



### Suitability water quality parameters for *Eucheuma cottonii* culture at Majene Waters

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#### ARTICLE INFO

#### ABSTRACT

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Seaweed cultivation in Majene Regency, West Sulawesi, has not experienced significant development as in neighboring Polewali Mandar and Mamuju Regency. This can be seen from the absence of active seaweed cultivation activities in Majene Regency. The aim of this research is to assess the physical and chemical aspects of water to determine the suitability of locations for cultivating *Eucheuma cottonii* seaweed in Majene waters. The method used to measure ecological suitability included parameters such as temperature, salinity, dissolved oxygen (DO), pH, phosphate, nitrate and salinity. Subsequently, the data is scored to determine suitability classes: suitable (S1) with values ranging from 37 to 48, moderately suitable (S2) with values between 36 and 25 and non suitable (S3)/N) with value <25. The results showed that after applying weighting and scoring, locations such as East Banggae, Pamboang 1, Tubo Sendana, and Sendana 2 showed suitable scoring result with scores of 39, 39, 40, and 40. While locations such as Pamboang 2, Pamboang 3, Malunda, and Sendana 1 showed moderately suitable scoring results with scores of 33, 33, 34 and 36. Majene waters have potential areas for seaweed cultivation based on classes S1 (suitable) and S2 (moderately suitable).

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#### Introduction

Indonesia exported 195,574 tons of seaweed with a value of USD 279.58 million in 2020, making Indonesia the second-largest seaweed producer after China (Putra *et al.*, 2022). Seaweed has a significant market prospect both domestically and internationally. The demand for seaweed as a fundamental ingredient in various industries gives this commodity a high market value. It is used in various industrial and health-related applications (Suparmi and Sahri, 2009), as well as in derivative products such as cendol, sweets, agar-agar (Nafed, 2011), paper (Kustantiny, 2011), paint, cosmetics (Andiewati *et al.*, 2019; Jesumani *et al.*, 2019; Akbar & Hasan, 2024), and for environmental purposes (Arbit *et al.*, 2018).

The Ministry of Marine Affairs and Fisheries (KKP) has set a target to achieve a national seaweed production of 24,74 million tons by 2024 (KKP, 2024). Therefore, efforts to provide high-quality and sustainable raw materials are of utmost importance. Additionally, the development of seaweed cultivation areas in Indonesia has only utilized approximately 2.7% (328,825 hectares) of the available potential area, which is estimated to be around 12,123,383 hectares (KKP, 2022). This indicates that the development of these areas has great potential for expansion and growth.

Majene Regency is one of the regencies in the West Sulawesi Province, where nearly all of its regions are bordered by the sea. The coastline of Majene Regency is approximately 125 kilometers long, with a marine area of around 13,124 square

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kilometers (Badan Pusat Statistik, 2022). Given the characteristics of the region, its potential, and development strategies in place, the marine and fisheries sector should ideally be the economic flagship and serve as the economic foundation for increasing income. The Makassar Strait, which connects the Indian Ocean and the South China Sea from south to north, encompasses 95% of the marine waters in Majene Regency.

Seaweed has not yet become a prominent commodity in Majene Regency. This is evident from the absence of seaweed cultivation activities in Majene Regency, while neighboring regencies like Polewali Mandar and Mamuju have seen growth in seaweed cultivation. Therefore, Majene Regency has the potential to be developed as a fisheries product that can increase local income, provide employment opportunities, and contribute to the country's foreign exchange earnings (Sari and Kurniawan, 2021).

One of the obstacles in the development of seaweed cultivation in an area is the lack of accurate data and information about the extent of land and the suitability of marine locations for seaweed cultivation (Pong-Masak et al., 2016; Ferdiansyah, Pratikto, and Suryono, 2019; Akbar et al., 2024). To address these challenges, it is essential to conduct an analysis of water quality parameters, including the physical and chemical characteristics of the marine environment (Saleky, Tuhumury, and Waileruny, 2020).

Based on the information provided, it is crucial to consider the carrying capacity of the marine environment when selecting a location for optimal seaweed growth and livelihood support. Therefore, research with the title "Suitability water quality parameters for *Eucheuma cottonii* culture at Majene Waters" is essential.

This research aims to evaluate the physical and chemical aspects of water to determine the suitability of locations for cultivating *Eucheuma cottonii* seaweed in Majene waters. It is expected that the study's results can be used to establish sustainable seaweed cultivation practices. This, in turn, will enable local seaweed cultivators to increase their income and contribute to economic growth in the region.

## Materials and Methods

### Location and time of research

This research was conducted from January to June 2023 in the marine waters of Majene Regency. The study employed a survey method and was conducted in three phases: (i) Gathering secondary data from relevant institutions, including the Majene Regency Marine and Fisheries Office. (ii) Initial survey to identify representative observation stations. (iii) Main survey to assess the suitability of the area for seaweed

cultivation by measuring physic and chemical parameters. Water quality analysis was performed at the Water Quality Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar. The research locations are detailed in Table 1.

**Table 1.** Position of eight location transects on Majene waters.

Location Names	Positions
Banggae Timur	S 03°32'57.02" and E 118°58'38.04"
Pamboang 1	S 03°32'26.704" and E 118° 55'07.756"
Pamboang 2	S 03°29'37.924" and E 118° 53'31.474"
Pamboang 3	S 03°27'08.209" and E 118° 52'40.550"
Sendana 1	S 03°20'21.000" and E 118°50'54.562"
Sendana 2	S 03°17'38.056" and E 118°51'07.538"
Tubo Sendana	S 03°05'02.66" and E 118°47'33.40"
Malunda	S 03°00'42.00" and E 118°51'26.30"

## Map Making

The research focus is on creating a land use map and collecting field data. The process of creating the land cover map begins with geometric correction to align the RBI (Rupa Bumi Indonesia or Indonesian Topographic Map) with geographic coordinates. Subsequently, digitization is carried out to identify land cover types based on the RBI map legend.

## Data analysis

The seaweed cultivation suitability analysis is conducted in three stages. The first stage involved determining requirements (parameters and criteria), weighting and scoring (Table 2). Suitable criteria or constraints received the highest score, and determining parameters received the highest weight. The suitability level is determined based on suitability of the physical and chemical parameters of the water for aquaculture organisms (Yuspita et al., 2022).

Parameters that are expected to have greater influence as a limiting factor for aquaculture organisms are given a higher weight. Land suitability criteria are based on physical-chemical parameters of the water that are required with reference to the suitability matrix suitability matrix. Giving weights and scores in Table 2 considers the influence of variables that determine the success of fish farming (Hastari et al., 2017).

Given is lower, namely 1 and 3. According to Susanto et al. (2021), based on the land suitability level for seaweed cultivation, the water land classes are divided into the following levels:

Class S1: Highly Suitable

Highly suitable refers to land or areas that are highly suitable for seaweed cultivation without

significant limiting factors. The physical and chemical parameters of the water meet ideal requirements, or they have minor limiting factors that do not significantly reduce productivity. Class S1 land has a value ranging from 37 to 48 out of the maximum value allocated for seaweed cultivation.

**Class S2: Moderately Suitable**

Moderately suitable means that the physical and chemical parameters of the water do not meet ideal conditions. The land or area has significant or relatively large limiting factors that impact seaweed activities or production. This class requires more technological input and treatment. The maximum value for seaweed cultivation falls between 25 and 36.

**Class S3: Not Suitable**

Not suitable refers to areas that are not suitable for sustainable seaweed cultivation due to significant limiting factors or because the physical and chemical parameters of the water do not meet ideal conditions. Class S3:N has a value less than 25, which is the maximum value for seaweed cultivation. The criteria for seaweed cultivation suitability in the water are presented in the following [Table 2](#).

**Table 2.** Land Suitability Criteria

No	Parameter	Criteria	Class	Assessment Number (A)	Weight (B)	Score AXB	Reference
1	DO (ppm)	>4, 3-8	S1	3	2	6	(Susana, 2009)
		2-4	S2	2		4	
		<2	N	1		2	
2	Temperature (°C)	24-30	S1	3	3	9	(Rusdi et al., 2017)
		20-123	S2	2		6	
		<20;>30	N	1		3	
3	pH	7-8,2	S1	3	2	6	(Nur, Syam and Patang, 2016)
		>8,2-9	S2	2		4	
		<7 dan >9	N	1		2	
4	Salinity (ppt)	28-34	S1	3	3	6	(Yuliyana, Rejeki and Widowati, 2018)
		25-27;35-36	S2	2		4	
		<25; >36	N	1		2	
5	Nitrate (ppm)	0,1-0,7	S1	3	3	9	(Afandi and Musadat, 2018)
		0,01-0,1	S2	2		6	
		<0,01-	N	1		3	
6	Phosphate (ppm)	0,002-0,03	S1	3	3	9	(Pauwah, Irfan and Muchdar, 2020)
		0,04-0,1	S2	2		6	
		<0,003;>0,1	N	1		3	

**Explanation:**

The assessment scores are based on the guidelines (Susanto, et al., 2021) 3: Suitable ; 2: Moderately Suitable ; 1: Not Suitable.

To determine location suitability using the formula:

$$Ci = \frac{\text{maximum weight}-\text{minimum weight}}{n}$$

**Explanation:**

- Ci: the range between classes
- n: number of classes planned

The maximum weight is 3, the minimum weight is 1. So  $2+3+2+3+3+3=16$ . The value of 16 is the sum of the weights of each variable. Then the result is the maximum weight =  $16 \times 3 = 48$ , while the minimum weight is  $16 \times 1 = 16$ .

The range between classes (Ci) is determined by the following equation:  $n = 3$  (S1, S2, S3 =N)

$$Ci = \frac{48-16}{3} = 11$$

Evaluation of water suitability assessment for seaweed cultivation sites

**Table 3.** Evaluation of Waters Suitability Assessment

No	Value range (Skor)	Suitability level	Evaluation Conclusion
1	37-48	S1	Suitable
2	36-25	S2	Moderately Suitable
3	<25	S3:N	Not Suitable

**Results**

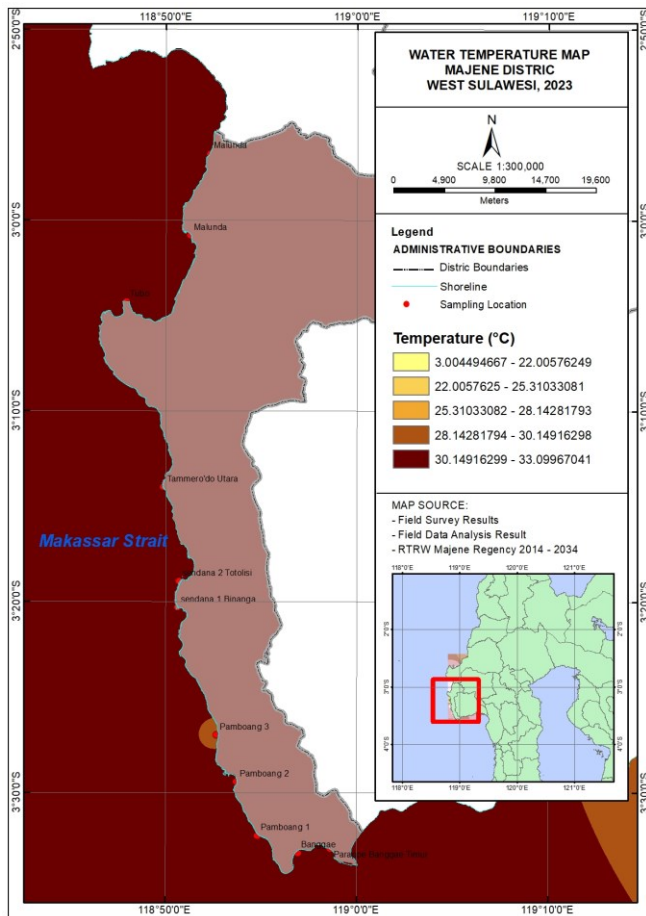
**Water Quality**

The results of water temperature measurements are classified as very good for seaweed cultivation. The temperature at the research site is in the range of 28.9-33.1 °C, with an average temperature of 30.97 °C where the temperature is classified as very good for seaweed cultivation. (Badan Standar Nasional, 2010) explains the temperature of 26-32 °C is a good enough temperature for seaweed cultivation. The distribution map of water temperature measurements in Majene Regency in each sub-district can be seen in the [Figure 1](#).

The results of salinity measurements during the study were classified as very good for seaweed cultivation. Salinity at the study site ranged from 24-32 ppt, with an average value of seawater salinity for grass cultivation in Majene district of 29.83 ppt. Based on (Madina et al., 2022) states that the optimal salinity range for seaweed growth is 25-33 ppt. where salinity is already very good for seaweed cultivation. The map of water salinity measurements in Majene Regency in each sub-district can be seen in the [Figure 2](#).

The results of pH measurements during the study were classified as less suitable for seaweed cultivation. The pH value at the study site ranged from 5.81 to 8.7, with an average pH value of 6.75 where the pH is below the optimum range for seaweed cultivation. According to Badan Standar Nasional (2010) pH 7-8.5 is a good pH to support the growth of seaweed. The pH measurement map

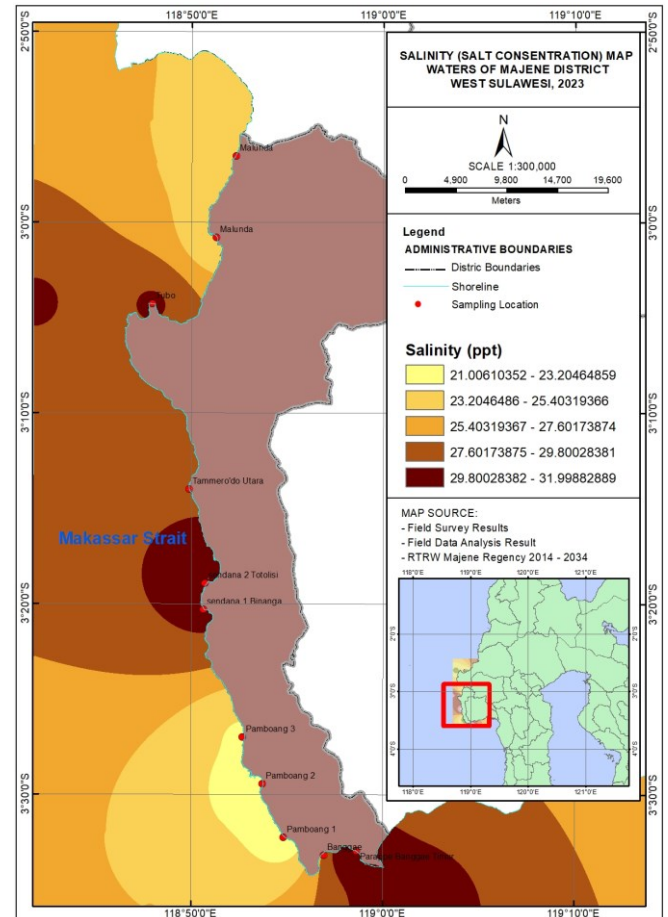
of waters in Majene Regency in each sub-district can be seen in the [Figure 3](#).



**Figure 1.** Temperature parameter distribution map of Majene Regency.

The results of dissolved oxygen measurements during the study were classified as very good for seaweed cultivation. The DO value of seawater in Majene Regency ranges from 4.6-9.4 ppm with an average value of 6.47 ppm, where the DO is very suitable for seaweed cultivation. According to [Badan Standar Nasional \(2010\)](#) seaweed will grow well if the dissolved oxygen conditions in the waters is more than 4 mg/L. The map of DO measurements of waters in Majene Regency in each sub-district can be seen in the [Figure 4](#).

The range of nitrate is quite low so it is not good for seaweed cultivation. The results of nitrate measurements in Majene waters ranged from 0.0015-0.031 ppm with an average nitrate value of 0.02 ppm. According to [Badan Standar Nasional \(2010\)](#), nitrate content is more than 0.04 mg/L is the optimal nitrate value for seaweed cultivation. Nitrate measurement map of waters in Majene Regency in each sub-district can be seen in the [Figure 5](#).

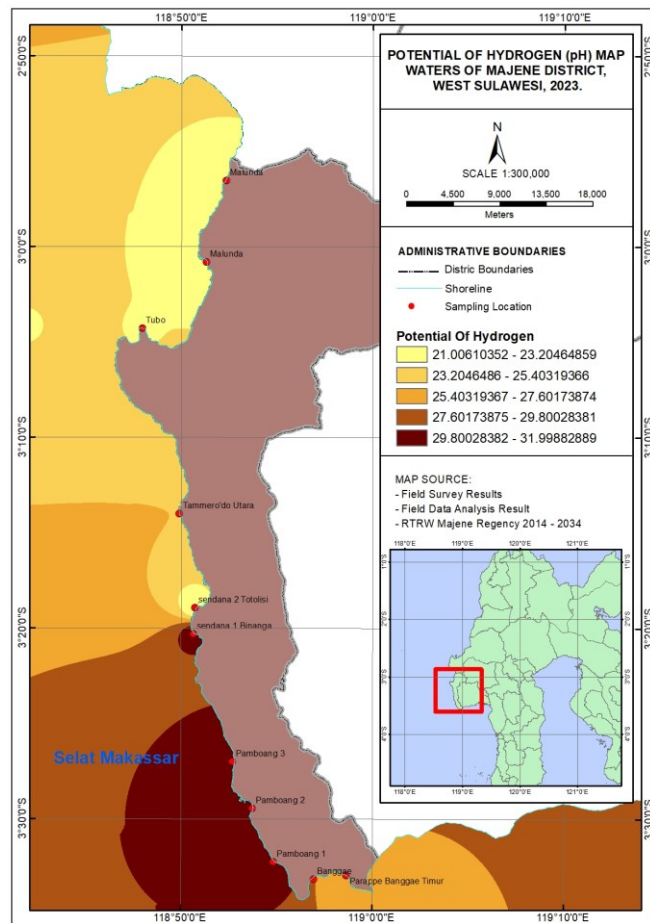


**Figure 2.** Salinity parameter distribution map of Majene Regency.

The range of phosphate in Majene waters is good to support the growth of seaweed. The results of phosphate measurements in Majene waters ranged from 0.0019-0.0297 ppm with an average phosphate value of 0.02 ppm. According to [Ruslaini \(2016\)](#), the value of phosphate in seawater is 0.005-0.020 mg/L. Phosphate measurement map of waters in Majene Regency in each sub-district can be seen in the [Figure 6](#).

### Feasibility of Seaweed Cultivation Sites

The Location Suitability Map of Seaweed Cultivation in the waters of Majene Regency, Locations such as Pamboang 1, Tubo Sendana, Sendana 2, and Banggae Timur show suitable scoring results. On the other hand, locations such as Pamboang 2, Pamboang 3, Malunda, and Sendana 1 showed moderately suitable scoring results in each sub-district can be seen in the [Figure 7](#).



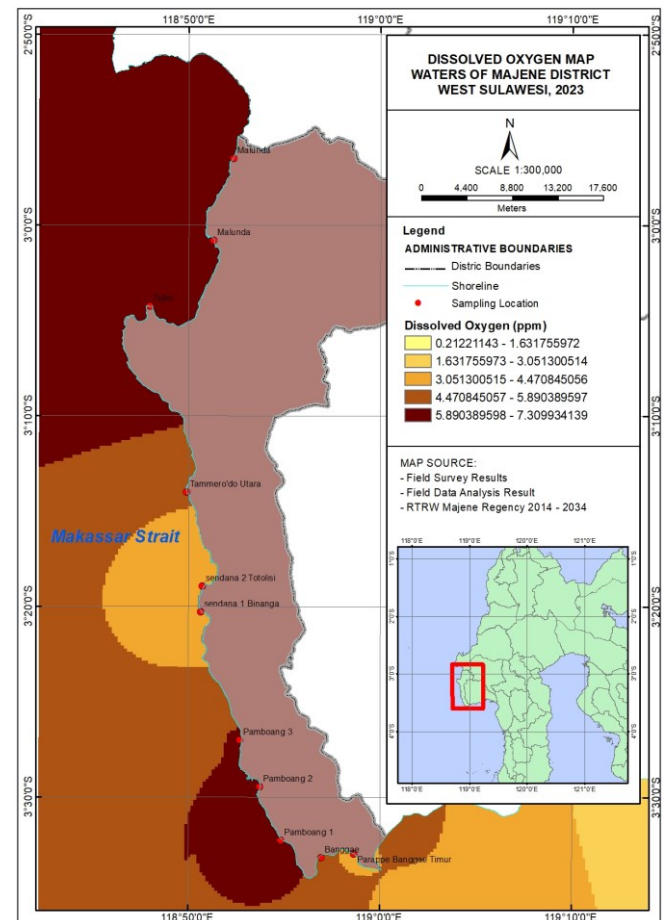
**Figure 3.** Distribution map of pH parameters of Majene Regency.

### Discussion Water Quality

Temperature is one of the factors controlling the speed of biochemical reactions that determine the rate of metabolism of aquatic biota through changes in the activity of related molecules (Riani, 2012). Temperature greatly affects the growth of seaweed in the process of photosynthesis and indirectly affects the solubility of oxygen used for the respiration process of organisms in the sea. Surface water temperature is influenced by meteorological conditions such as rainfall, evaporation, air humidity, wind speed and sunlight intensity. If there is a high temperature increase, the thallus will become pale yellowish and unhealthy (Burdames and Ngangi, 2014).

The temperature at the research site is in the range of 28.9-33.1 °C, with an average temperature of 30.97 °C where the temperature is classified as very good for seaweed cultivation. (Badan Standar Nasional, 2010) explains the temperature of 26-32 °C is a good enough temperature for seaweed cultivation. According to Yulius *et al.* (2019) the optimum temperature for the cultivation of seaweed *Kappaphycus alvarezii* is 25-31 °C. Therefore, this

shows that the temperature conditions in the waters of Majene Regency are suitable for seaweed cultivation.

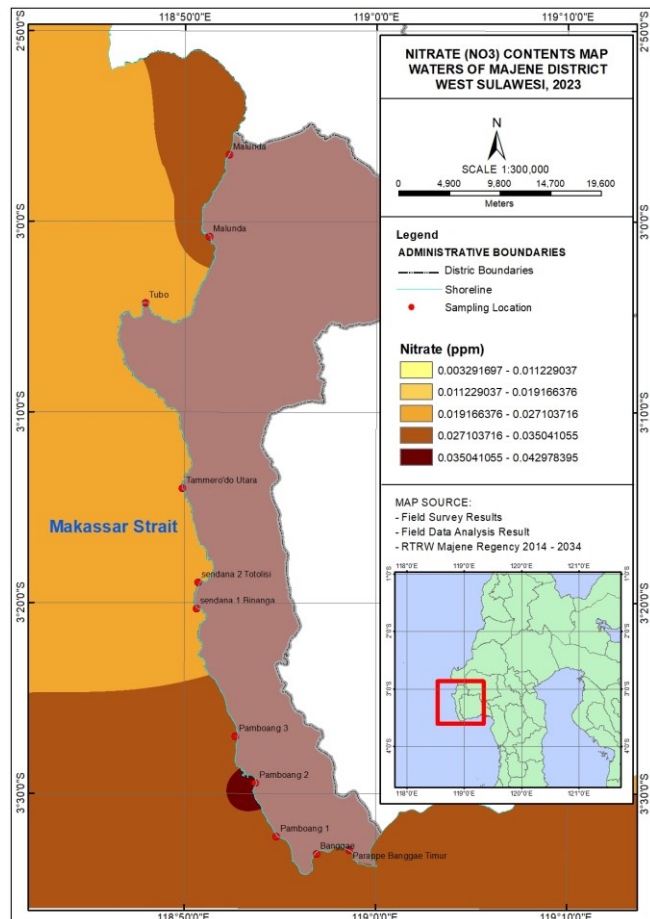


**Figure 4.** Distribution map of DO parameters of Majene Regency.

Salinity in the sea is influenced by various factors such as water circulation, evaporation, rainfall and river flow so that salinity can also directly affect the growth of seaweed. Rainfall will be able to reduce salinity levels because rainwater has a low salinity while evaporation will cause high salinity in a body of water (Sunada and Indriyawan, 2006). Seaweed can grow well in a certain salinity range depending on its tolerance and adaptation to the environment. If the salinity of the waters is low, the seaweed will be pale, the thallus becomes soft and easily broken, and the seaweed cannot grow normally (Asni, 2015). The same thing will also happen if the water salinity is high.

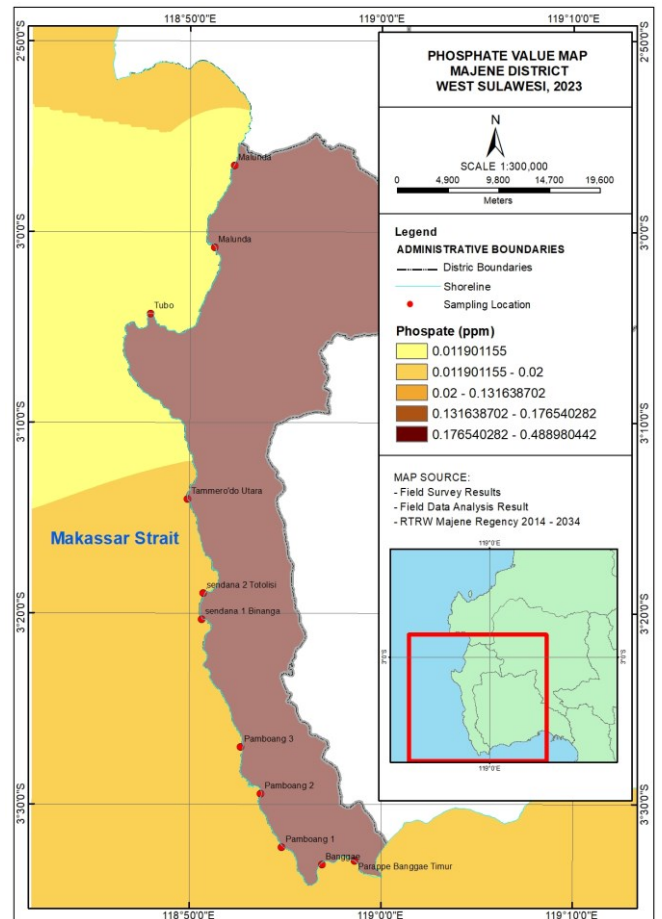
Salinity at the study site ranged from 24-32 ppt, with an average value of seawater salinity for grass cultivation in Majene district of 29.83 ppt. Based on (Madina *et al.*, 2022) states that the optimal salinity range for seaweed growth is 25-33 ppt. where salinity is already very good for seaweed cultivation. According to Badan Standar Nasional (2010)

explains that the growth of seaweed will be good if the water salinity ranges from 28-34 ppt. This is in accordance with the opinion of Patang, Mustarin and Rivai (2021) which states that good salinity for seaweed cultivation ranges from 28-34 ppt and the optimal one is at 33 ppt salinity. Therefore, this shows that the salinity conditions in the waters of Majene Regency are suitable for seaweed cultivation.



**Figure 5.** Nitrate parameter distribution map of Majene Regency.

The degree of acidity (pH) is a chemical factor that can determine the growth of seaweed. Luning (1990), suggests that changes in the pH of the waters, both in the alkaline direction (pH rises) and in the acidic direction (pH falls) will disrupt the life of seaweed and other aquatic organisms. The pH value is important to know because many chemical and biochemical reactions that occur at certain pH levels. Waters that receive large amounts of organic waste have the potential for high acidity (Susana, 2009). If the pH value of seawater is in a high enough range, it will affect the physiology of organisms, the toxicity of some pollutants such as ammonia and heavy metals, and can cause sudden death in organisms (Rukminasari, Nadiarti and Awaluddin, 2014).

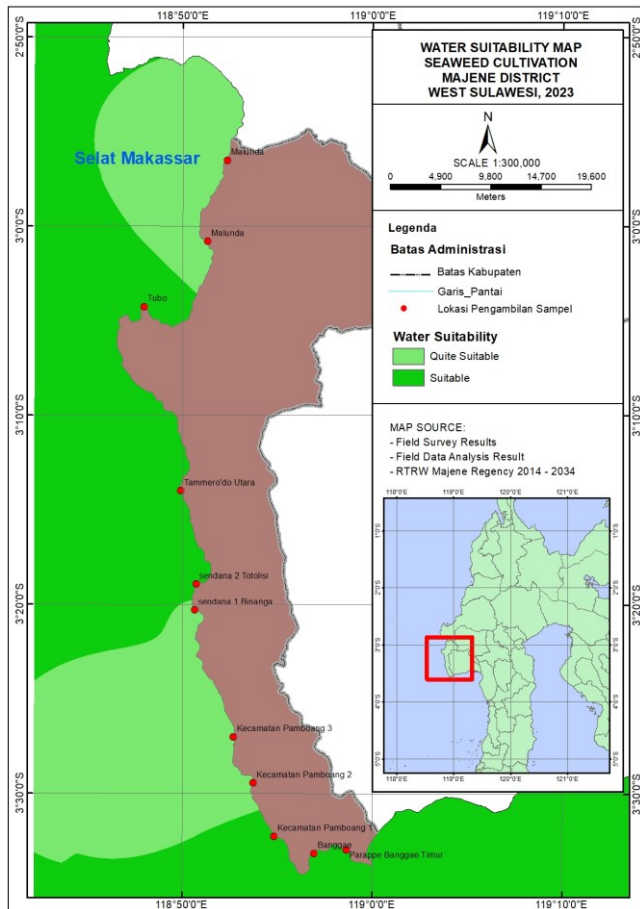


**Figure 6.** Phosphate parameter distribution map of Majene Regency.

The pH value at the study site ranged from 5.81 to 8.7, with an average pH value of 6.75 where the pH is below the optimum range for seaweed cultivation. According to Badan Standar Nasional (2010) pH 7-8.5 is a good pH to support the growth of seaweed. This is in accordance with the opinion of Susana (2009) that the pH degree of acidity (pH) 7-9 is a suitable range for the growth of seaweed *Eucaema* sp. and the optimum range is 7.3-8.2. Although the pH value is relatively low, but seaweed is still able to tolerate the pH range. Almost every seaweed species shows a high degree of adaptability and thrives in a pH range of 6.8 to 9.6 (Rukka et al., 2022).

Dissolved Oxygen (DO) is one of the most important water quality parameters to consider, because dissolved oxygen plays an important role for seaweed growth. Dissolved oxygen is usually found in high concentrations in the surface layer, because in the surface layer there is a process of oxygen diffusion from the air into the water. According to Nur, Syam and Patang (2016), the DO quality standard value for seaweed is more than 5 mg/L. This means that if dissolved oxygen in the waters

reaches 5 mg/L or more, then seaweed metabolism can run optimally.



**Figure 7.** Final Thematic Map of Seaweed Cultivation Site Suitability in Majene Waters.

Dissolved oxygen in water is strongly influenced by temperature. According to (Mulyadi, 2023), oxygen saturation in water is influenced by water temperature. The higher the temperature, the lower the concentration of dissolved oxygen. Basically, the process of decreasing oxygen in water is caused by chemical, physical and biological processes, namely the process of respiration by both animals and plants. The DO value of seawater in Majene Regency ranges from 4.6-9.4 ppm with an average value of 6.47 ppm, where the DO is very suitable for seaweed cultivation. According to (Badan Standar Nasional, 2010) seaweed will grow well if the dissolved oxygen conditions in the waters is more than 4 mg/L. While according to Astriana et al. (2019) seaweed requires dissolved oxygen of 2-4 mg/L or more to cloud the growth of seaweed.

Ammonia measurement results ranged from 0.0017-0.0139 ppm. Good ammonia levels for marine algae of 0.01-0.03 ppm (Shpigel et al., 2019). Ammonia has an important role in the waters to support the growth of seaweed. Ammonia levels in

Sendana District is included in the low category, and is suitable for seaweed cultivation. If the waters have high ammonia levels, then ammonia will be toxic and inhibit seaweed growth. Therefore, for photosynthesis in seaweed to run optimally, the waters must have low ammonia levels.

The results of nitrate measurements in Majene waters ranged from 0.0015-0.031 ppm with an average nitrate value of 0.02 ppm. According to Badan Standar Nasional (2010), nitrate content is more than 0.04 mg/L is the optimal nitrate value for seaweed cultivation. Meanwhile, according to Yulius et al. (2019) states that the nitrate content is good enough for seaweed at 0.9-3.5 mg/L. The presence of nitrates in waters is very important to support the growth of seaweed such as the formation of carbohydrates, proteins, fats, production, and produce food reserves in organic form (Lutfiati, Cokrowati and Azhar, 2022). The range of nitrate in Sendana Sub-district is quite low so it is not good for seaweed cultivation.

The results of phosphate measurements in Majene waters ranged from 0.0019-0.0297 ppm with an average phosphate value of 0.02 ppm. According to Ruslaini (2016), the value of phosphate in seawater is 0.005-0.020 mg/L. While according to Badan Standar Nasional (2010) states that the growth of seaweed will be maximized if the phosphate content in the waters is more than 0.1 mg / L. The phosphate content in good waters for seaweed productivity ranges from 0.02-1 mg/L (Lutfiati, Cokrowati and Azhar, 2022). The presence of phosphate in the waters is closely related to the fertility of the waters themselves, if the waters have the appropriate phosphate value for seaweed cultivation it will accelerate its growth. The range of phosphate in Majene waters is good to support the growth of seaweed.

### Feasibility of Seaweed Cultivation Sites

Based on the scores Table 4 given to water quality parameters such as temperature, salinity, dissolved oxygen (DO), pH, nitrate, and phosphate, land suitability for seaweed cultivation can be classified into three categories, namely suitable, moderately suitable, and unsuitable (Rusdi et al., 2017).

**Table 4.** Feasibility of Seaweed Cultivation Sites for each location.

Location Names	value range (skor)	Suitability level	Evaluation Conclusion
Banggae Timur	39	S1	Suitable
Pamboang 1	39	S1	Suitable
Pamboang 2	33	S2	Moderately Suitable
Pamboang 3	33	S2	Moderately Suitable
Sendana 1	36	S2	Moderately Suitable
Sendana 2	40	S1	Suitable
Tubo Sendana	40	S1	Suitable
Malunda	34	S2	Moderately Suitable

Based on the results of scoring at each station using class intervals, it can be categorized Pamboang 1 and East Banggae locations are included in the highly suitable (S1) for seaweed cultivation sites with a suitability value of 39, the value meets the requirements of the assessment of water quality criteria. Tubo Sendana, Sendana 2 are included in the highly suitable (S1) for seaweed aquaculture sites with a suitability value of 40, indicating that the scoring appropriate results. This means that water quality parameters such as temperature, salinity, DO, pH, nitrate, and phosphate in locations to support life and optimal growth of seaweed (Rusdi *et al.*, 2017). Therefore, these lands are considered very suitable for seaweed cultivation.

Meanwhile, the locations of Pamboang 2, Pamboang 3, are included in the moderately suitable category (S2) for seaweed cultivation sites with a suitability score of 33. Malunda, and Sendana 1 show moderately suitable scoring results with scoring results of 34 and 36 respectively. Although the water quality parameters in these locations meet most of the requirements, but there are several aspects that need to be considered so that life and growth of seaweed can be optimal. Nevertheless, these lands still allow for seaweed cultivation with some adjustments.

## Conclusion

Based on the evaluation of water quality parameters, land for seaweed cultivation in Majene Regency can be classified into three categories, namely suitable, moderately suitable. Locations such as Pamboang 1, Tubo Sendana, Sendana 2, and Banggae Timur show suitable scoring results, with water quality parameters that meet the optimal requirements for seaweed cultivation. On the other hand, locations such as Pamboang 2, Pamboang 3, Malunda, and Sendana 1 showed moderately suitable scoring results, requiring some adjustments for optimal seaweed cultivation.

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