polyculture systems; they increase shrimp growth and may also reduce lead contamination in the cultivation environment.

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