Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Analysis of Seawater Quality in Seaweed Farming Areas of Labuhan Kertasari Village, West Sumbawa Regency

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Received: April 28, 2026. Accepted: May 19, 2026. Published: June 28, 2026

Abstract: Seawater quality is a key factor determining the success of seaweed cultivation. Unsuitable water quality conditions can lead to reduced productivity or even the failure of seaweed cultivation. This study aims to analyze seawater quality at a seaweed cultivation site in Labuhan Kertasari Village, West Sumbawa Regency, to identify the factors causing cultivation failures that have occurred over the past year. Water quality is a critical factor influencing seaweed growth and productivity; therefore, a comprehensive evaluation of the water's physical and chemical parameters is necessary. The research method used was quantitative descriptive, with sampling conducted at three horizontal points along a ±1 km stretch, each repeated three times. The parameters analyzed included temperature, salinity, dissolved oxygen (DO), pH, turbidity, current velocity, nitrate, and phosphate, measured in situ and through laboratory analysis. The results of the study indicate that most water quality parameters remain within the optimal range for seaweed cultivation, namely temperature 28–30°C, salinity 31–34 ppt, DO 4.2–6 mg/L, pH 6.4–8.2, turbidity 50–210 cm, current velocity 0.35–0.43 m/s, and phosphate at 0.03 mg/L, so that, in general, water conditions still support seaweed growth. However, nitrate levels were not detected at any sampling site, indicating low availability of nitrogen nutrients in the water. This suggests a potential nutrient limitation that could affect seaweed growth. Therefore, further analysis is needed regarding the role of nitrate nutrients in seaweed growth in Labuhan Kertasari Village. In addition, nutrient management strategies and regular water quality monitoring are needed to improve the success of seaweed aquaculture in the future.

Keywords: Nitrate; Oceanographic Parameters; Phosphate; Seaweed Aquaculture; Seawater Quality.

Introduction

Water quality is a vital factor in aquaculture activities [1]. Including seaweed cultivation. Several water quality parameters, such as dissolved oxygen, turbidity, salinity, pH, nutrient levels, temperature, and current velocity, influence the survival of aquatic organisms [2]. To support the physiological processes and growth of cultured organisms, water quality must be good and within the optimal range [3].

In seaweed cultivation, one of the key factors influencing growth and productivity is water quality [4]. If water parameters fall outside the optimal range, they can adversely affect seaweed growth, including thallus development, gel content, and resistance to disease and environmental stress [5]. Unsuitable water conditions can also have adverse effects, such as causing slow growth, discoloration, and even the death of the seaweed itself [6]. Therefore, regular monitoring of seawater quality in seaweed cultivation is necessary to track its condition.

Seaweed is a high-value fishery commodity and a source of income for coastal communities in addition to fish [7]. Seaweed has many processed forms that can be utilized, such as food, pharmaceuticals, cosmetics, agar-agar, and carrageenan [8]. Seaweed has become a leading export product due to the continuously increasing demand in export markets, both locally and internationally [9]. Furthermore, seaweed cultivation is considered an environmentally friendly practice because it does not require additional feed. Seaweed also plays a crucial role in maintaining seawater quality by absorbing carbon and excess nutrients [10].

Labuhan Kertasari Village, located in West Sumbawa Regency, is the only major seaweed cultivation center in West Sumbawa Regency [11]. The beach serves as the seaweed cultivation site in Labuhan Kertasari Village, which features extensive waters, calm currents, clear water, and a seabed substrate conducive to rope-suspended cultivation [12]. Seaweed cultivation is a primary livelihood for most residents of Labuhan Kertasari Village, a practice passed down through generations [13].

However, based on field observations, seaweed farmers in Labuhan Kertasari Village have experienced cultivation failures over the past year. The seaweed failed to grow. The seedlings tied to hanging ropes did not develop and were damaged. Various efforts have been made, including repeated planting and replacing the seedlings with ones from outside the area, but the seaweed still failed to grow. The preliminary assumption is that this is due to the flood season that struck the cultivation site a year ago. To date, there has been no scientific study specifically analyzing the seawater quality at the cultivation site in an effort to identify the root cause of the seaweed cultivation failure.

Several previous studies have analyzed seawater quality for seaweed cultivation in various coastal areas [14, 15], but most of these studies have focused only on general assessments of the physical and chemical parameters of the water. To date, there has been no scientific study specifically analyzing seawater quality conditions in the seaweed

How to Cite:
A. Fajrin and A. Rahman, "Analysis of Seawater Quality in Seaweed Farming Areas of Labuhan Kertasari Village, West Sumbawa Regency", *J. Pijar.MIPA*, vol. 21, no. 3, pp. 620–625, Jun. 2026. https://doi.org/10.29303/jpm.v21i3.11973

farming area of Labuhan Kertasari Village following the cultivation failures experienced by the local community. Therefore, this study offers a novel approach by evaluating the physical and chemical parameters of the water that are directly linked to the seaweed cultivation failure experienced by farmers in Labuhan Kertasari Village.

Based on these conditions, this study was conducted to analyze seawater quality in the seaweed cultivation area of Labuhan Kertasari Village as an effort to identify environmental factors that may have caused the cultivation failure. The measured parameters include pH, salinity, dissolved oxygen (DO), current velocity, turbidity, temperature, nitrate, and phosphate. The measurement results were then compared with seawater quality standards and the optimal range for seaweed cultivation to assess the suitability of the waters for sustainable seaweed cultivation.

Research Methods

Materials and Instruments

The equipment used in this study included a DO meter to measure dissolved oxygen (DO) levels and water temperature, a pH meter to measure acidity, a Secchi Disk to measure water clarity, a refractometer to measure salinity, a nitrate test kit from Salifert to measure nitrate levels, and a phosphate test kit from Salifert to measure phosphate levels. a styrofoam rope to measure current velocity, 100 mL sample bottles for storing seawater samples, and a Global Positioning System (GPS) to determine the coordinate points of the sampling locations. All measurements were conducted using equipment available at the Laboratory of the Fisheries Resource Utilization Study Program. The material used in this study was seawater samples collected from seaweed cultivation sites in Labuhan Kertasari Village, West Sumbawa Regency.

Methods

This study was conducted over a period of one month and consisted of field and laboratory activities. Field activities were carried out at a seaweed cultivation site in Labuhan Kertasari Village for sampling and initial in situ measurements of several water quality parameters, while laboratory activities were conducted at the Laboratory of the Fisheries Resource Utilization Study Program for further analysis of seawater quality parameters.

Sampling was conducted along the cultivation area, approximately 1 km long, using purposive sampling. Three observation points were selected horizontally to represent the water conditions in the seaweed cultivation area. The distance between observation points was approximately 330 meters, and sampling was repeated three times at each point to improve data accuracy. Sampling was conducted during low-tide conditions to represent seawater characteristics at times when seaweed cultivation activities are commonly exposed to lower water levels. Water samples were collected at a depth of approximately 30–50 cm below the water surface and placed into 100 mL sterile sample bottles for laboratory analysis.

Temperature, water clarity, and current velocity were measured directly (in situ) in the field. Water clarity was measured using a Secchi disk, while current velocity was measured using a simple float method involving a styrofoam rope and calculation of the current's travel time. pH, salinity, nitrate, and phosphate were measured in the laboratory using available instruments and test kits.

Nitrate and phosphate analyses were performed using colourimetric methods with nitrate and phosphate test kits, based on changes in the color of the sample solution. Measurement results were obtained by matching the sample color to a standard color chart with numerical concentration values on the test kit indicator, so that the resulting color could be translated into quantitative nitrate and phosphate levels in accordance with the kit instructions.

Data analysis was conducted using a quantitative descriptive approach, comparing measured water quality parameters with standard or optimal ranges for seaweed cultivation, as reported in various references and previous studies (Table 1). The measurement data are presented in tables and graphs to facilitate the interpretation of water quality conditions at the study site. A reference for water quality parameters for seaweed cultivation is shown in Table 1.

Table 1. Reference guidelines for water quality parameters in seaweed cultivation

Parameter	Optimal value	Reference
Temperature	28–30°C	[16]
Salinity	28–34 ppt	[17]
pH	6.5–8.5	[18]
Dissolved Oxygen	>5 mg/L	[19]
Nitrate	0.01–3.5 mg/L	[20]
Phosphate	0.005–0.20 mg/L	[21]
Transparency	>1 meter	[22]
Current velocity	0.2–0.4 m/s	[23]

Results and Discussion

Salinity

Salinity levels at all sampling sites ranged from 32 to 34 ppt (Figure 1). At observation sampling 1, salinity ranged from 32 to 34 ppt with an average of 32.6 ppt, while sampling 2 showed a stable salinity value of 34 ppt across all measurements. At observation sampling 3, salinity ranged from 33 to 34 ppt with an average of 33.6 ppt. The relatively small variation in salinity across observations indicates that the study area has fairly stable seawater characteristics. The higher salinity values at observations 2 and 3 are likely related to the limited influence of freshwater and the stronger dominance of seawater, whereas the slightly lower salinity at observation 1 is likely influenced by freshwater inflow from land and mixing processes driven by tides. Salinity conditions are also thought to play a role in maintaining the stability of the aquatic environment that supports seaweed physiological processes, such as nutrient uptake and photosynthesis [24]. Overall, all salinity values obtained remain within a range suitable for seaweed cultivation [17].

Temperature

Water temperatures measured at the sampling sites ranged from 28°C to 30°C (Figure 2). At sampling 1, temperatures averaged 29.5°C. Meanwhile, observation sampling 2 and 3 showed slightly lower temperatures, with averages of 28.5°C. The relatively uniform temperature distribution across the sampling indicates fairly stable environmental conditions, likely influenced by solar radiation intensity and local water mass movements [25]. Overall, the recorded temperatures remain suitable for seaweed cultivation. According to [16], the optimal temperature range for seaweed growth is 28°C to 30°C; thus, the temperature conditions at the study site remain suitable for supporting seaweed growth.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) concentrations measured during the study ranged from 4.2 to 6 mg/L (Figure 3). Sampling 1 showed DO values between 4.2 and 5.7 mg/L, with an average of 5.13 mg/L, while sampling 2 showed an average of 5.7 mg/L. At sampling 3, DO with an average of 6 mg/L. The relatively small differences in DO values between samples indicate that oxygen distribution at the study site tends to be stable. The higher DO values at points 2 and 3 are likely related to improved water circulation and higher photosynthetic activity, while the lower values at sampling 1 are likely due to low water movement or high rates of organic matter decomposition. Dissolved oxygen plays a crucial role in supporting respiration and metabolic processes in aquatic organisms [26,27]. These conditions are still considered suitable for seaweed cultivation. According to [19], the appropriate DO level for seaweed growth is above 5 mg/L; thus, the water quality at the study site generally still supports seaweed cultivation.

pH

pH values of the water at all sampling sites ranged from 6.4 to 8.2. Sampling 1 had an average pH of 6.73, while sampling 2 had an average of 7.83 (Figure 4). At sampling with an average of 8.1. Low variation in pH between sampling indicates fairly stable water conditions. The higher pH values at sampling 2 and 3 are likely related to more intensive photosynthetic activity, thereby reducing the concentration of dissolved CO_2 in the water [28]. while the lower pH value at sampling 1 was influenced by the input of organic matter or decomposition processes. These pH conditions are still considered suitable for supporting the physiological processes and growth of seaweed. According to Ministry of Environment Decision No. 51/MENKLH/2004 [18], the water conditions at the study site generally still support seaweed growth well.

Water transparency

The water clarity levels recorded during the observations ranged from 50 to 210 cm (Figure 5). At sampling 1, the light penetration values ranged from 50 to 200 cm, with an average of 116 cm. Sampling 2 also showed the same range, namely 50 to 200 cm with an average of 116 cm, while observation sampling 3 had light penetration values between 80 and 210 cm with an average of 140 cm. Ideal seaweed cultivation sites generally have light penetration exceeding 1 m and a minimum light intensity of 6 m [22,29]. In this study, sunlight still reached the seabed along the coastline. Luminance values of 50 to 210 cm were obtained based on water depth at the time of measurement, so the measured light penetration levels corresponded to the water depth at each observation point

Phosphate

Phosphate levels at all 3 sampling sites, with 9 replicates each, were consistently 0.03 mg/L (Figure 6). This indicates that the distribution of phosphate at the study site is relatively stable and uniform. Phosphate is an essential nutrient that promotes seaweed growth [30,31]. The appropriate phosphate concentration for seaweed cultivation ranges from 0.005 to 0.20 mg/L [21]. Based on this reference, phosphate levels at the study site remain suitable for supporting seaweed growth.

Nitrate

Test results for nitrate levels at all sampling points were undetectable (zero). The optimal nitrate concentration for seaweed is 0.01–0.79 mg/L [32]. The absence of nitrate at all sampling points may be influenced by various factors. One of the most likely causes is the high uptake of nitrate by aquatic organisms, particularly phytoplankton and seaweed, resulting in nitrate levels in the water becoming undetectable [33, 34]. Additionally, water characteristics classified as oligotrophic, meaning they have low nutrient content, contribute to nitrate scarcity. This condition generally occurs when there is no nutrient supply from land, such as agricultural runoff, domestic wastewater, or river inflow [35].

Current velocity

The current velocity at all testing samples was nearly the same, ranging from 0.35 m/s to 0.43 m/s (Figure 7). At sampling 1, it ranged from 0.35 m/s to 4.0 m/s, with an average of 0.37. At point 2, the current velocity range was the same, with the same average value. Meanwhile, at sampling 3, it ranged from 0.36 to 0.43 m/s with an average of 0.4 m/s. The ideal current velocity for seaweed cultivation activities ranges from 0.2 to 0.4 m/s. Based on this reference, the current velocity in this study remains within the normal range, albeit slightly higher [23].

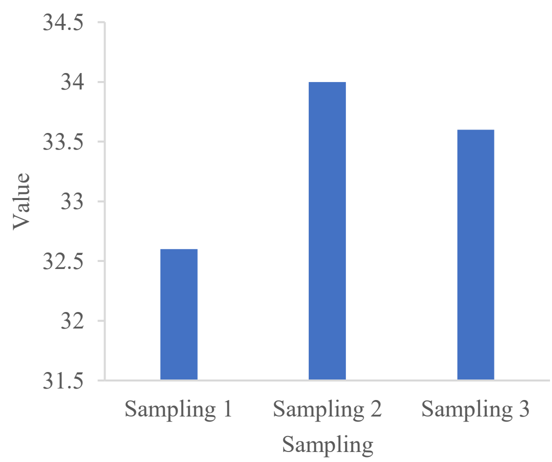

Figure 1. Salinity

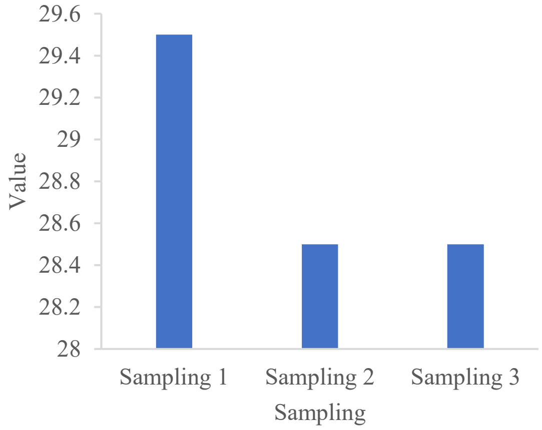

Figure 2. The water temperature (°C)

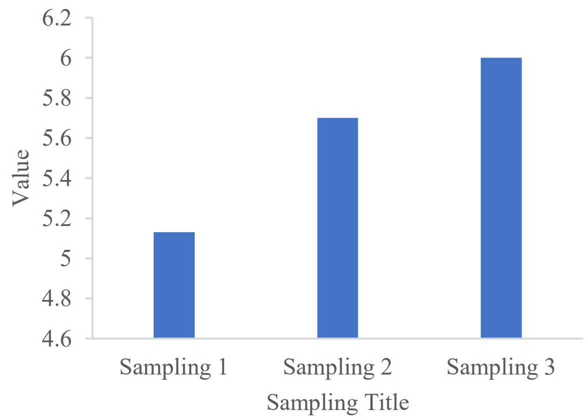

Figure 3. Dissolve oxygen (mg/L)

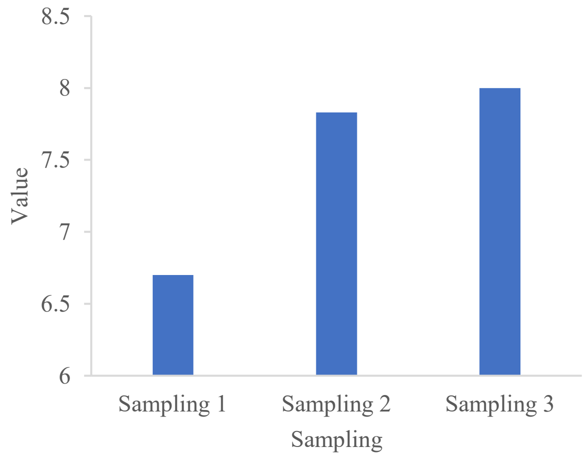

Figure 4. pH

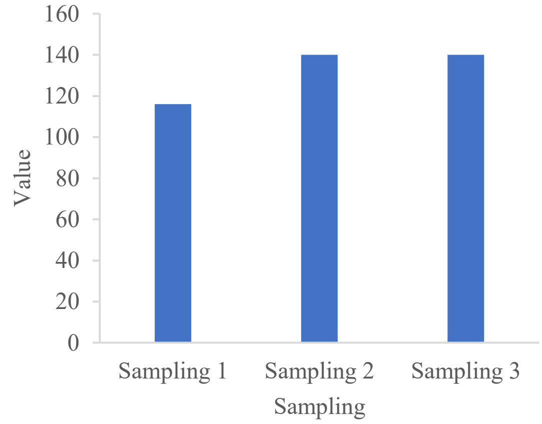

Figure 5. Water Transparency

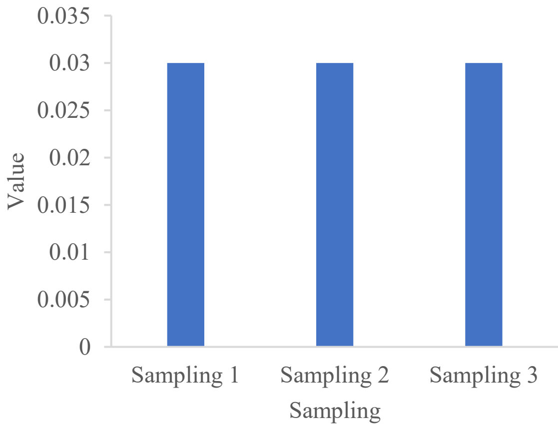

Figure 6. Phosphate (mg/L)

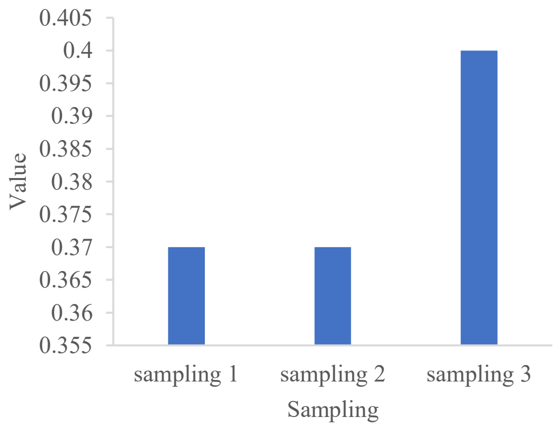

Figure 7. Current velocity

Conclusion

Based on the research findings, water quality parameters at the seaweed cultivation site in Labuhan Kertasari Village generally remain within a range that supports seaweed growth. However, nitrate was not detected at any observation point, suggesting it may be a limiting factor for seaweed growth due to low nitrogen availability in the water. These findings highlight the importance of nutrient management and regular water quality monitoring to support the sustainability of seaweed cultivation in coastal areas. This study has limitations due to the short sampling period and the lack of direct testing of seaweed growth. Therefore, future research is recommended to include seasonal monitoring, nutrient enrichment experiments, and studies of the influence of sediments and river flow on nutrient dynamics in water.

Author's Contribution

A. Harya: as the principal investigator, was responsible for formulating the research concept, developing the methodological design, overseeing all research activities, analyzing the data, and writing and revising the manuscript through to publication. A. Rahman: as a research team member, contributed to field data collection, data processing and analysis, drafting the initial manuscript, and assisting with the revision and refinement of the manuscript through to publication.

Acknowledgements

The author would like to express gratitude to the Labuhan Kertasari Village Government and the Laboratory of the Fisheries Resource Utilization Program for their support throughout the research, as well as to all those who assisted with data collection, analysis, and the preparation and publication of this manuscript.

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