



Horizontal Distribution of Total Suspended Solids (TSS) and Chlorophyll-a at Tirang Beach Semarang

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ABSTRACT

Tirang Beach receives nutrient supply from activities along the Silandak River, triggering changes in the condition of its sea waters. The most affected impact is the decrease in primary water productivity due to the increase in Total Suspended Solid (TSS) content in the waters due to the disruption of sunlight penetration into the waters. This study aims to determine the effect of TSS on chlorophyll-a concentration in the waters of Tirang Beach, Semarang. Water sampling was carried out on March 7, 2024. Water quality measurements such as pH, DO, temperature, salinity, and brightness were carried out in situ. Meanwhile, chlorophyll-a and TSS measurements were analyzed in the laboratory using spectrometry and gravimetry methods. The results showed that the highest concentrations of TSS and chlorophyll-a were in the river body and decreased away from the river mouth with concentrations of 76.70 -163.13 mg/L and 0.05 - 2.97 µg/L. Based on the results of the Pearson correlation test analysis, it shows that chlorophyll-a affects TSS by 60.6% ($r = 0.778$; $P < 0.01$). The high relationship between TSS and chlorophyll-a is caused by the input of large amounts of inorganic particles in the Silandak River body which makes the river waters turbid which are used by phytoplankton for the photosynthesis process so that what is contained in TSS in addition to sediment particles is also phytoplankton.

Keywords: TSS, Chlorophyll-a, Horizontal distribution, Tirang Beach

Introduction

The beach is one of the tourist attractions in Semarang City with a high percentage (Youth, Sports and Tourism office of Central Java Province, 2022). Tirang Beach is located in Tambakrejo village, Tugurejo, Tugu, Semarang City. Now the development of Tirang Beach tourism is relatively very good after the Covid-19 pandemic with around 12,000 tourists. In addition, around Tirang Beach there are also mangrove forests, fish ponds, and the Silandak River estuary. The high activity in the coastal area has resulted in changes in water quality.

Suspended Solid Material or Total Suspended Solid (TSS) is all solid substances (sand, mud, and clay) or particles suspended in water and can be living components (biotic) such as zooplankton, phytoplankton, fungi, bacteria, or dead components (abiotic) such as detritus and inorganic particles (Bose et al., 1991). Suspended solids in the sea are influenced by input from river flows, winds that determine the direction of surface currents, and sediment resuspension, which causes light penetration into the water column to be disrupted so that the photosynthesis process in the area is disrupted (Garno, 2020).

Chlorophyll-a is one of the primary products of water, a phytoplankton pigment. Muslim and Jones (2003) explained that phytoplankton is a constituent of TSS besides other particles. This means that TSS and chlorophyll-a have a relationship. The greater the chlorophyll-a in a body of water, the higher the TSS content. The distribution of TSS and chlorophyll-a is influenced by phenomena in the sea such as tides and currents. Based on these factors, it is necessary to research the horizontal distribution of TSS and Chlorophyll-a in Tirang Beach, Semarang.

Material and Method

Field sampling was conducted on March 7, 2024, in the waters of Tirang Beach Semarang and its surroundings located in the northern part of Semarang City at coordinates 6°57'04.40" LS - 6°57'04.38" LS and 110°21'29.54" BT - 110°21'36.14" BT (Figure 1.). Sample preparation and data analysis were carried out in the Geology laboratory of the Faculty of Fisheries and Marine Sciences, Diponegoro University. Meanwhile, measurements of water quality parameters such as clarity, DO, salinity, pH, and temperature were carried out in situ.

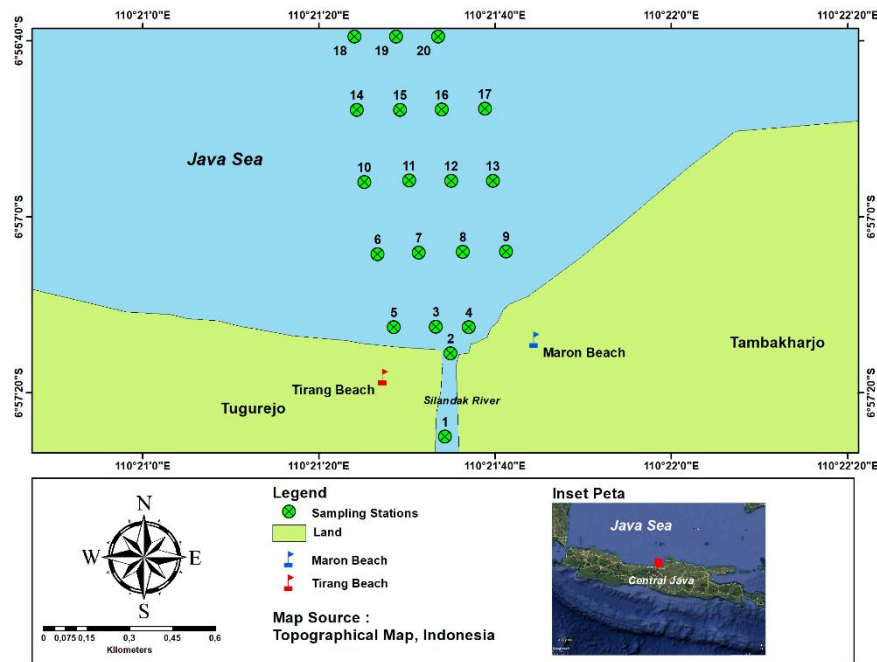


Figure 1. Research Location

Research Material

The research method used is quantitative. The quantitative method referred to in this study is in the form of numbers and is analyzed statistically to describe the distribution of suspended solids and chlorophyll-a in Tirang Beach, Semarang. The depiction of tidal variables aims to see the tidal pattern in the area and the depiction of TSS and chlorophyll-a concentration values aims to see the distribution and relationship between TSS and chlorophyll-a in Tirang Beach, Semarang.

Research methods

This study uses a descriptive quantitative method. The quantitative method in question is the use of survey data in numerical form and analyzing it using statistics and models. The descriptive method is a method that describes an event to create a picture or description of a phenomenon being studied in a certain period and area.

Location Determination

The determination of the research location was carried out using the purposive sampling method. This method is a sampling technique or data source with certain considerations (Sugiyono, 2011). The determination of the station location is based on conditions that can represent the overall conditions of the area and consider the ease of achieving the objectives. The determination of the station location is divided into zone 1 which represents the Silandak River estuary and zone 2 represents the open sea. Sampling was carried out at 20 observation stations. Tirang Beach is thought to be greatly influenced by land activities, such as households, mangrove vegetation, and the Silandak River. The distance range from each station is used to optimize the results obtained related to samples of chlorophyll-a and the nutrient content of the waters obtained which can provide a representation of the characteristics of each parameter in the area.

Water Sampling

Seawater samples were taken at high tide to low tide. Water samples were taken at the surface using a dipper and then immediately put into a dark 1000 mL sample bottle to prevent photosynthesis where the sample bottle had been cleaned first using distilled water and labeled per station. Furthermore, the sample bottle containing seawater was stored in a cool box containing ice blocks/stones and immediately taken to the laboratory to be analyzed for TSS and chlorophyll-a content. Seawater sampling for TSS and chlorophyll-a was carried out simultaneously with the measurement of water quality parameters. Measurement of water quality parameters includes acidity (pH), dissolved oxygen (mg/L), temperature (°C), salinity (‰), brightness (cm), direction, and current speed (o or m/s).

Preparation of Chlorophyll-a Concentrate

Samples that have been stored in the laboratory are treated as follows according to Parsons et al., (1984):

1. The water sample was dripped with 6 drops of 0.12 M MgCO₃ solution. This aims to prevent acidification which can break down chlorophyll by forming phaeophytin and also aims to facilitate the filtration process.
2. Water samples were filtered using 0.45 µm cellulose filter paper and a vacuum pump.
3. The filter paper from chlorophyll-a filtration is inserted into a test tube using a clamp and 10 mL of 90% acetone solvent is added to destroy the filter paper, then cover the test tube with aluminum foil.
4. The test tubes were stored in the refrigerator for 16 hours to 1 day.
5. After that, the sample was centrifuged at a speed of 3000 rpm for 20 minutes. This process is done to separate the extraction results of chlorophyll-a content which is clear or green with filter paper dissolved in acetone.
6. The sample solution was then poured into a glass cuvette to be analyzed using a UV-Vis spectrophotometer with a wavelength of 750 nm (corrector), 664 nm, 647 nm, and 630 nm so that the absorbance value could be determined.

Chlorophyll-a values were measured using the following equation:

$$C = \frac{[(11.85 \times \lambda_{664}) - (1.54 \times \lambda_{647}) - (0.08 \times \lambda_{630})] \times V_e}{V_s \times d}$$

Information:

λ_{664} = Abs 664 nm – Abs 750 nm

λ_{647} = Abs 647 nm – Abs 750 nm

λ_{630} = Abs 630 nm – Abs 750 nm

d = Width of cuvette diameter (1 cm)

V_e = Volume of acetone extract (10 mL)

V_s = Volume of filtered sample water (1 L).

Preparation of TSS Concentrate

Determination of TSS using the Gravimetric method (SNI 06-6989.27-2005) utilizing a homogenized sample of 1 L filtered with Whatman filter paper whose weight has been previously measured. After the filtering is complete, the filter paper is taken and dried in an oven at a temperature of 103°C - 105°C for 1 hour. After drying, the filter paper is transferred to a desiccator to absorb the remaining moisture in the filter paper for 30 minutes. The filter paper is weighed with 3 repetitions.

The calculation of MPT concentration is done as follows:

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

Information:

A = Weight of filter paper containing suspended residue (mg)

B = Weight of empty filter paper (mg)

C = Volume of water sample (1000 mL)

Correlation Analysis of TSS Concentration with Chlorophyll-a

Correlation analysis of TSS and chlorophyll-a using IBM SPSS Statistics 26 software. The relationship between one variable and another can be known using the Pearson correlation (Ekaputra et al., 2019). The correlation analysis is divided into 3 areas, namely the entire sample, the area representing the river estuary to the transition to the sea, and the area representing the transition from the sea to the estuary to the open sea.

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Information:

r = Correlation coefficient

x = TSS value

y = Chlorophyll-a value

n = Amount of data

Table 1. Correlation Classification Pearson

Coefficient Interval	Relationship Level
0	Relationships do not exist
0 – 0.25	Very weak relationship
0.25 – 0.5	Medium relationship
0.5 – 0.75	Strong relationship
0.75 – 0.99	Very strong relationship
1	Perfect relationship

(Source: Ekaputra et al., 2019)

Results and Discussion

The research results obtained include the distribution of TSS concentration, chlorophyll-a concentration, current, and environmental parameters, and the results of the correlation analysis of the relationship between TSS and chlorophyll-a.

The highest TSS concentration was seen at stations 1 and 3 at 163.13 and 151.90 mg/L and the lowest TSS concentration was seen at stations 18 and 19 at 76.70 and 79.40 mg/L. The average TSS concentration from all stations was 107.23 mg/L with the distribution of TSS concentration approaching land or river mouths, the concentration is getting higher, and towards the sea, the concentration is getting lower (Figure 2.).

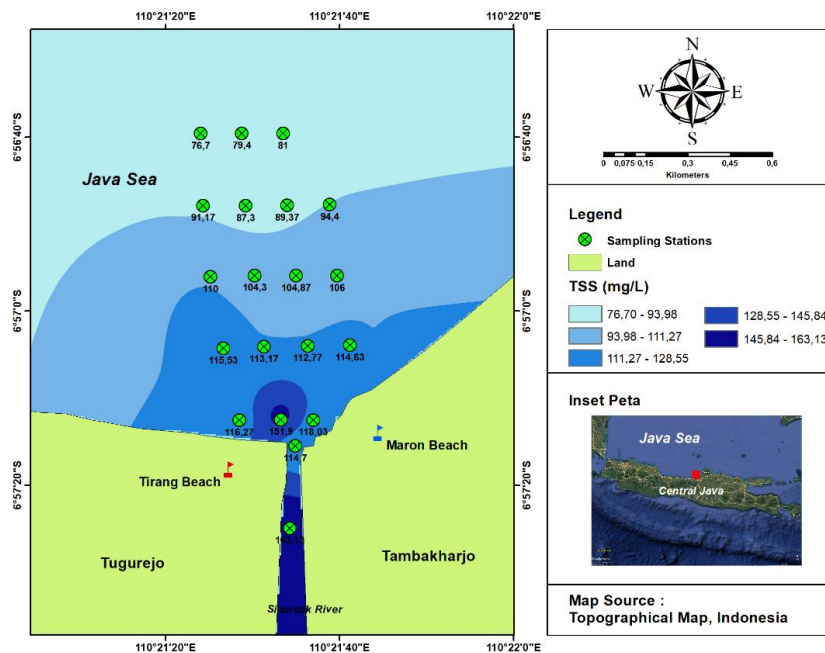


Figure 2. TSS Concentration Distribution

The distribution of TSS concentrations in Tirang Beach, Semarang shows a decrease in concentration as it moves away from the mouth of the Silandak River (Figure 2). This is because the further away from the river mouth, the area is far from dense human activities such as shipping, the lower it is, so the area's stirring process is lower, in addition to the fact that the depth is getting deeper. According to Muslim and Jones (2003) and Marwoto et al. (2021), the TSS contributors in waters are due to supplies from land, also because of the influence of the results of the stirring of the bottom sediment that is stirred upwards. Besides that, the tidal conditions during the study were high tide towards low tide, where the dominance of sea currents towards the river was greater than the input of river water towards the sea so that the distribution of TSS which was initially high in the estuary decreased because it was carried by the current according to the direction of the current (Amna et al., 2022).

The highest concentration is at station 1 (Figure 2.) because the location is closest to the source, namely in the river body and closest to residential areas, besides that in the area before sampling there was rain which caused high river flow. So the highest MPT is at station 1 because it is greatly influenced by TSS from the mainland which is mostly carried by rainwater from upstream (Utama et al., 2021).

In this study, the average TSS value in Tirang Beach waters was 107.23 mg/L. This result is higher than the study conducted by Amna et al., (2022) in Muara Bodri, Central Java with an average value of 78.93 mg/L. This is thought to be because the sampling time was outside the rainy season so that the contribution from the land was not greater than during the rainy season and in Muara Bodri there were no activities such as tourist boats. The distribution of TSS concentrations at Tirang Beach, Semarang shows a decrease in concentration as it moves away from the Silandak River estuary (Figure 2). This is because the further away from the river estuary, the area is far from dense human activities such as shipping, the lower it is, so the area's mixing process is lower, in addition to the fact that the depth is getting deeper. According to Muslim and Jones (2003) and Marwoto et al., (2021), the contributors to TSS in waters are not only due to supply from land but also due to the influence of the results of mixing bottom sediments that are stirred upwards. In addition, the tidal conditions during the study were high tide towards ebb tide, where the dominance of sea currents towards the river was greater than the input of river water towards the sea so that the distribution of TSS which was initially high at the estuary decreased because it was carried by the current according to the direction of the current (Amna et al., 2022).

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The highest chlorophyll-a concentration was seen at stations 1 and 2 at 2.97 and 2.76 $\mu\text{g/L}$ and the lowest chlorophyll-a concentration was seen at stations 18 and 19 at 0.05 and 0.33 $\mu\text{g/L}$. The average concentration value of all stations was 1.457 mg/L with a high distribution of chlorophyll-a concentration in the estuary and decreasing offshore (Figure 3.).

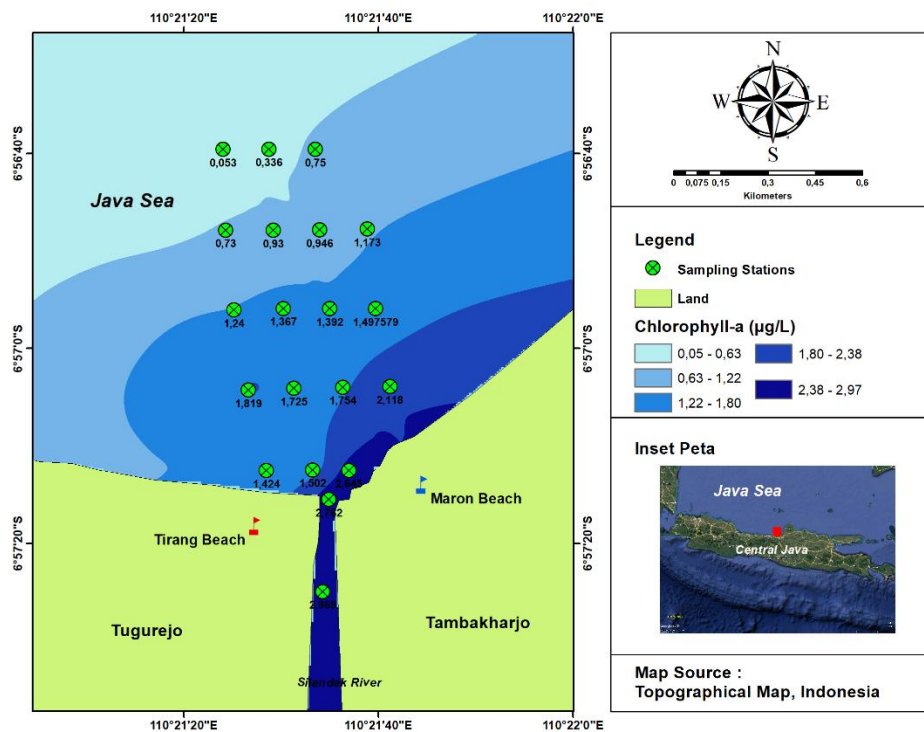


Figure 2. Chlorophyll-a Concentration Distribution

The distribution of chlorophyll-a concentrations at Tirang Beach shows an increase in concentration towards the Silandak River (Figure 3). This is due to activities in the river area resulting in nutrient enrichment from the mainland through river flows such as mangrove forests and pond activities. Fallen mangrove leaf litter and pond waste undergo decomposition contributing nutrients to phytoplankton growth in the river area Hidayah et al., (2016). In addition, the tidal conditions during the study were tides towards, where the dominance of sea currents towards the river was greater than the input of river water towards the sea so that the distribution of chlorophyll-a which was initially high at the estuary decreased due to being carried by the current and the movement of chlorophyll according to the direction of the current (Amna et al., 2022).

The highest chlorophyll-a value was at station 1 (Figure 3.) because it was closest to the source resulting from human activities that utilize rivers such as fish farming areas and household waste disposal channels, the source of which is the nutrient material as a result of degradation carried out by microbes (Amna et al., 2022). At this location, the high chlorophyll-a was not greatly influenced by brightness but rather by the amount of nutrient supply through river input and the depth of the river area (Dahuri et al., 1996).

The lowest chlorophyll-a concentration was at station 18 (Figure 3). The low concentration of chlorophyll-a at this station was caused by the station being located in the open sea which is far from the supply of nutrients from land, because one of the things that affects the photosynthesis process is nutrients (Marwoto et al., 2021).

In this study, the average chlorophyll-a value in the waters of Tirang Beach was 1.49 µg/L. This result is higher than the study conducted by Raharjo et al., (2016) at Slamaran Beach, Pekalongan with an average chlorophyll-a concentration of 0.435 µg/L. This is thought to be because Slamaran Beach is dominated by batik industry waste and perhaps the turbidity is also higher, so the photosynthesis process is not as good as in the waters of Tirang Beach.

Table 2. Water Quality Parameter Measurement Data

Station	pH	DO (mg/L)	Temperature (°C)	Salinity (%)	Brightness (m)
1	7.96	5.22	31.9	26	0.25
2	8.15	5.88	31.4	29	0.40
3	8.05	5.63	31.9	29	0.35
4	8.1	6.11	31.7	29	0.30
5	8.05	6.04	31.9	30	0.43
6	8.26	6.31	31.4	32	0.45
7	8.25	6.72	31.6	31	0.52
8	8.24	6.77	31.6	31	0.50
9	8.28	6.54	31.6	32	0.48
10	8.30	7.35	31.3	33	0.80
11	8.32	8.17	31.5	32	0.90
12	8.33	8.11	31.5	32	0.90
13	8.35	7.89	31.5	33	0.85
14	8.37	8.31	31.4	33	1.00
15	8.38	8.32	31.3	33	1.08
16	8.39	8.33	31.3	33	1.05
17	8.4	8.37	31.3	33	0.95
18	8.45	8.53	31.1	34	1.20
19	8.43	8.45	31.2	34	1.15
20	8.41	8.41	31.2	34	1.10
Average	8.274	7.273	31.48	31.65	0.732

Table 3. Results of Pearson Correlation Analysis of all samples.

Correlations			
		TSS	Chlorophyll-a
TSS	Pearson Correlation	1	.778**
	Sig. (2-tailed)		.000
	N	20	20
Chlorophyll-a	Pearson Correlation	.778**	1
	Sig. (2-tailed)	.000	
	N	20	20

** . Correlation is significant at the 0.01 level (2-tailed).

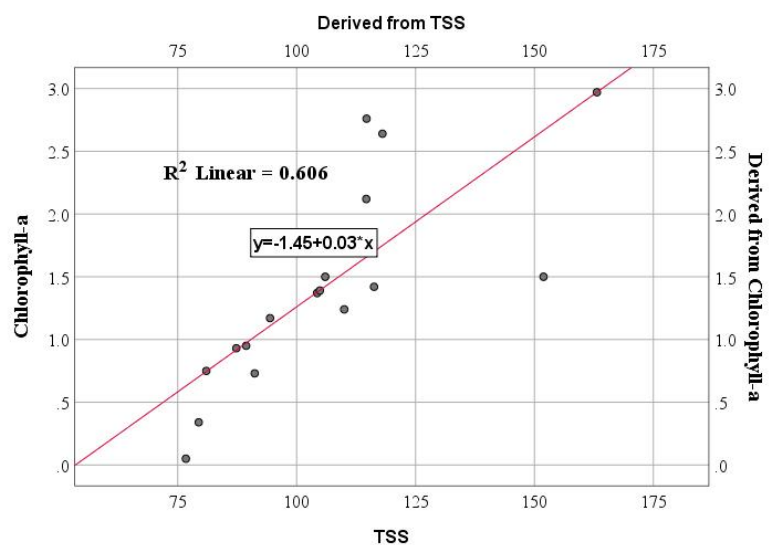


Table 4. Correlation Analysis Results Pearson at the River Mouth

Correlations			
		TSS	Chlorophyll-a
TSS	Pearson Correlation	1	.268
	Sig. (2-tailed)		.486
	N	9	9
Chlorophyll-a	Pearson Correlation	.268	1
	Sig. (2-tailed)	.486	
	N	9	9

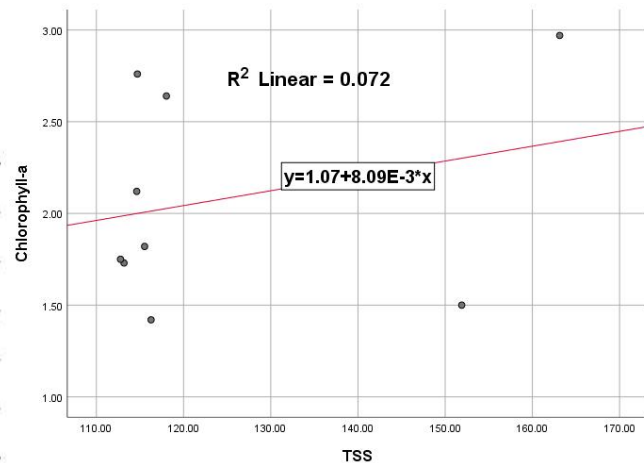
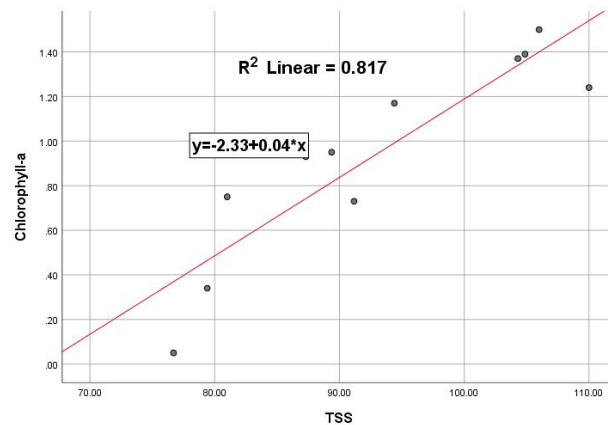


Table 5. Correlation Analysis Results Pearson on the High Seas

Correlations			
		TSS	Chlorophyll-a
TSS	Pearson Correlation	1	.904**
	Sig. (2-tailed)		.000
	N	11	11
Chlorophyll-a	Pearson Correlation	.904**	1
	Sig. (2-tailed)	.000	
	N	11	11

** Correlation is significant at the 0.01 level (2-tailed).



The results of the correlation test between TSS and Chlorophyll-a of all samples (Table 3.) show a value $r = 0.778$ ($P < 0.01$) and $R^2 = 0.606$ which means when TSS is high then chlorophyll-a is high, and vice versa while the $P < 0.01$ means that TSS and chlorophyll-a have a very significant correlation level. Chlorophyll-a which is a phytoplankton biomass may be the dominant component of TSS, this is what happened in the Great Barrier Australia (Muslim and Jones, 2003).

The above conditions are different if after grouping the stations into 2, namely the first group is stations 1 to 9 which represent the estuary to the transition with the sea, and group 2 at stations 10 to 20 represents the transition from the sea to the estuary to the open sea (Figure 1.). The results of the correlation test for group 1 show $r = 0.268$ and $R^2 = 0.072$, $P > 0.01$ (Table 4). while in group 2 showed $r = 0.904$ and $R^2 = 0.817$, $P < 0.01$ (Table 5). From the correlation results, the R^2 value in group 2 has a higher correlation value than the correlation value of the station as a whole sample and with group one. This is because in group 1 the area has little disturbance from the coast, on the other hand, the TSS content is more dominantly influenced by input from the river (Marwoto et al., 2021).

4. Summary

Based on the discussion above, the conclusions of this study are:

1. The distribution of TSS concentrations in Tirang Beach, Semarang is between 76.70 and 163.13 mg / L. The highest concentration is at station 1 which is located in the river body and the lowest concentration is at station 18 because it is the furthest from the estuary. The horizontal distribution pattern of TSS is dominated by waters near land such as rivers and estuaries, and then gradually the distribution of TSS decreases towards offshore.
2. The distribution of chlorophyll-a in Tirang Beach, Semarang is between 0.05 - 2.97 µg/L. The highest concentration was found in the river body (station 1) and the lowest concentration was at the station furthest from the estuary (station 18). The horizontal distribution of chlorophyll-a is dominated by waters near land such as rivers and estuaries, and then gradually the distribution of chlorophyll-a decreases towards offshore.

The relationship between TSS concentration and chlorophyll-a concentration on the coast of Tirang Beach, Semarang shows a significant positive relationship ($r = 0.778$; $P < 0.01$). The relationship will be more significant when the stations are only taken at offshore stations where the value ($r = 0.904$; $P < 0.01$).

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