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Analysis of the Relationship Between Phytoplankton Abundance and Total Oil Content in Bayur Bay Waters, Padang City, West Sumatera Province

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ABSTRACT

The research was conducted in January - February 2024 in the waters of Teluk Bayur, Padang City, West Sumatra Province. This study analyzes the relationship between total oil content and phytoplankton abundance in Bayur Bay waters. The method used in this study is a survey method with a purposive sampling technique. Based on the results found. The value of oil content at each station and sampling point varies. The highest value is obtained at station III with an average value of 0.00005387 ppm, while the lowest is obtained at station IV with a content value of 0.00001153 ppm. In the Bayur Bay waters, 16 species of phytoplankton were found, consisting of *Bacillariophyceae* (10 species), *Cyanophyceae* (2 species), *Coscinodiscophyceae* (2 species), *Dinophyceae* (1 species), *Raphidophyceae* (1 species). Phytoplankton abundance in Bayur Bay waters shows different values for each station, where the highest average phytoplankton abundance is found at station IV, with a total of 9216.55 (ind/L). In contrast, the lowest abundance is found at station I, with a total of 1016.77 (ind/L). The results of linear regression analysis, the relationship between phytoplankton abundance and oil content in Bayur Bay waters at each station obtained a mathematical equation y = 6245.3 + (-7E+07x) with a coefficient of determination R^2 = 0.3016 and the correlation coefficient r = 0.5491. With the conclusion that the relationship between phytoplankton abundance and total oil content in Bayur Bay waters is included in the average group.

Keywords: Bayur Bay, Total Oil Content, Phytoplankton.

1. INTRODUCTION

The bay is a body of water that protrudes into the mainland and is bounded by land on the sides of the waters. Generally, bay waters are often used as harbours or fishery activities such as floating net cages. Teluk Bayur is one of the bays located on the west coast of Sumatra Island, directly facing the Indian Ocean. Bayur Bay plays a vital role as an open ocean port that supports export-import activities of various commodities. Various loading and unloading activities of commodities such as cement, fertilizer, oil, and coal are carried out in the waters of Teluk Bayur (Nurdin & Afrizal, 2013).

Besides being filled with shipping activities, Teluk Bayur is surrounded by industrial activities such as crude palm oil processing, coal industry, and cement factories. Various activities in the waters carried out are related to physical and chemical changes in waters, as the definition of environmental pollution described in Law Number 11 of 2020, namely: Marine pollution is the entry or inclusion of living things, substances, energy, and or other components into the marine environment by human activities so that it exceeds the established quality standards for the marine environment. Organic and inorganic components from loading and unloading activities will enter water bodies so that they can affect the state of the environment and then impact the biota's life.

One of the types of pollution that has occurred in the waters of Teluk Bayur is oil pollution. This opinion is reinforced because activities such as loading and unloading oil on the coast and leakage of ship oil tanks are the reasons for oil entry into the waters (Abdullah et al., 2016). This condition is exacerbated by water carrying domestic waste from local settlements, increasing the pollutant load. In addition, the source of contamination in Bayur Bay is also thought to come from industrial activities around the dock, such as one of the Palm Fatty Acid Distillate (PFAD) spills or the rest of the Crude Palm Oil (CPO) processing process in Bayur Bay on October 28, 2017, by PT. Wira Inno Mas (WIM).

Oil spills in waters can have various negative impacts because hydrocarbons contained in waters tend to accumulate in marine biota tissues such as fish, molluscs, shellfish, and other mammals (Rahmani, 2015). In addition, oil on the surface of the water, commonly called the film layer, can inhibit the penetration of light into the water due to the density of oil, which is lighter than water; it will affect the photosynthesis process by phytoplankton, which will consequently reduce oxygen levels in the water (Nasution et al., 2017).

Phytoplankton is a microorganism that lives in water, and its movement is only influenced by the movement of water masses. Besides, this organism ranks first as a primary producer because of its ability to photosynthesize. Hence, the abundance of phytoplankton in a body of water greatly influences the life cycle of other organisms in water. The abundance of phytoplankton in a water body is influenced by physical and chemical factors such as light intensity, temperature, salinity, pH, and the availability of nutrients in the water body. Therefore, phytoplankton can be used as a natural biological parameter (bioindicator) that can give an idea of the quality and fertility of a water body by calculating its abundance.

Information on the impact of oil pollution on phytoplankton and the condition of phytoplankton is the basis for considering this research in the waters of Bayur Bay. Based on the background that has been described, this research needs to be carried out to provide information related to the condition of the aquatic environment in Teluk Bayur from biological parameters, namely phytoplankton abundance.

2. RESEARCH METHOD

Time and Place

The research was conducted in January - February 2024 in the waters of Teluk Bayur, Padang City, West Sumatra Province. Analysis of phytoplankton samples and oil content in the Marine Biology Laboratory and Marine Chemistry Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

Method

The method used in this research is a survey method that observes, measures, and samples phytoplankton and oil content in the water at the research site. Analysis of phytoplankton samples was observed using a microscope, and then they were identified. In contrast, total oil content samples were analyzed using the gravimetric method at the Marine Chemistry Laboratory of the Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau.

Procedures

Determining Research Locations

This research was conducted by taking samples at four stations, where each station consisted of 3 sampling points. Determining sampling locations was based on a purposive sampling technique, which determined each station based on different criteria and activities. Station I has a palm oil processing industry area and a dock for ships transporting export and import commodities. At this station, there is very dense shipping activity. Station II has dense residential activities of people living on the beach. In addition to settlements, at station II, there is a traditional market close to the coastal area of Teluk Bayur. Station III is located in the tourist area, namely Nirvana Beach. In addition to the location of tourism, station III is also the anchorage of ships of residents who work as fishermen. Then, station IV is in waters with minimal activity or near the open sea.

Oil Sample Sampling, Handling, and Analysis

Water samples were taken using an aluminium dipper at the water's surface (0- 30 cm). After that, water samples were put into 1000 mL glass bottles, and two drops of concentrated H_2SO_4 were labelled. After that, the sample was put into an ice box and then analyzed for oil content in the laboratory (Nasution et al., 2017). Analysis of the total oil content in the sample using the $CHCl_3$ extract method by calculating the total oil content refers to the American Petroleum Institute or API 1340. Calculation of oil content using the following formula:

$$\text{Total oil content (ppm)} = \frac{(A-B)g \ x \ 75ml}{(C \ ml \ x \ 1000)}$$

Description:

A : Weight of flask after evaporation (g)

B : Weight of empty flask (g)

C : Volume of $CHCl_3$ after extracting (mL)

Sampling Procedures, Handling, and Analysis of Phytoplankton Samples

Phytoplankton sampling was conducted during the day between 11:00 am - 3:00 pm, and this was done because phytoplankton requires optimal sunlight to photosynthesize. Water samples were taken as much as 100 L using a plastic bucket with a volume of 10 L and filtered using plankton net no. 25. The filtered water was put into a sample bottle of 100 mL, rinsed with seawater first, and then dipped with 4% lugol, which was as much as 3-4 drops. The sample to be analyzed was stirred well beforehand. Analysis of phytoplankton abundance using the 12 field of view method. Calculation of phytoplankton abundance was calculated using the APHA (1995) formula based on the Lackey Drop Macrotransec Counting (LDMC) formula as follows namely:

$$N = \frac{T}{L} \text{ x } \frac{Vo}{V1} \text{ x } \frac{P}{p} \text{ x } \frac{1}{W}$$

Description:

N	:	Phytoplankton abundance (ind/L)
T	:	Area of cover glass (20 x 20 mm^2)
L	:	Microscope field of view (1.882 mm^2)
$V0$	:	Filtered sample volume in sample bottle (100 mL)
$V1$	:	Volume of sample water under the cover glass (0.06 mL)
P	:	Number of individual phytoplankton counted
p	:	Number of fields of view (12)
W	:	Total volume of filtered water sample (100 L)

To interpret the value of the strength of the correlation between oil content and phytoplankton abundance quantitatively divided into five groups according to Sugiyono (2016), namely: 0,00 – 0,199 (very low); 0,20 – 0,399 (low); 0,40 – 0,599 (average); 0,60 – 0,799 (strong); and 0,80 – 0,1000 (very strong)

3. RESULT AND DISCUSSION

General Conditions of Research Locations

Hills and calm waters surround the geographical location of Teluk Bayur, which has sandy and coral substrates. To the north, Teluk Bayur is bordered by West Padang Subdistrict, to the south by Bungus Bay and Karsik Bay, to the west by the Indian Ocean, and to the east by Lubuk Begalung Subdistrict. The waters of Teluk Bayur have potential. In addition to being dense with various industries such as coal, palm oil, cement, and fertilizer, these waters are also the location of tourist attractions such as Nirvana Beach. In addition, many people around Teluk Bayur also work as permanent fishermen or part-time fishermen. Measurement of water quality parameters was carried out during the day. The results of water quality measurements at the location can be seen in Table 1.

Table 1. Water quality parameters

Station	pH	Temperature (°C)	Salinity (‰)	Current speed (m/s)	Brightness (m)
I	8,4	31	30	0,29	1,9
II	8,5	31,4	31	0,24	2,4
III	8,4	32	29	0,27	2,9
IV	8,4	31,3	30	0,32	2,6

Total Oil Content

The value of oil content at each station and sampling point varies. The highest value is obtained at station III with an average value of 0.00005387 ppm, while the lowest is obtained at station IV with a content value of 0.00001153 ppm (Figure 1).

Based on the results of laboratory analysis, the average value of total oil content between stations ranged from 0.00001153 - 0.00005387 ppm, with the lowest value at station IV, which is in a location with minimal activity, while the highest average value is at station III which is located in the tourism area. At the same time, research conducted by Ariani (2012) in the waters around Bungus Teluk Kabung found differences in oil content of 0.3530-0.5300 ppm. The difference in the value of oil content found is thought to be due to several reasons, such as the source of entry of oil contamination, dispersion of oil in the waters by currents and waves, and handling of samples in the field and laboratory can also be the reason for the different content values of oil content in a body of water. At station I, an industrial area, the average oil content between sampling points is 0.00003946 ppm. Oil sampling at station I was sampled in the Crude Palm Oil (CPO) processing industry area and the dock of the transport ship in Teluk Bayur. The dense shipping activity that occurs at this location is one of the causes of the entry of oil contamination into the waters, according to Qowiyah et al. (2021), which state that the high value of oil content in the waters can come from the activities of tankers passing by. Another activity that allows pollution at this station is the loading and unloading process carried out by commodity transport ships at the dock, which can also enter the water body during transportation. Then, the process of processing palm oil that does not follow procedures can also cause oil pollution to water, such as in the case of the leakage of the PT Wira Inno Mas palm oil temporary storage tank pipe in Teluk Bayur in 2017.

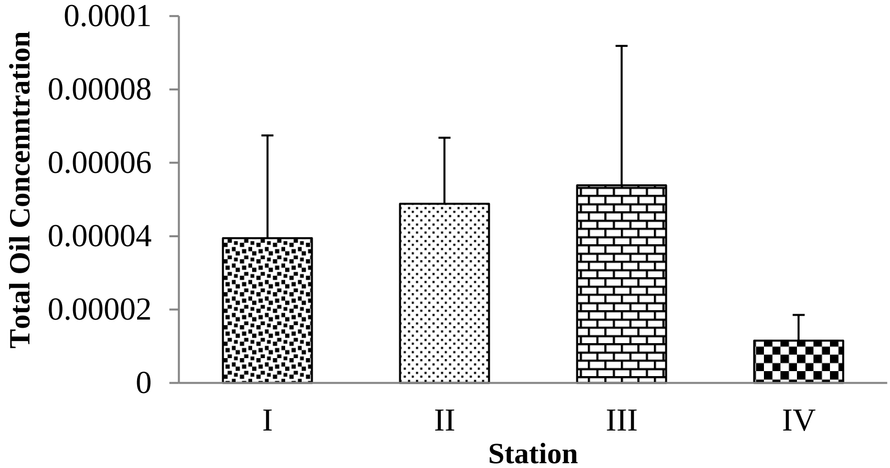

Figure 1. Differences in total oil content between stations

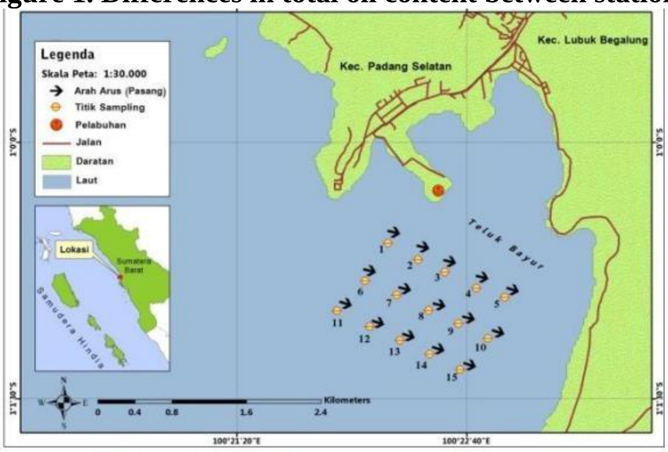

Figure 2. Current direction at high tide (Barus, 2017)

Station II is located in a densely populated area, so the source of oil at this station is thought to come from the run-off of household waste from the settlement, which then enters and spreads to marine waters. This follows the statement of Mukhtator in Darza (2020), which states that household waste entering marine waters directly can come from outfalls on the seashore, from rivers that empty into the sea and river flows. At this station, the average value of oil content is 0.00004884 ppm.

Station III is a tourism area with the highest average oil content of all stations, 0.00005387 ppm. In addition to being a tourism area, this station is also used as a location to lean the ships of the surrounding community who work as fishermen, thus increasing the amount of oil content that enters the waters. According to Nedi (2010), the oil layer on the sea surface can spread and move due to coastal dynamics caused by currents and waves. Based on this statement, the high oil content at this station is also supported by the pattern of tidal currents in Bayur Bay, which then leads to Station III, and this also follows the statement of Barus (2017), which states that at high tide the direction of the current in Bayur Bay ranges from 500 -800 to the southeast, right at Station III.

Station IV is an area with minimal activity, both community activities and shipping activities by ships. This area is located in a hilly area directly adjacent to the Bungus Bay area.

The average oil content obtained at this station is 0.00001153 ppm. The lack of activity at this station makes the average oil content have the smallest value of all stations, so the oil content at this location is thought to only come from other areas carried by the current.

Based on the calculation of the total oil content at each station, the total amount contained in Teluk Bayur waters can still be tolerated by organisms or has not endangered aquatic biota. This refers to Government Decree No. 22 of 2021, which states that the quality standard of seawater for biota is 1 mg/L or 1 ppm.

Phytoplankton Abundance and Composition

The results of the calculation of phytoplankton abundance between sampling points and the average difference between stations can be seen in Figure 3.

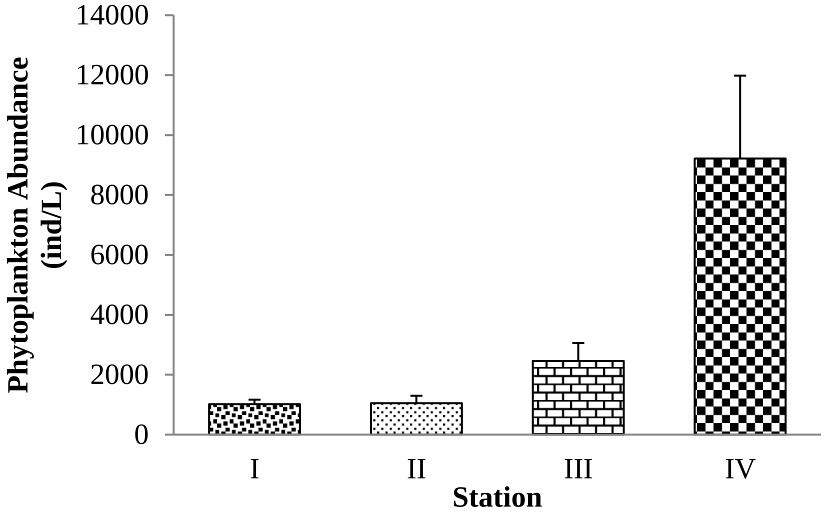

Figure 3. Differences in phytoplankton abundance between stations

Phytoplankton abundance values obtained at the study site varied. The phytoplankton abundance values ranged from 1016.77 - 9216.55 ind/L. Station I, located around the industrial area and the port of the transport ship, has the lowest phytoplankton abundance value among all stations, where the abundance is only 1016.7 ind/L. The low value of phytoplankton abundance is influenced by the physical condition of turbid and dirty waters due to the pollution that enters the waters characterized by low brightness values at this station, making it less supportive of phytoplankton growth at this location.

This is supported by the opinion of Nontji in Merina et al. (2023), which states that good water brightness can facilitate sunlight into the waters so that the photosynthesis process can run optimally. Based on this statement, the low abundance of phytoplankton at this location can also be characterized by low dissolved oxygen content in the waters, as research conducted by Darlianto (2019) at the exact location which found that the dissolved oxygen content at this location was only 4.6 mg/L the lowest of all observation stations.

The phytoplankton abundance value found at station II, located in a residential area, was 1049.57 ind/L. Phytoplankton conditions at this station are influenced by anthropogenic activities, such as traditional markets and coastal community activities that bring nutrients from nitrates and phosphates into the waters. This is because phytoplankton's high and low abundance is highly dependent on the water's nutrient content. As the opinion of Mulyani et al. in Nofrita & Nurdin (2023) states, the high level of nutrients in the waters is due to the input of nutrients from run-off. It will cause the waters to experience fertilization. Seygita et al. (2015) researched the exact sampling location and found nitrate and phosphate contents of 0.0208 mg/L and 0.3550 mg/L. The existence of activities that allow nutrient enrichment in this location causes phytoplankton abundance in Station II to be slightly higher than in Station I.

Station III, located in the tourism area, has a reasonably high phytoplankton abundance value of 2459.94 ind/L. When viewed from the characteristics of the sampling location, the presence of phytoplankton at this station is also still affected by human activities that are quite dense around the sampling location because, in addition to being a tourism location, at this station, there are still settlements of residents who work as local fishermen so there is a possibility that the entry of nutrients from anthropogenic waste from coastal communities and tourists is the reason for the high abundance of phytoplankton at this station. Then, according to its definition, phytoplankton is an organism that floats in water, and its movement only follows the water current so that, in line with the opinion of Aramita et al. (2015), the current is a transportation medium in the sea that always moves without stopping. Therefore, water dynamics are also the reason for the high value of phytoplankton abundance in an aquatic environment. This reason is reinforced by research by Barus (2017), which found that at high tide, the water current leads 500 -800 to the southeast, right at the location of station III.

At station IV, located in an area with minimal activity, all stations' highest phytoplankton abundance value was found at 9216.55 ind/L. The physical condition of the waters at this station looks clean and maintained because the lack of shipping activity at this location is also rarely visible anthropogenic activity. The high abundance of phytoplankton at this station can occur due to several things, such as the good physical condition of the waters, so it becomes an optimal habitat for phytoplankton to grow and develop. Another reason can also occur due to the lack of pollutants, especially oil found at this station, so that the growth and development of phytoplankton will be minimized because, according to Sari (2016) states that high oil content can cause physiological disturbances to death in aquatic organisms.

Based on the results of the study, 16 species of phytoplankton were found in the waters of Bayur Bay, consisting of 10 species of *Bacillariophyceae* class (*Chaetoceros* sp, *Navicula* sp, *Thalassionema* sp, *Cerataulina* sp., *Striatella* sp, *Bacteriastrum* sp, *Skeletonema* sp, *Hemiaulus* sp, *Diatoma* sp, *Coscinodiscus* sp), from the class *Cyanophyceae* as many as two species (*Anabaena* sp and *Oscillatoria* sp), class *Coscinodiscophyceae* as many as two species (*Isthmia* sp and *Leptocylindrus* sp), class *Dinophyceae* one species namely *Ceratium* sp, class *Raphidophyceae* as many as one species namely *Chattonella* sp. The composition of phytoplankton found can be seen in Table 2.

Table 2. Composition of phytoplankton found

Class	Species	Station I	Station II	Station III	Station IV
Bacillariophyceae	*Chaetoceros* sp	+	+	+	+
	Navicula sp	-	-	-	+
	Thalassionema sp	-	-	-	+
	Cerataulina sp	-	+	-	+
	Striatella sp	-	-	+	-
	Bacteriastrum sp	-	-	-	+
	Skeletonema sp	-	+	+	+
	Hemiaulus sp	-	-	+	+
	Diatoma sp	+	+	-	-
	Coscinodicuss sp	+	-	+	+
Cyanophyceae	*Anabaena* sp	+	-	-	-
	Oscillatoria sp	-	+	+	+
Coscinodiscophyceae	*Isthmia* sp	+	+	+	+
	Leptocylindrus sp	+	+	+	+
Dinophyceae	*Ceratium* sp	-	-	-	+
Raphidophyceae	*Chattonella* sp	-	-	-	+
Total	16	6	7	8	13

Phytoplankton from the *Bacillariophyceae* class, commonly called diatoms, were found to be the most abundant among other classes found at the sampling station location, namely 62%. Several things can cause the number of diatom species found. In addition to their ability to survive in extreme conditions and good adaptation to environmental changes, diatoms also have high reproductive abilities (Odum *in* Aisoi, 2019).

Relationship between phytoplankton abundance and oil content

The results obtained based on the linear regression test of the relationship between oil content and phytoplankton abundance at each station obtained a systematic equation, namely y = 6245.3 + (-7E+07x) with a correlation coefficient r = 0.5491 and the coefficient of determination R^2 = 0.3016. From these results, based on the assessment criteria according to Sugiyono (2016) for the correlation coefficient (r), it can be interpreted that the level of relationship between oil content and phytoplankton abundance in Teluk Bayur waters is classified as an average relationship (0.51 - 0.75), the results of the correlation coefficient also show a negative relationship marked by a decreasing graph (opposite), meaning that the higher the value of the 'independent' variable (total oil content), the lower the value of the 'dependent' variable (phytoplankton abundance).

This condition can occur because oil is insoluble and floats on the water's surface. It can hinder light penetration into the waters and reduce primary productivity. According to Darza (2020), the chemical components contained in oil are toxic to organisms, especially plankton.

Therefore, oil can affect the presence of phytoplankton in the water. This opinion is also supported by similar research conducted by Khaironisa (2021) in the waters of the Pelintung Dumai Industrial Estate, which found that the weak negative correlation value with r = 0.10 means that the higher the oil content in these waters, the phytoplankton abundance will also decrease. The coefficient of determination (R^2) in this study was obtained at 0.3016, which means that the oil content in Teluk Bayur waters can affect phytoplankton abundance only by 30.16%. In comparison, other environmental factors influence the remaining 69.84%. This shows that oil content affects phytoplankton abundance in Bayur Bay waters. The relationship of phytoplankton abundance to total oil content can be seen in Figure 4.

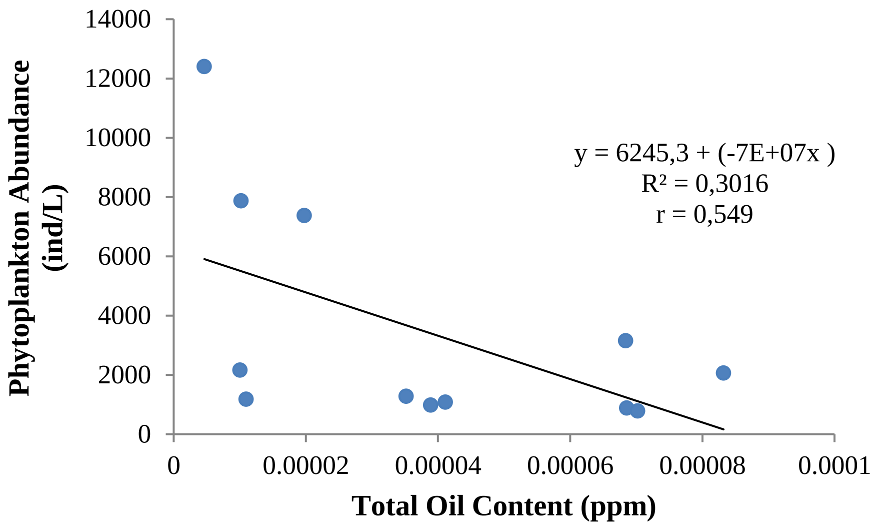

Figure 4. Linear regression of phytoplankton abundance and oil content in Bayur Bay

4. CONCLUSION

The total oil content at the study site has a different average that ranges from 0.00001153-0.00005387 ppm, with the highest content at station III, which is located in the tourism area, while the lowest content is at station IV, which is a water body with minimal activity. Phytoplankton abundance at the study site has an average of 1016.77-9216.55 ind/L, with the highest abundance at station IV, which has minimal activity, while the lowest abundance is at station I in the industrial area. High and low phytoplankton abundance depends on physical, chemical and biological parameters and the amount of nutrients entering the water. Besides that, the level of pollution also has a significant impact on phytoplankton abundance in water.

The relationship between phytoplankton abundance and oil content in Bayur Bay waters has a moderate negative correlation value with a value of r = 0.5491, where the increasing amount of oil content, the more the abundance of phytoplankton will decrease. There is an opportunity to conduct further research by linking phytoplankton abundance with other limiting variables such as nitrate and phosphate nutrients and current distribution patterns or linking total oil content with dissolved oxygen production in waters by phytoplankton. Then, there is a need for further research related to the potential occurrence of the HABS phenomenon at this location to provide more detailed information.

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