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RESEARCH ARTICLE

Relationship of Physicochemical Water Parameters and Sediment Characteristics to the Growth of *Eucheuma cottonii* Cultivated Using the Longline Method on Karampuang Island, West Sulawesi

Hubungan Parameter Fisika-Kimia Perairan dan Karakteristik Sedimen dengan Pertumbuhan Eucheuma cottonii yang Dibudidayakan Menggunakan Metode Longline di Pulau Karampuang, Sulawesi Barat

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Abstract. Seaweed is an economically valuable commodity with the potential to improve the welfare of coastal communities, including *Eucheuma cottonii*. However, *E. cottonii* cultivation faces challenges from extreme changes in aquatic conditions and sediment input from river estuaries, which may inhibit its growth. This study aimed to analyze the relationship between physicochemical water parameters and sediment characteristics and the growth of *E. cottonii* cultivated using the longline method on Karampuang Island, West Sulawesi. A quantitative approach was applied through a field experiment using a completely randomized design (CRD) on three longline stretches over 30 days. Water quality and sediment parameters were analyzed descriptively, while relationships among variables were tested using partial correlation analysis. The results showed that most physicochemical water parameters were within the optimal range, except for current velocity, which was relatively low at 0.11 m/s. Sediment at the study site was dominated by medium sand, with a dynamic daily sedimentation rate ranging from 0.08 to 0.43 g/L/hour. The absolute growth of *E. cottonii* reached 477.00 g, with an average daily growth rate of 16.66 g/day. Partial correlation analysis showed that the growth of *E. cottonii* was closely associated with sedimentation rate and salinity. The cultivation of *E. cottonii* using the longline method on Karampuang Island showed positive growth, supported by suitable physicochemical water conditions, although sedimentation remained dynamic.

Keywords: *Eucheuma cottonii*, physicochemical water parameters, sedimentation rate, longline, Karampuang Island.

Abstrak. *Rumput laut merupakan komoditas bernilai ekonomi yang berpotensi meningkatkan kesejahteraan masyarakat pesisir, salah satunya Eucheuma cottonii. Namun, budidaya E. cottonii menghadapi tantangan berupa perubahan kondisi perairan yang ekstrem serta masukan sedimen dari muara sungai yang dapat menghambat pertumbuhan. Penelitian ini bertujuan menganalisis hubungan parameter fisika-kimia perairan dan karakteristik sedimen terhadap pertumbuhan E. cottonii yang dibudidayakan menggunakan metode longline di Pulau Karampuang, Sulawesi Barat. Penelitian menggunakan pendekatan kuantitatif melalui eksperimen lapangan dengan Rancangan Acak Lengkap (RAL) pada tiga bentangan selama 30 hari. Parameter kualitas air dan sedimen dianalisis secara deskriptif, sedangkan hubungan antarvariabel diuji menggunakan Partial Correlation Analysis (PCA). Hasil penelitian menunjukkan bahwa sebagian besar parameter fisika-kimia perairan berada pada kisaran optimum, kecuali kecepatan arus yang tergolong lambat, yaitu 0,11 m/s. Sedimen di lokasi penelitian didominasi pasir sedang (medium sand) dengan laju sedimentasi harian yang dinamis, berkisar antara 0,08–0,43 g/L/jam. Pertumbuhan mutlak E. cottonii mencapai 477,00 g dengan rata-rata laju pertumbuhan harian sebesar 16,66 g/hari. Analisis korelasi parsial menunjukkan bahwa pertumbuhan E. cottonii berkaitan erat dengan laju sedimentasi dan salinitas. Budidaya E. cottonii dengan metode longline di Pulau Karampuang menunjukkan pertumbuhan positif, didukung oleh kondisi fisika-kimia perairan yang sesuai, meskipun sedimentasi bersifat dinamis.*

Kata Kunci: Eucheuma cottonii, fisika-kimia perairan, laju sedimentasi, longline, Pulau Karampuang.

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INTRODUCTION

Seaweed is an economically valuable commodity that can improve the welfare of coastal communities. Several coastal regions have developed seaweed cultivation centers, including South Sulawesi, East Nusa Tenggara, Central Sulawesi, and Southeast Sulawesi (Mansur et al., 2023). However, this does not imply that seaweed cultivation can be carried out easily. The main limiting factor in seaweed cultivation is water quality, including both physical and chemical parameters.

Eucheuma cottonii is a red macroalga that is suitable for cultivation in shallow tropical waters and is therefore commonly found growing naturally in Indonesia. One of its advantages is its high carrageenan content, which can reach up to 68%, making it useful as a raw material for the food, cosmetic, and pharmaceutical industries (Devi et al., 2020). Extreme changes in aquatic environmental conditions require the continuous availability of *E. cottonii*, thereby necessitating appropriate aquaculture technology interventions.

The longline method in seaweed cultivation has been widely practiced by fishers and has also been studied and proven to support optimal growth of *E. cottonii*. Its main advantages are low cost and flexibility in adjusting cultivation depth, allowing seaweed to be positioned to receive sufficient light intensity for photosynthesis (Hasan et al., 2015).

The primary limiting factor in aquaculture is water quality, particularly physical and chemical parameters. *E. cottonii* naturally grows in shallow tropical waters because it requires sunlight for photosynthesis. Chemically, the main limiting factor is salinity, making this species highly vulnerable to freshwater input that can reduce salinity levels.

The shallow-water habitat of *E. cottonii* is also vulnerable to sedimentation. Intense wave action in shallow waters can increase sediment resuspension into the water column and even toward the surface, causing turbidity and inhibiting seaweed photosynthesis. Resuspended sediments may settle on the seaweed when currents weaken. The presence of sediment on seaweed can cause physical disturbance and induce stress in the organism.

Previous research on *E. cottonii* cultivation using the longline method reported a growth rate of 11.69 g/day (Nurqomar et al., 2022). Other studies have shown that *E. cottonii* exhibits more significant growth than other seaweed species, such as *Gracilaria* sp., when cultivated using the longline method (Hernanti et al., 2015). From a spatial perspective, *E. cottonii* production has been reported to reach 4,726.83 g/m² (Afandi et al., 2026).

Karampuang Island, West Sulawesi, is geographically located off the mainland of Mamuju Regency, which receives discharge from two rivers, namely the Mamuju River and the Karama River (Noor et al., 2020). Several fisheries activities are carried out on Karampuang Island, including seaweed cultivation, which extends from the western to the northern part of the island. The development of land-based activities on the mainland of Mamuju Regency has triggered land clearing along riverbanks, causing river mouths to become less capable of retaining sediment pollutant loads and facilitating sediment transport into offshore waters, including toward Karampuang Island (Noor et al., 2020).

Studies on *E. cottonii* cultivation have generally focused on its relationship with water quality, whereas the influence of sediment dynamics remains insufficiently investigated, particularly in seaweed cultivation activities on small islands. Therefore, this study aimed to evaluate the effects of water physico-chemical parameters and sedimentation on the growth of *E. cottonii* on Karampuang Island, which is influenced by inputs from two major rivers.

MATERIALS AND METHODS

This study employed a quantitative approach using a field experiment technique. The study was conducted in the northern part of Karampuang Island, Mamuju Regency, West Sulawesi, from October to November 2025. The field experiment applied the longline cultivation method and was carried out using an observational technique with three observation replicates (A1, A2, and A3). The coordinates of the study site were 2°37′30.51″ S and 118°52′35.02″ E.

The initial weight of *Eucheuma cottonii* used in this study was 100 g. The seaweed was attached to a 1.5-m cultivation line, with a spacing of 15 cm between attachment points, resulting in 10 attachment points per line. The cultivation lines were positioned at a depth of 1–3 m. Seaweed growth was observed for 30 days, with data collected once a week from all cultivation lines. Sediment samples were collected using sediment traps made of pipes with a diameter of 3 inches and a height of 30 cm. The traps were attached to iron rods and installed on the seabed at the experimental site. Sediment collection was conducted according to the same observation period used for seaweed growth measurement. Water quality measurements were carried out during each observation period by assessing physical parameters, including temperature and current velocity, and chemical parameters, including salinity, dissolved oxygen, pH, phosphate, and nitrate. In situ measurements were conducted for temperature, current velocity, salinity, dissolved oxygen, and pH, whereas ex situ analysis was performed for phosphate and nitrate.

Seaweed growth data were analyzed using absolute weight gain and daily growth rate. The physico-chemical conditions of the waters were analyzed descriptively by referring to the suitability ranges that support the growth of *E. cottonii* seaweed, as presented in Table 1.

Table 1. Suitability Ranges for *Eucheuma cottonii* Cultivation

Parameter	Unit	Optimum Range	Reference
Physical Parameters			
Temperature	°C	20–30	Nikhlani dan Kusumaningrum (2021)
Current velocity	m/s	0.20–0.40	Nikhlani dan Kusumaningrum (2021)
Chemical Parameters			
Salinity	ppt	28–34	BSN (2011)
pH	-	6.5–9.0	BSN (2011)
Dissolved oxygen	mg/L	4–7	Alamsyah (2016)
Phosphate	mg/L	0.02–1.04	Nikhlani dan Kusumaningrum (2021)
Nitrate	mg/L	0.01–0.79	Patahiruddin (2020)

Sediment samples were analyzed in the laboratory using the gravimetric method and were then described to determine sediment characteristics based on the median grain size (D50) and the estimated daily sedimentation rate. The relationships between water physico-chemical parameters, sedimentation rate, and the growth of *E. cottonii* cultivated using the longline method were analyzed using Principal Component Analysis (PCA) and Spearman's rank correlation analysis at a significance level of $p \leq 0.05$. All statistical analyses were performed using XLStat software.

RESULTS AND DISCUSSION

Based on the mean values, most of the physico-chemical parameters of the waters around Karampuang Island showed optimal conditions that could support the growth of *Eucheuma cottonii* (Table 2). The main limiting parameter that did not reach the optimal range was current velocity. The study site on Karampuang Island is located near a coastal area protected by coral reef ecosystems; therefore, the current tends to be relatively slow, at less than 0.2 m/s (Putra et al., 2013).

The average temperature recorded during the study was 30.00°C, indicating an optimal condition because it remained within the suitable range of 20.00–30.00°C (Nikhlani & Kusumaningrum, 2021). However, temperature values fluctuated during the observation period and even reached a non-optimal value of 35°C. Temperature is closely related to the internal physiological processes of *E. cottonii*, particularly in supporting metabolic activity and photosynthesis, which are essential for optimal growth (Darmawati et al., 2023).

Salinity at the study site averaged 28.83 ppt, which was within the optimum range of 28–34 ppt for *E. cottonii* cultivation (BSN, 2011). Salinity is associated with the ability of seaweed to regulate osmotic pressure, allowing internal physiological processes to

function properly and support the growth of *E. cottonii* (Atmanisa et al., 2020). The average pH value during the study was relatively stable, ranging from 7.00 to 7.20, with a mean value of 7.13. *E. cottonii* can tolerate a relatively broad pH range of 6.5–9.0; therefore, the pH values recorded at the study site were suitable for supporting optimal seaweed growth (Atmanisa et al., 2020). Dissolved oxygen (DO) values ranged from 5.02 to 7.03 ppm, with a mean value of 5.98 ppm. This range was considered optimal for *E. cottonii*, which requires DO levels of 4–7 ppm (Alamsyah, 2016).

Dissolved oxygen concentration in aquatic environments is essential because it plays an important role in the food absorption processes of aquatic organisms (Zakariah et al., 2023). Phosphate concentration in the waters was relatively stable at 0.10 mg/L. This value was within the optimum range for *E. cottonii*, namely 0.02–1.04 mg/L (Nikhlani & Kusumaningrum, 2021). Phosphate is an essential nutrient for plant cell metabolism, particularly in supporting seaweed growth, and its concentration also influences the fertility level of aquatic bodies (Maulana et al., 2023). Nitrate values ranged from 0.10 to 0.50 mg/L, with a mean value of 0.17 mg/L. This range was considered optimal for *E. cottonii*, which requires nitrate concentrations within the range of 0.01–0.79 mg/L (Susanto et al., 2021). Nitrate is a form of nitrogen in aquatic environments that has undergone transformation processes and functions as an essential nutrient for seaweed growth (Patahiruddin, 2020).

Table 2. Water Suitability for *Eucheuma cottonii* Cultivation

Parameter	Unit	Optimum Range	Min.	Max.	Mean ± SD	Status
Physical Parameters						
Temperature	°C	20–30	28.00	35.00	30.00 ± 1.96	Optimal
Current velocity	m/s	0.20–0.40	0.06	0.10	0.08 ± 0.08	Not optimal
Chemical Parameters						
Salinity	ppt	28–34	23.00	35.00	28.83 ± 2.73	Optimal
pH	-	6.5–9.0	7.00	7.20	7.13 ± 0.06	Optimal
Dissolved oxygen	mg/L	4–7	5.02	7.03	5.98 ± 0.65	Optimal
Phosphate	mg/L	0.02–1.04	0.10	0.10	0.10 ± 0.01	Optimal
Nitrate	mg/L	0.01–0.79	0.10	0.50	0.17 ± 0.15	Optimal

Sediment entering the sediment traps was also observed. The data analysis showed that the D50 value corresponded to a sediment grain size ranging from 1.0 to 0.5 mm (Table 3). Based on this value, the sediment retained in the sediment traps was classified as medium sand. Substrates on small islands are generally dominated by coarse sandy sediments derived from fragmented coral debris. The input of sediment from rivers facing Karampuang Island may introduce finer fractions that mix with coarse sand, resulting in medium-sand characteristics (Noor, 2018). Medium sand can be easily resuspended, particularly during high-wave conditions.

Table 3. Sediment Type Classification

Sample Type	Grain Size (mm)							D50
	2	1	0.5	0.25	0.125	0.063	<0.063	
Dry weight (g)	34.55	7.16	12.91	17.83	23.77	3.494	0.32	Medium sand

The sedimentation rate at the study site showed an increasing trend, from 0.08 g/L/h in the first week of observation to 0.43 g/L/h in the fourth week (Figure 1). The sedimentation rates recorded in the first week (W1) and second week (W2) were classified as low, with values of <0.10 g/L/h, indicating that the sediment tended to settle easily (Pastorok & Bilyard, 1985). In contrast, the third week (W3) and fourth week (W4) showed

moderate sedimentation rates, ranging from 0.10 to 0.50 g/L/h, which indicated the possibility of sediment resuspension.

Sediment resuspension may occur due to sea waves generated by wind or tidal processes. Sediment resuspension is one of the processes that contributes to the input of essential nutrients into aquatic environments (Oktaviani et al., 2015). Marine sediments originate from the erosion of materials, including rock fragments of various sizes and shapes. These eroded materials are transported by river flow, wind, melting ice, or groundwater flow, and the resulting rock fragments may be formed through both organic and inorganic processes (Wahab & Agusdiansyah, 2023).

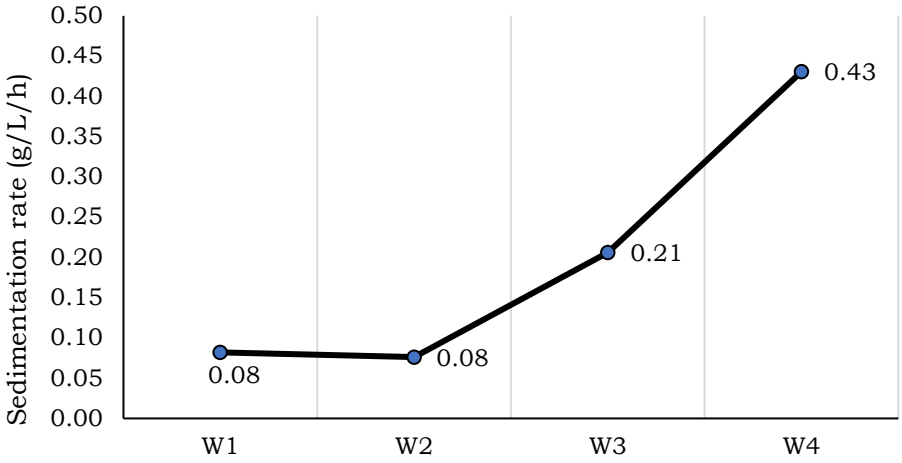

Figure 1. Sedimentation Rate at the Study Site

E. cottonii cultivated using the longline method showed positive growth. Absolute growth reached 477.00 g, with an increasing growth trend as the cultivation period progressed (Figure 2). The average daily growth rate, calculated from total growth and the number of observation days, was 16.66 g/day. The highest daily growth rate was recorded in the fourth week (W4), reaching 38.40 g/day, whereas the lowest was recorded in the first week (W1) at 15.32 g/day.

This progressive growth pattern is consistent with previous findings reporting that *E. cottonii* cultivated using the longline method achieved an absolute growth rate of 11.69 g/day (Nurqomar et al., 2022). This pattern indicates that the adaptation phase was likely short and that the seaweed entered the active growth phase earlier. This may be attributed to the placement of the longline system, which was not too close to the seabed, thereby reducing exposure to mud and minimizing attachment by mosses or other fouling organisms. The longline method also provides advantages by allowing greater access to nutrients, as well as optimal sunlight and temperature conditions for photosynthesis (Cokrowati et al., 2021; Halimah et al., 2021).

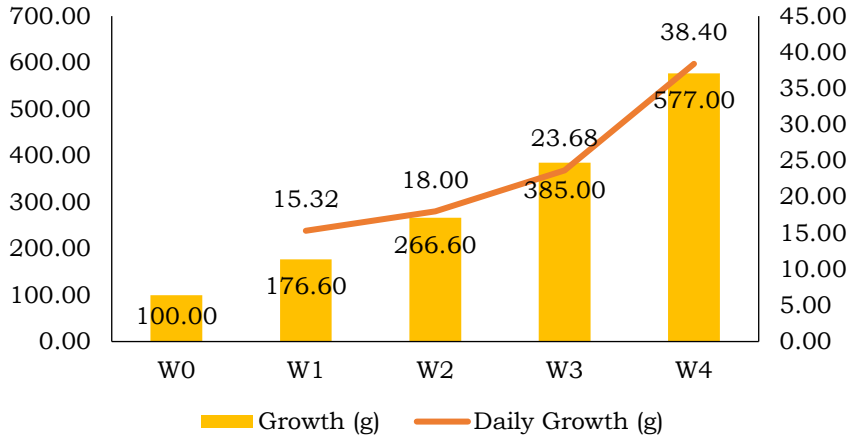

Figure 2. Growth of *Eucheuma cottonii* Cultivated Using the Longline Method

The PCA results showed that the growth of *Eucheuma cottonii* on Karampuang Island was closely associated with sedimentation rate and salinity (Figure 3). The correlation coefficient between sedimentation rate and *E. cottonii* growth was 0.973 (p = 0.027), while the correlation coefficient for salinity was 0.995 (p = 0.005). Other parameters showed varying degrees of association; however, these correlations were not statistically significant (Table 4).

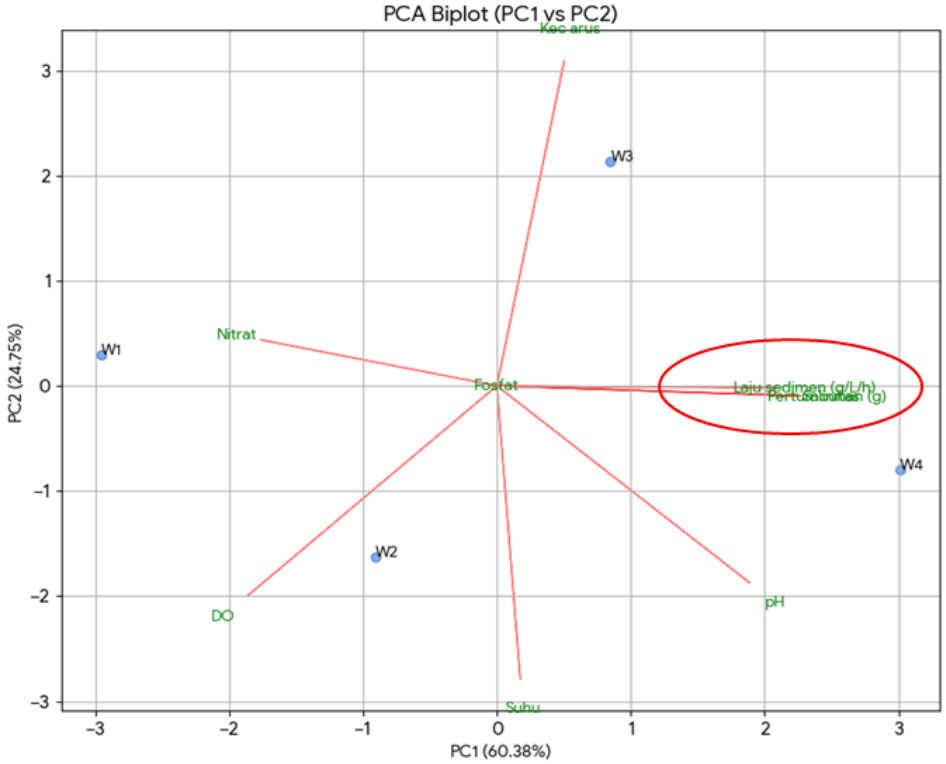

Figure 3. PCA Analysis Results

Table 4. Results of Correlation Analysis Between Water Physico-Chemical Parameters and the Growth of *Eucheuma cottonii*

Parameter	Correlation	Sig.
Sedimentation rate	0.973	0.027*
Salinity	0.995	0.005*
pH	0.886	0.114
Dissolved oxygen	0.776	0.224
Temperature	0.003	0.997
Current velocity	0.326	0.674
Phosphate	0.130	0.870
Nitrate	0.673	0.327

Note: $p \leq 0.05$.

The quality of seaweed products is influenced by several factors, including site characteristics, nutrient availability, and water quality. This is because environmental carrying capacity can affect seaweed growth and development, carrageenan content, and overall product quality. One of the influencing factors is sediment, which can also serve as a nutrient source. In addition, sediment can provide an indication of the presence of heavy metals in aquatic environments, which may pose health risks to aquatic biota, including seaweed (Widyaningsih et al., 2022).

Salinity is one of the key parameters supporting seaweed growth in cultivation environments (Nikhlani & Kusumaningrum, 2021). A decrease or increase in salinity beyond the optimal range may not directly cause mortality, but it can make seaweed less elastic, more prone to breakage, and may inhibit its growth (Kramandondo et al., 2022). Moreover, high salinity fluctuations can increase the susceptibility of seaweed to ice-ice disease.

CONCLUSION

Eucheuma cottonii cultivated using the longline method showed good growth, with an average daily growth rate of 16.66 g/day. The physico-chemical parameters of the waters at the study site were generally within the optimum ranges to support the growth of *E. cottonii*. The sediment observed at the study site was classified as medium sand, with a dynamic sedimentation rate influenced by estuarine inputs. The analysis indicated that the limiting factors directly associated with the growth of *E. cottonii* cultivated using the longline method were sedimentation rate and salinity. Therefore, seaweed cultivation management should consider salinity stability and sedimentation dynamics to maintain cultivation productivity.

AUTHOR CONTRIBUTIONS STATEMENT

The authors declare that their contributions to the preparation of this manuscript were as follows: CRM served as the main contributor and corresponding author, and was responsible for designing the study, collecting data, conducting the analysis, and preparing the manuscript for publication. RJN and IYM contributed to data analysis and manuscript preparation. MAA and MA contributed to data collection and manuscript preparation.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest with any party regarding the publication of this article.

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