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SEAWEED (*Gracilaria* sp.) AS A PHYTOREMEDIAN FOR WASTE WATER FROM INTENSIVE PONDS FOR VANAMEI SHRIMP (*Litopenaeus vannamei*) IN LUWU REGENCY

Rumput Laut (*Gracilaria sp.*) Sebagai Fitoremedian Limbah Air Tambak Intensif Udang Vanamei (*Litopenaeus vannamei*) di Kabupaten Luwu

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ABSTRACK

Sanitizing the water environment in vanamei shrimp (Litopenaeus vannamei) ponds will increase shrimp growth and improve the economy. Obstacles in aquaculture are the decreasing quality of production results and decreasing water quality. A biofilter is needed as a phytoremediation to reduce the high ammonia content from leftover feed and feces. The main component of this technology is seaweed (Gracilaria sp.) as a living technology that provides services in overcoming environmental problems. Therefore, phytoremediation technology can be used to manage nutrient and water dynamics; This can result in significant improvements in water quality as well as the restoration of degraded ecosystems. The aim of the research was to determine the effect of differences in density of Gracilaria sp. as a phytoremedian in the cultivation system to reduce the ammonia (NH3) content of shrimp pond wastewater in Batu Lotong, South Larompong District, Luwu Regency, South Sulawesi. The research used a completely randomized design (CRD) with 4 treatments and 3 repetitions. The results of measurements in the experiment showed that the highest ammonia (NH3) content in treatment D (0 g seaweed) ranged from 0.0074 mg/L - 0.0335 mg/L and the lowest in treatment A (100 g seaweed) ranged from 0.0032 mg/L-0.0335 mg/L. Specific growth rate of daily weight of seaweed Gracilaria sp. in treatment A (2.95%) per day, B (2.59%) per day, C (1.81%) per day, and D (0%) control / not given seaweed. This shows that the difference in density of the seaweed Gracilaria sp. as a phytomedian in the cultivation system, it has an effect on reducing the ammonia (NH3) content and the daily specific growth rate of the seaweed Gracilaria sp. The Anova statistical test shows that the seaweed Gracilaria sp has a real influence on reducing the ammonia (NH3) content in pond water (F.hit > f table 5%).

Keywords: Vanamei shrimp; Intensive; Gracilaria sp.; Quantitative; Ammonia.

ABSTRAK

Sanitasi lingkungan perairan tambak udang vanamei (*Litopenaeus vannamei*) akan meningkatkan pertumbuhan udang dan peningkatan ekonomi. Kendala dalam budidaya perairan adalah menurunnya kualitas hasil produksi dan penurunan kualitas air. Dibutuhkan biofilter sebagai fitoremidiasi untuk mengurangi kandungan amoniak yang tinggi dari sisa pakan dan feses. Komponen utama dari teknologi ini adalah rumput laut (*Gracilaria* sp.) sebagai teknologi hidup yang memberikan layanan dalam mengatasi permasalahan lingkungan. Oleh karena itu, teknologi fitoremediasi dapat digunakan untuk mengelola dinamika unsur hara dan air; Hal ini dapat menghasilkan peningkatan kualitas air yang signifikan serta pemulihan ekosistem yang terdegradasi. Tujuan penelitian adalah untuk mengetahui pengaruh perbedaan kepadatan *Gracilaria* sp. sebagai fitoremedian dalam sistem budidaya terhadap penurunan kandungan amonia (NH_3) limbah air tambak udang di Batu Lotong, Kecamatan Larompong Selatan, Kabupaten Luwu, Sulawesi Selatan. Penelitian Menggunakan Rancangan Acak Lengkap (RAL) dengan 4 perlakuan 3 kali pengulangan. Hasil pengukuran pada percobaan menunjukkan bahwa kandungan amonia (NH_3) tertinggi pada perlakuan D (0 g rumput laut) berkisar 0,0074 mg/L - 0,0335 mg/L dan terendah pada perlakuan A (100 g rumput laut) berkisar 0,0032 mg/L-0,0335 mg/L. Laju pertumbuhan spesifik bobot harian rumput laut *Gracilaria* sp. pada perlakuan A (2,95) % per hari, B (2,59 %) per hari, C (1,81 %) per hari, dan D (0 %) kontrol / tidak diberi rumput laut. Hal ini menunjukkan bahwa perbedaan pemberian kepadatan rumput laut *Gracilaria* sp. sebagai fitoremedian pada sistem budidaya berpengaruh terhadap penurunan kandungan amonia (NH_3) dan laju pertumbuhan spesifik harian rumput laut *Gracilaria* sp.

Kata Kunci: Udang vanamei; Intensif; *Gracilaria* sp.; Kuantitatif; Amoniak.

INTRODUCTION

Phytoremediation is an environmentally friendly method that utilizes plants to neutralize pollutants in soil and water. This technique is widely chosen by intensive shrimp farmers because it is economical and helps preserve the environment. Phytoremediation is carried out by utilizing pollutant-absorbing plants, where pollutants are stored in plant cells (phytoextraction) (Black, 1995) and the ability to break down pollutants through metabolic processes (phytodegradation) to meet the energy needs and growth of plants. (Boyajian & Carreira, 1997). Gracilaria sp. is a type of seaweed that has the potential as a phytoremediation agent. In addition to having a high nitrogen accumulation capacity, so it is nicknamed "Nitrogen Starved Gracilaria", this type is also able to convert organic waste into a source of nutrients for energy and growth (Komarawidjaja, 2005). According to (Kartono *et al*., 2008) *Gracilaria sp*. is a fishery commodity and also functions as a phytoremediation agent. This is because the seaweed is able to absorb nutrients such as ammonia, nitrate, and nitrite from the water through the diffusion process on its thallus wall during growth. *Gracilaria sp*. is considered the most effective phytoremediation agent for ecological engineering applications in improving water quality in aquaculture environments (Izzati, 2011). The role of phytoremediation in ponds is very crucial, especially in locations with water sources that have high turbidity due to mud content or other suspended particles.

As a leading commodity, the cultivation of whiteleg shrimp (*Litopenaeus vannamei*) continues to experience intensification in the aquaculture industry due to its promising profitability (Alfarizi1 & Putra, 2022). The increasing export demand makes whiteleg shrimp have high economic value and contribute greatly to increasing the country's foreign exchange. Intensive cultivation of whiteleg shrimp in Indonesia has begun to cause problems, including organic waste from leftover feed and shrimp waste (feces) (Afriansyah et al., 2016; Kurniaji *et* *al*., 2020). Intensive shrimp ponds produce wastewater with high ammonia content. The entry of wastewater with high ammonia into the waters can disrupt the quality of the waters (Arfiati *et al*., 2019). The accumulation of leftover feed, most of which is protein sourced from fishmeal, can cause an increase in the concentration of Ammonia, Nitrite and Nitrate (Izzati, 2011).

The pond area represents an ecotone zone that functions as an interface between freshwater and marine ecosystems. In this transitional ecosystem, various aquaculture systems have developed, from traditional to intensive. Along with the rapid development of development, pond ecosystems that are included in the brackish and coastal waters have great potential to become waste accumulators, both from shrimp/fish farming activities along the coast and from anthropogenic activities in upstream areas. This condition necessitates the implementation of an effective waste management system to mitigate the risk of environmental pollution, especially those caused by intensive whiteleg shrimp (*Litopenaeus vannamei*) farming waste. This study aims to determine and prove whether the ammonia content of intensive shrimp farming wastewater can be reduced by *Gracilaria sp*. as a phytoremidian. fitoremidian.

METHODS

This research was conducted for 45 days starting from August 1 to September 15, 2024 in an intensive pond area in Batu Lotong, South Larompong District, Luwu Regency, South Sulawesi. The research method used was a quantitative experimental method with a Completely Randomized Design (CRD) experimental design. The treatments given were treatment A (100 grams of *Gracilaria sp.*), B (200 grams of *Gracilaria sp.*), C (300 grams of *Gracilaria sp.*) and D (0 grams of *Gracilaria sp.*) each of which was put into 100 liters of wastewater from whiteleg shrimp ponds (*Litopenaeus vannamei*) which were aerated using a blower as an oxygen supplier. The pond water used was pond water at the end of the shrimp cultivation period or pond water after the total harvest. The containers used were 12 pieces of Styrofoam, the positions of which were arranged after randomization. Measurement of ammonia content in 84 water samples was carried out at the Water Quality Laboratory of Hasanuddin University (UNHAS) in Makassar. The measurement data on days 1, 8, 15, 22, 29, 36, and 43 were statistically tested using Analysis of Variance (ANOVA) and analyzed descriptively quantitatively. The seaweed (*Gracilaria sp.*) used in this study came from seaweed cultivation ponds in Labombo, Salekoe Village, Palopo City. Before use, the seaweed was cleaned of mud and various attached organisms. Weighing of seaweed to measure growth rate was carried out every seven days when water samples were taken. Weighing was carried out after water samples were taken. The water quality parameters measured included temperature, pH, and salinity. Water quality measurements were carried out every seven days at the same time as water samples were taken.

RESULTS

The ammonia (NH_3) content at the beginning of the study was quite high, namely 0.0335-0.0337 mg/L. At the end of the study, the highest ammonia content was in treatment D, namely 0.0074 mg/L and the lowest was in treatment A with a content of 0.0032 mg/L (figure 1).

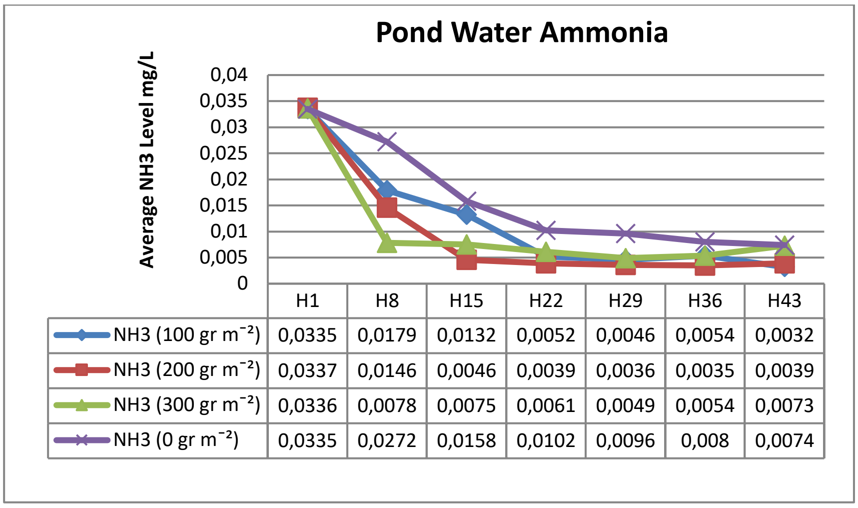

Figure 1. Results of measuring the ammonia levels of pond water

The results of the study also showed that at the beginning of the study there was a fairly high decrease in ammonia content with an average of 0.0167 mg/L with an average growth rate of seaweed (*Gracilaria sp.*) of 3.4% (Figure 2.). Overall, the results of observations and measurements of the daily growth rate were 2.5% and still below the threshold for a good growth rate. A good growth rate of seaweed (*Gracilaria sp.*) is above 3%/day (Patahiruddin, 2020). According to (Mubarok & Zainuri, 2024; Wandira *et al*., 2018) Ammonia (NH_3) and nitrate (NO_3^-) are easier and more efficient for Gracilaria to use because these two compounds can be used directly for growth and metabolism, while nitrite (NO_2^-) is often not used efficiently by many aquatic plant species, including Gracilaria.

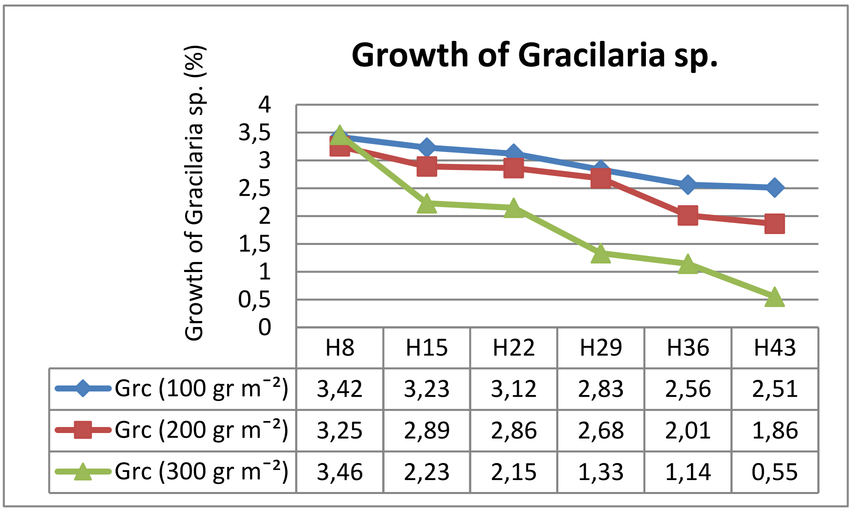

Figure 2. Daily growth rate of seaweed (*Gracilaria* sp.)

Water quality parameters as research support include temperature, salinity, and pH, the measurements of which were carried out directly at the research location (Table 1). The data are as follows:

Table 1. Results of water quality measurements

Treatment	Water Quality Parameters		
	Temperature	**Salinity**	**pH**
A	28,6-30,8	21-26	7,2-8,2
B	28,4-30.7	21-27	7,1-8,3
C	28,6-30.9	21-26	7,2-8,1
D	28,3-30.6	21-28	7,3-8,2

DISCUSSION

The ammonia content at the beginning of the study was recorded as quite high, this is because in intensive shrimp ponds excessive feeding often causes an increase in uneaten feed residue which then rots and decomposes, producing ammonia. This process is known as ammonification, where organic matter from feed residue is decomposed by microorganisms in water and soil (Fardilla, 2018). Feed residue in aquaculture cultivation containing protein will decompose in water, undergoing hydrolysis into amino acids. These amino acids then undergo an oxidative deamination process, where the amine group is released and converted into ammonia. The ammonia formed is the main nitrogenous waste in the aquaculture system and can reduce water quality if not managed properly (Li *et al*., 2021; Yang *et al*., 2024). The results of measuring the ammonia (NH3) content of shrimp pond wastewater in Batu Lotong, South Larompong District, averaged 0.0336 mg/L. The ammonia content is still within the appropriate limits for cultivation according to the opinion of Susanto *et al*., (2021) who stated that the optimal Nitrate Concentration for cultivation is 0.01-0.79 mg/L. The results of research conducted by Huda, (2018) explained that the ammonia (NH3) content of shrimp pond wastewater tends to be higher (7.698 mg/L) compared to waters that have not been mixed with shrimp pond wastewater (0.585 mg/L).

Considering the existing conditions and potential pollution from intensive cultivation activities, although currently shrimp ponds in Luwu Regency are not required to have a Wastewater Treatment Plant (IPAL), early implementation of IPAL is highly recommended. This aims to reduce the rate of water pollution and ensure that the waste produced remains within the established environmental quality threshold (Mubarok & Zainuri, 2024). Concentrations that exceed the quality threshold can cause a decrease in water quality, which in turn can have a negative impact on the life of aquatic biota in it (Desanti *et al*., 2023). The accumulation of organic matter in the cultivation process can cause an increase in the rate of sedimentation, lack of oxygen and changes in water productivity (Bara'padang *et al*., 2020).

The results of the ANOVA analysis showed that the treatment of different densities of seaweed (*Gracilaria sp.*) in the wastewater of whiteleg shrimp (*Litopenaeus vannamei*) cultivation ponds had a significant effect on reducing the ammonia (NH3) content of the wastewater of the cultivation ponds (F.Calculated > f Table 5%). The results of observations and measurements showed that the relationship between treatments A, B, C and D with the ammonia (NH3) content in the maintenance media showed a fairly close relationship. Gracilaria sp. has a high ability to absorb ammonia from the aquatic environment. When the amount of seaweed added increases, the total capacity to absorb ammonia also increases. Research shows that Gracilaria sp. can reduce ammonia levels in water with significant efficiency, especially in treatments with higher weights (Figure 1). This is also in line with the results of research (Trianti & Adharini, 2020; Widowati *et al*., 2021) which found that increasing the density of Gracilaria sp. is directly proportional to decreasing ammonia levels.

In addition, the results of the study showed that the longer the research period for seaweed cultivation (*Gracilaria sp.*) with high seed density (300 gr/m2) using wastewater from whiteleg shrimp (*Litopenaeus vannamei*) cultivation ponds, the ammonia content will increase because some seaweed will die and cause an increase in the ammonia content in the waters. Treatment D (0 grams of seaweed (*Gracilaria sp.*) had a high ammonia content at the end of the study of 0.0074 mg/L. This is in line with the results of research by Wandira *et al*., (2018) which stated that the treatment without (*Gracilaria sp.*) had a higher ammonia content. The use of macroalgae (*Gracilaria sp.*) as a bioremediation agent to restore the quality of degraded waters, especially in brackish water cultivation ecosystems, can be implemented through various technological approaches, ranging from basic to more complex systems. However, from a biological perspective, the application of (*Gracilaria sp.*) in waste treatment offers several advantages, namely a very simple application method, high adaptability, easy maintenance, and has economic value (Komarawidjaja, 2005). From an economic perspective, the integration of a seaweed-based biofilter system (*Gracilaria sp.*) has a high potential for adoption by the community considering the economic added value generated. In several studies by Trianti & Adharini, (2020), seaweed (*Gracilaria sp.*) has the ability to absorb nitrogen (N) of 0.08% and phosphorus (P) of 0.35%, thus showing its effectiveness as a biofilter. This study confirms that (*Gracilaria sp.*) verrucosa can function as an effective biofilter to improve the quality of shrimp pond wastewater. The rapid decrease in ammonia levels indicates that this seaweed can absorb ammonia from water, which contributes to reducing pollution in the aquatic environment.

In the first week, Gracilaria sp. showed a high ability to absorb ammonia from wastewater. This process occurs because seaweed utilizes ammonia as a nitrogen source for its growth. Research shows that Gracilaria verrucosa can reduce ammonia levels significantly in a short time, with a drastic decrease in the early days of cultivation. At the beginning of cultivation, environmental conditions such as pH and temperature may be in the optimal range for the growth of Gracilaria sp., thus facilitating efficient ammonia absorption. When the pH is above 7, ammonia ions are more easily absorbed by seaweed, which contributes to a rapid decrease in ammonia levels. After the first week, the decrease in nutrient levels in the water due to absorption by Gracilaria sp. can cause a decrease in seaweed biomass growth. When ammonia and other nutrient levels decrease, seaweed may not have enough resources to support its growth optimally, so biomass begins to decrease. This is in line with the finding that decreased nutrients in the environment can inhibit the growth of microalgae and seaweed.

The growth of Gracilaria sp. is greatly influenced by various environmental factors found in the cultivation area, such as substrate type, temperature, salinity, light intensity, and planting and maintenance methods. This condition shows that at low densities, biomass increases are highly dependent on the number of individuals, but when the population grows densely to the point of influencing each other, biomass becomes more determined by interactions between individuals and available resources, no longer solely by the number of plants (Anh et al., 2019; Banik *et al*., 2023).

Gracilaria sp. growth tends to decrease after reaching the adult phase because the energy that was originally used for growth is diverted to the reproduction process. In this phase, the population no longer shows direct dependence on seedling density within a certain range because individual size becomes the main compensatory factor. As population density increases, growth is increasingly influenced by competition between individuals which has an impact on survival and reproduction rates (Araújo *et al*., 2014; Vieira *et al*., 2018). In addition, differences in population size at the same age in an ecosystem can be caused by genetic variation in growth rate or differences in the time of emergence of new individuals, such as seeds or shoots (Forsman & Wennersten, 2016).

The growth of seaweed (*Gracilaria sp.*) in the study was quite good with an average daily growth rate of 2.5%. This growth was supported by sufficient nutrients from the wastewater of vaname shrimp farming ponds and water quality that was suitable for the growth of seaweed (*Gracilaria sp.*). The temperature during 45 days of measurements in shrimp ponds could range from 28.30C-30.90C (Table 1) with an average temperature during the study of 29.60C. Susanto *et al*., (2021) stated that the optimal temperature for the growth of seaweed (*Gracilaria sp.*) is 20-280C although in the study of Rokhmatin & Purnomo (2022) the water temperature in seaweed cultivation (*Gracilaria sp.*) reached 350C. Salinity during the study ranged from 21-28 ppt (Table 1). This condition is very suitable for the optimal salinity of seaweed growth (*Gracilaria sp.*), which is between 15-30 ppt (Palayukan et al., 2016; Susanto *et al*., 2021). The pH of the water during the study ranged from 7.1-8.3 with an average of 7.7. These results are in line with the statements of Hamuna *et al*., (2018) and Susanto *et al*., (2021) which state that the pH range of the waters is between 6.28 - 8.7 and ranges from 5-8.

CONCLUSION

The study conducted for 45 days showed that the effectiveness of seaweed (*Gracilaria sp.*) in reducing the lowest ammonia content value in treatment A (100 grams of seaweed), which was 0.0032 mg/L at the end of the study and the highest treatment D (0 grams of seaweed), which was 0.0074 at the end of the study. Based on the ANOVA Statistical Test, the treatments tested gave a significantly different effect (f count> f table 0.05).

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