Relationship between Total Suspended Solid and Chlorophyll-a in Coastal Waters of Sepahat Beach, Bandar Laksamana Bengkalis

Muhamad Ryan Fatiha Putra[1*], Rifardi[1], Yusni Ikhwan Siregar[1]
[1]Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru 28293 Indonesia
Corresponding Author: muhamad.ryan1716@student.unri.ac.id

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ABSTRACT

TSS and chlorophyll-a are important indicators of water quality and fertility. Increased TSS inhibits light and photosynthesis of phytoplankton, thus reducing primary productivity. The research was conducted in February-April 2025, in the seawaters of Sepahat Beach, Bandar Laksmana District, Bengkalis Regency, to analyze and understand the relationship between TSS and Chlorophyll-a content, and to provide information about the fertility of waters in the study area. The method used in this research is a survey with a purposive sampling technique, targeting objects along the coast and 10 observation points. At each sampling point, 2 times water sampling is carried out, namely on the surface of 0-3 m and the middle of 3-6 m. The results showed the TSS content and the content of Chlorophyll-a in the Sepahat Beach sea area. The results showed TSS content and chlorophyll-a content with an average of 99.3 mg/L and 0.5236 on the 0-3 m surface. TSS content and chlorophyll-a content with an average of 69.2 mg/L and 0.3974 at 3-6 m. The weak relationship between TSS and chlorophyll-a, with a correlation coefficient value of 0.318 on the surface 0-3 m, has no significant effect <0.4 and a moderate relationship between TSS and chlorophyll-a with a correlation coefficient value of 0.592 at 3-6 m depth.

Keywords: Chlorophyll-a, Coastal Waters, Sepahat Beach, Total Suspended Solids

1. INTRODUCTION

The quality of aquatic ecosystems is strongly influenced by various physical, chemical, and biological parameters, including TSS. Total suspended solids are particles or living components (biotic) such as phytoplankton, zooplankton, bacteria, fungi, or dead components (abiotic) such as detritus, and solids such as sand, mud, and clay suspended in water with sizes ranging from 0.004 mm to 1.0 mm (Sinaga et al., 2020).

An increase in the concentration of suspended solids material will cause turbidity that can interfere with the penetration of light into the waters, siltation, and disruption of several aquatic ecosystems and environmental damage (Rifardi, 2012). The low light intensity that penetrates the water layer will disrupt the photosynthesis process of phytoplankton, which in turn can reduce chlorophyll-a production. Chlorophyll-a is one of the pigments found in phytoplankton that plays a role in photosynthesis. Phytoplankton, zooplankton, and bacteria are the most important elements in the food chain because they greatly affect the fertility of a water body (Nababan and Simamora, 2012). The high primary productivity indicated by the value of chlorophyll a in coastal waters can also increase TSS because one of the constituents of TSS is phytoplankton (Julita et al., 2023).

Phytoplankton can be used as a study material to determine the quality and fertility of a water body (Armiani, 2021). Phytoplankton act as primary producers, converting inorganic substances into organic compounds using the photosynthetic pigment chlorophyll-a and sunlight (Nontji, 2008).

The sea waters of Pantai Sepahat are an area with unique oceanographic characteristics, influenced by ocean currents from the Malacca Strait and Bengkalis Strait. This causes activity in ship lanes that pass through marine waters. The increase in suspended solids that can occur will result in a decrease in primary productivity in water, namely chlorophyll-a, which plays a role in determining the quality of the aquatic environment. Water quality in the seawaters of Sepahat Beach, Bandar Laksamana District, Bengkalis Regency, Riau Province, can be monitored using Chlorophyll-a and Total Suspended Solids (TSS) parameters.

Chlorophyll-a can be used as an indicator of water fertility (Jiyah et al., 2016).

Observations of TSS distribution are often used to evaluate water quality, as high TSS values indicate a high pollution potential and inhibit light penetration, which can, in turn, interfere with the photosynthesis of aquatic organisms. The impact of high TSS concentrations can reduce the photosynthetic activity of micro and macro marine algae, so that the oxygen produced by plants will decrease, and can cause fish death. Thus, the increase in TSS concentration has the potential to reduce the quality of coastal and marine aquatic ecosystems (Isman et al., 2022). Therefore, it is important to conduct this proposed research. This study aims to determine the relationship of total suspended solids (TSS) with chlorophyll-a and the relationship between other water quality parameters in the marine waters of Sepahat Beach, Bengkalis.

2. RESEARCH METHOD

Time and Place

The research was conducted in February-April 2025, in the Sea Waters of Sepahat Beach, Bandar Laksmana District, Bengkalis Regency, Riau.

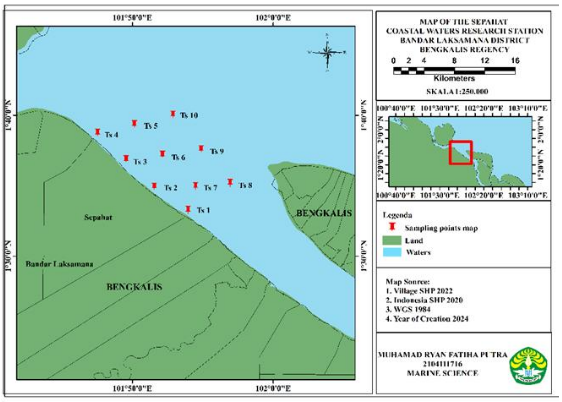

Figure 1. Research location map

Method

The research method used is a survey. Determination of the research location using purposive sampling. The research location was determined to be 10 sampling points (Figure 1). Samples were taken at high tide to low tide to determine the effect of current movement patterns on the distribution of TSS using vandorn. Sampling was carried out at the surface 0-3 m. Sampling at this depth was carried out to analyze the surface layer directly affected by human activities, and the middle 3-6 samples were taken at this depth to obtain information about deeper water conditions, which may differ from the surface layer in the field.

Procedures

Sample Analysis

Sample analysis was carried out at the Marine Chemistry Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Riau. The materials used in this study were seawater samples, and the tools included: a turbidimeter, 1000 mL and 500 mL sample bottles, Whatman no. 42 filter paper, a vacuum pump, a 0.45 µm Millipore filter, a spectrophotometer, an analytical balance, and an oven. TSS (Total Suspended Solids) sample analysis using the Gravimetric method (SNI, 2004).

$$\text{TSS (mg/L)} = \frac{(A-B)}{V} x\ 1000$$

Description:

A : Final weight of filter paper (mg)
B : Starting weight of filter paper (mg)
V : Sample volume (ml)

Analysis of chlorophyll-a samples based on Boyd (1979), the calculation of chlorophyll-a concentration is done by measuring absorbance at wavelengths of 665 nm and 750 nm. Calculation of chlorophyll-a with the Vollenweider equation in Boyd (1979), as follows:

$$\text{chlorophyll -a (µg/L)} = 11{,}9\ (A665-A750) \times \frac{V}{L} \times \frac{1000}{S}$$

Description:

A665 : Absorbance at wavelength 665 nm
A750 : Absorbance at wavelength 750 nm
V : Extraction of the acetone obtained (ml value slightly less than the acetone added
L : Length of light trajectory in the liquid in the cuvette (cm)
S : Volume of sample filtered (ml)

3. RESULT AND DISCUSSION

Total Suspended Solid Concentration

Based on the results of the analysis, the value of total suspended solids ranged from 69-117 mg/L at a depth of 0-3 m, and 52-90 mg/L at a depth of 3-6 m (Table 1). Total suspended solids (TSS) measurements were conducted at two depth ranges, 0-3 m and 3-6 m, at ten sampling points. The measurement results show variations in TSS concentration at each depth. At a depth of 0-3 meters, the sampling point with the highest TSS value was at sampling point 4 at 117 mg/L, while the lowest value was recorded at sampling point 3 at 69 mg/L. At a depth of 3-6 m, the highest TSS value at this depth was found at sampling point 1 at 90 mg/L, while the lowest value was found at sampling point 3 at 52 mg/L.

Table 1. Total suspended solids concentration in February 2025

Sampling points	0-3 m	3-6 m
1	116	90
2	87	59
3	69	52
4	117	73
5	100	64
6	101	67
7	103	62
8	115	81
9	91	86
10	94	58
average	99,3 ± 14,98	69,2 ±12,81

Some sampling points, such as sampling point 1 and sampling point 4 at a depth of 0-3 m, showed higher spikes in TSS concentrations than other sampling points, both in the surface and deeper layers. This indicates a significant accumulation of suspended material in these areas, which is most likely influenced by inputs from land, either through river flow, stormwater runoff, or anthropogenic activities on the coast.

This material generally accumulates first in surface waters before being deposited into deeper layers. The presence of TSS can still have a positive impact if it does not exceed the tolerance threshold set in the Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management for seawater quality. The TSS quality standards for waters are based on their designation, namely marine biota (coral reefs) at 20 mg/L, mangroves (seasonal average concentration) at 80 mg/L, seagrasses at 20 mg/L, and marine tourism at 20 mg/L.

The highest TSS concentration was recorded in the surface layer (0-3 m), averaging 99.3 mg/L, which significantly exceeded the quality standard thresholds for mangrove ecosystems (80 mg/L), seagrass (20 mg/L), and marine tourism (20 mg/L). Meanwhile, at a depth of 3-6 m, the average TSS concentration was 69.2 mg/L, exceeding the quality standard threshold for marine biota and tourism. This indicates the potential for high ecological pressure, especially in the surface waters. Based on the results of field measurements, sampling points with high TSS concentrations, such as sampling points 4 and 1 of 117 and 116 mg/L, show brightness values that tend to be lower at 3.20 m and 3.28 m, respectively.

In contrast, sampling points with lower TSS, such as sampling points 6 and 10 (91 and 100 mg/L), had relatively better brightness, at 4.17 m and 3.29 m, respectively. This shows a negative relationship between TSS and brightness, where an increase in TSS tends to decrease water brightness.

Sampling points 3 and 4 that have high TSS values also show high turbidity values, 75 NTU and 72 NTU, respectively. In contrast, sampling points with lower TSS, such as 5 and 8, showed lower turbidity (57 NTU each). Turbidity and brightness are interrelated parameters, as an increase in TSS is proportional to an increase in turbidity (Saputra et al., 2016).

Chlorophyll-a Concentration

Chlorophyll-a concentration measurements were conducted at two depths, namely 0-3 m and 3-6 m, at ten sampling points. Based on the analysis of chlorophyll-a samples at the research site, the results were obtained with chlorophyll-a values of 0.3094-0.7021 µg/L at a depth of 0-3 m, and 0.3213-0.4879 µg/L at a depth of 3-6 m.

At depths of 0-3 m, chlorophyll-a concentrations ranged from 0.3094 to 0.7021 µg/L, with the highest at sampling point 1 and the lowest at sampling point 8. Meanwhile, at a depth of 3-6 m, chlorophyll-a concentration ranged from 0.3213-0.4879 µg/L, with the highest value recorded at sampling point 3 and the lowest value at sampling point 10 (Figure 2).

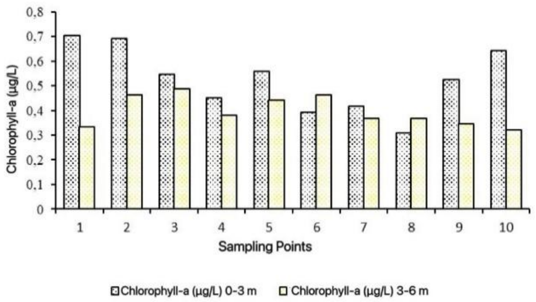

Figure 2. Chlorophyll-a concentration at different depths

At deeper levels, chlorophyll content decreases. At a depth of 3-6 m, the intensity of light penetrating the water column decreases due to the presence of a layer of suspended solids, which causes a decrease in brightness. At a depth of 0-3 m, sampling point 1 had the highest concentration (0.7021 µg/L), while sampling point 8 had the lowest (0.3094 µg/L). At a depth of 3-6 m, sampling point 3 recorded the highest concentration (0.4879 µg/L) and sampling point 10 remained the lowest (0.3213 µg/L).

Chlorophyll-a level at all sampling points, both at depths of 0-3 m and 3-6 m, are below 2.0 µg/L. The highest value is 0.7021 µg/L at 0-3 m, and 0.4879 µg/L at 3-6 m. According to the 2009 Regulation of the Minister of Environment, the waters of Sepahat Beach have chlorophyll-a level below 2.0 µg/L and are classified as oligotrophic. This means that these waters have low nutrient levels.

Although chlorophyll-a levels at all sampling points are low and still in the oligotroph category, they show the influence of local environmental parameters. High chlorophyll-a concentration at sampling points 1, 2, and 3 at depths of 0-3 m show no correlation with relatively low brightness values and higher turbidity. The availability of nutrients carried by suspended particles actually contributes to higher values. In contrast, sampling points with low chlorophyll-a value, such as sampling point 10, are characterized by high brightness and low turbidity, which may indicate a lack of nutrient supply. In addition, variations in pH, temperature, and salinity at the observation sites did not show a dominant influence on chlorophyll a distribution. However, relatively stable water conditions in these parameters still play a role in maintaining ecosystem balance.

Relationship between TSS and Chlorophyll-a

Based on simple linear regression calculations, the relationship between suspended solids and chlorophyll a at depths of 0-3 m and 3-6 m can be seen in Figures 3 and 4.

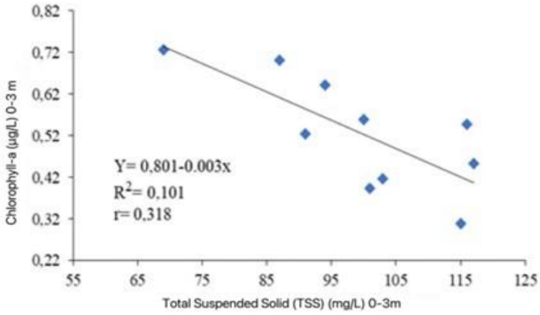

Figure 3. Relationship between TSS and Chlorophyll-a at depth 0-3 m

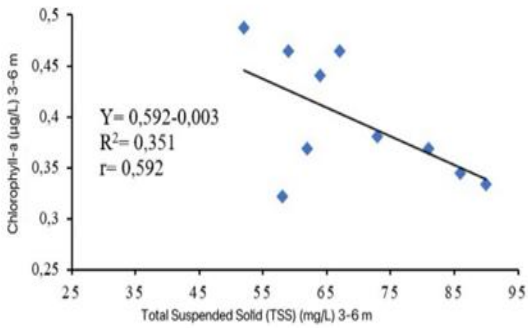

Figure 4. Relationship between TSS and Chlorophyll-a at 3-6 meters depth)

There is a moderate negative correlation between TSS and chlorophyll-a, as indicated by the slope of the regression line. This means that the higher the TSS concentration, the more likely it is to cause a decrease in chlorophyll-a concentration in waters at that depth. The R2 value of 0.351 indicates that about 35.1% of the variation in chlorophyll-a concentration is influenced by variations in TSS, while the rest is influenced by other factors.

The regression analysis results showed that the relationship between total suspended solids (TSS) and chlorophyll-a concentration varied with depth. At a depth of 0-3 m, the relationship between TSS and chlorophyll-a is weak, with a coefficient of determination (R^2) of 0.101 and a correlation coefficient (r) of 0.318. This low R^2 value indicates that TSS variation explains only about 10.1% of the variation in chlorophyll-a concentration, while other factors influence the remaining variation.

The correlation coefficient is weak and not significant, with the regression equation between TSS and chlorophyll-a negative, indicating that an increase in TSS tends to decrease chlorophyll-a concentration. In contrast, at a depth of 3-6 m, a moderate relationship was observed between TSS and chlorophyll a, with R2 = 0.351 and r = 0.592. This indicates that, even at a depth of 3-6 m, an increase in TSS concentration is associated with a decrease in chlorophyll-a concentration.

High TSS concentrations increase water turbidity, limiting sunlight penetration. Sunlight is needed by phytoplankton for the photosynthesis process, so when light penetration decreases due to high TSS, photosynthetic activity also decreases and has a direct impact on chlorophyll-a concentration. This is in line with Arifelia et al. (2017), who found that the low intensity of light that can penetrate the water layer due to high TSS inhibits phytoplankton growth and decreases chlorophyll-a concentration.

In addition to this, chlorophyll-a concentrations can be higher at the surface than at depths of more than 3 m, even though TSS levels are also high. High chlorophyll-a concentrations at the surface do not solely depend on the TSS value, but are also influenced by other nutrient inputs, especially nitrate. According to Isnaeni & Purnomo (2015), the nutrient in the water that affects the amount of chlorophyll-a is nitrate. The closeness of the relationship between chlorophyll-a and nitrate is thought to be due to the molecular composition of the chemical compounds of chlorophyll-a, containing the element N.

In contrast, at depths of more than 3 m, the high concentration of TSS that causes a decrease in water brightness becomes a limiting factor for the photosynthesis process, resulting in low chlorophyll-a concentrations. This decrease becomes a limiting factor for sunlight penetration, hindering the photosynthesis process and resulting in low chlorophyll-a concentrations. In this layer, the light intensity is already naturally reduced, and the high TSS exacerbates the condition. On the other hand, nutrient input from the surface is also increasingly limited, so primary productivity, such as phytoplankton growth, decreases. Therefore, the higher the TSS value in deep water, the greater the inhibition of phytoplankton growth due to decreased light availability. This is reflected in a stronger negative relationship between TSS and chlorophyll-a at depths >3 m than in the surface layer.

4. CONCLUSION

Based on the results of the study, (1) TSS concentration is higher in surface waters 0-3 m with an average of 99.3 mg/L, compared to 3-6 m depth with an average TSS ranging from 69.2 mg/L. The high TSS concentration at the surface is influenced by the input of suspended material from land via river flow, surface runoff, and anthropogenic activities in coastal areas.

(2) Chlorophyll-a concentrations show that chlorophyll-a concentrations are higher at depths of 0-3 m, ranging from 0.3094-0.7021 µg/L, compared to depths of 3-6 m, which have concentration values from 0.3213-0.4879 µg/L, where waters are categorized as oligotrophs, i.e., waters with low nutrient levels and natural water quality.

(3) The relationship between TSS and chlorophyll-a is weak at 0-3 m depth, indicating that an increase in TSS tends to decrease chlorophyll-a concentration. Meanwhile, at a depth of 3-6 m, the relationship is moderate, showing a tendency for chlorophyll a to decrease as TSS increases. The relationship is shown by a linear regression equation with a relatively small correlation coefficient between TSS and Chlorophyll-a, indicating an inverse relationship between the two variables; thus, the higher the TSS concentration, the lower the chlorophyll-a concentration. Periodic monitoring is needed to control TSS in coastal areas.

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