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Analysis of Detergent Content and Diatom Abundance in the Waters of Pakning Village, Bukit Batu Subdistrict, Bengkalis Regency, Riau

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ABSTRACT

Water pollution from domestic waste, particularly detergents, is a serious problem that can disrupt aquatic ecosystems and the lives of phytoplankton, such as diatoms. Diatoms are biological bioindicators sensitive to changes in water quality. This study was conducted in April 2025 in the waters of Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis Regency, Riau Province. The objectives of this study were to analyse detergent content, assess diatom abundance, and determine the relationship between the two. Samples were collected at three stations representing residential, mangrove, and industrial areas. Detergent content was analysed using the MBAS method with a UV-Vis spectrophotometer, while diatom identification and abundance analysis were conducted microscopically in the laboratory. The results showed that the highest detergent content was found at Station I (2.8676 mg/L) and the lowest at Station III (0.5152 mg/L). The highest diatom abundance was found at Station III (390.625 ind/L) and the lowest at Station I (248.2 ind/L). *Rhizosolenia* sp. was the dominant species found at all stations. Regression analysis showed a weak negative relationship between detergent content and diatom abundance ($r = 0.342$; $R^2 = 0.117$), indicating that detergent is not the main factor influencing diatom abundance. In conclusion, although detergents contribute to diatom community variation, other environmental factors such as nutrients, salinity, and light intensity also play significant roles.

Keywords: Detergent, Diatom, Pollution, Abundance

1. INTRODUCTION

Pakning Asal Village is a coastal area in Bukit Batu Subdistrict, Bengkalis Regency, Riau Province, located directly adjacent to residential areas, mangrove forests, and industrial areas. The increase in population and domestic activities, such as washing and the direct disposal of household waste into the water, has caused pollution, particularly from detergents. Along with this development, domestic and industrial waste, especially containing detergents, is increasingly being disposed of directly into water bodies without undergoing treatment. Detergents generally contain surfactants such as Linear Alkylbenzene Sulfonate (LAS), which are toxic and difficult to break down in the environment (Sulistyaningsih et al., 2024). High detergent concentrations can inhibit light penetration, disrupt photosynthesis, reduce dissolved oxygen levels, and impact aquatic organisms that serve as environmental bioindicators (Ummah, 2019).

One organism sensitive to environmental quality changes is diatoms. Diatoms are a group of single-celled phytoplankton that play a crucial role as primary producers in aquatic food chains (Min et al., 2024). Diatoms are also known as effective biological bioindicators due to their rapid responses to environmental parameters such as nutrients, detergents, heavy metals, and light fluctuations. The presence and abundance of diatoms are highly dependent on water's physical-chemical parameters, and environmental degradation, such as increased detergent content, can affect their community composition (Ummah, 2019).

However, in coastal areas such as Pakning Asal Village, research on the direct impact of detergent content on diatom abundance remains very limited. The lack of local data on this biological indicator complicates efforts to implement ecosystem-based environmental management. Therefore, it is important to conduct a study on the Influence of detergent content on diatom abundance as a bioindicator of water quality. Detergents can disrupt the structure of microalgae communities by altering water chemistry, though their effects may vary with local environmental conditions, such as salinity, nutrient levels, and light intensity.

Therefore, this study was conducted to understand the characteristics of detergent content and diatom abundance, as well as their relationship in the waters of Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis District.

2. RESEARCH METHOD

Time and Place

The research was conducted in April 2025 in the waters of Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis Regency.

Method

The methods used included field surveys and water sampling at three stations. Station 1 is located in the residential area. Station 2 is located in the mangrove forest area. Station 3 is located in the industrial area of PT. Pertamina RUU II Sungai Pakning, Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis District, Riau Province.

Procedures

Sample collection and handling

Detergent samples were collected three times at each station using 125 mL bottles. The collected water samples were then placed in an ice box and taken to the laboratory for analysis using a BK-UV 1800 spectrophotometer.

Diatom samples were collected during the daytime between 11:00 and 15:00 WIB, as diatoms are expected to be on the surface for photosynthesis at that time (Dionfriski et al., 2021). Surface water samples were collected using a 10-L plastic bucket at a depth of approximately 1 m, then filtered through a No. 25 plankton net. The filtered water (125 mL) was placed in a sample bottle, and then 3-4 drops of 4% Lugol solution were added. Each sample was labelled and placed in an ice box. The samples were then taken to the laboratory for identification.

Sample Testing Procedure

100 mL of water sample was placed in a 250 mL separating funnel. Three to five drops of phenolphthalein indicator were added to the sample. Next, 1 N NaOH solution was added dropwise until a pink colour appeared. The pink colour is then removed by adding 1 N H_2SO_4 solution drop by drop until the colour disappears. The conversion formula for absorbance to concentration (mg/L) is:

Regression equation on the calibration curve ($y = a + bx$)
Where:
Y = absorbance read by the instrument
X = concentration (mg/L) to be found

The content of anionic surfactant detergents (SNI 06-6989.51-2005)

The analysis of detergent content can be carried out as follows: a) Preparation of a 100 mg/L anionic surfactant stock solution. 100 g of Linear Alkylbenzene Sulfonate (LAS) 100% active or 1 N sulphuric acid (H_2SO_4) solution is dissolved in 250 mL of distilled water in a 250 mL volumetric flask. Distilled water is then added until the mark is reached. The solution is then stirred until homogeneous to ensure that all ingredients are thoroughly mixed.

b) Preparation of 100 mg/L anionic surfactant standard solution. The prepared anionic surfactant stock solution is measured using a pipette according to the required volume, then transferred to a 100 mL volumetric flask. Distilled water is then added until the mark, and the solution is stirred until homogeneous. c) Preparation of anionic surfactant working solution, the 100 mg/L anionic surfactant standard solution is measured using a pipette in volumes of 1.0, 2.0, 3.0, 4.0, and 5.0 mL, then added to each 100 mL volumetric flask. Next, distilled water is added to each measuring flask until the mark, then the solution is stirred until homogeneous. These yield working solutions with anionic surfactant concentrations of 1, 2, 3, 4, and 5 mg/L MBAS.

d) Preparation of the calibration curve: The calibration curve was prepared by first optimizing the spectrophotometer according to the instructions for measuring anionic surfactant concentrations. 100 mL of working solution was placed in a 250 mL separating funnel, then 25 mL of methylene blue solution and 10 mL of chloroform were added. The mixture is shaken for 30 seconds while occasionally opening the flask cap to release gas. After two phases form, if an emulsion occurs, the flask is gently shaken, and isopropyl alcohol is added gradually until the emulsion disappears.

The chloroform phase is transferred to a reaction tube and labelled according to the sample identity. The extraction process on the aqueous phase is repeated twice more with the same steps, then all the chloroform phases are combined. After that, 50 mL of washing solution is added, and the mixture is stirred again for 30 seconds to separate the chloroform phase cleanly. The final chloroform phase is placed in a labelled test tube, and its absorbance is measured at 652 nm using a spectrophotometer. The absorbance data is used to create a calibration curve by determining the linear equation relating surfactant concentration to absorbance.

Diatom Abundance Measurement Procedure

Diatom samples were collected through direct field surveys in the waters of Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis Regency. The samples were then analyzed in the Marine Biology Laboratory. a) The samples are mixed thoroughly, then taken using a dropper, dropped onto an object glass, covered with a cover glass, and observed under a microscope.

b) Diatoms are observed using the sweep method, by observing all columns on the object glass at 10x10 magnification, repeated 3 times for each sample. c) The types of diatoms observed are identified using a book by Davis (1955). d) The same types of diatoms are grouped, and their abundance is counted.

Detergent Content Analysis and Diatom Abundance Analysis

Diatom abundance analysis was calculated using the APHA (1992) formula as follows:

$$N=\frac{X}{Y} \times \frac{1}{v} \times Z$$

Description:

N	:	Diatom abundance (ind/L)
X	:	Volume of water filtered with a plankton net (125 ml)
Y	:	Volume of sample under the cover glass (0.08)
v	:	Volume of filtered water (50 litres)
Z	:	Number of individuals found (ind)

The Relationship Between Detergent and Diatom Abundance

The relationship between detergent content and diatom abundance can be determined using a simple linear regression, as described by Yasmin & Kurniawan (2009). The regression equation is:

$$Y = a + bX$$

Explanation:

Y	:	Diatom abundance (ind/L)
a and b	:	Constant and regression coefficient
X	:	Detergent content (mg/L)

The value of b can be positive or negative. Furthermore, to determine the strength of the relationship, the correlation coefficient (r) is used, where the value of r ranges from 0 to 1. According to Sugiyono (2008), the strength of the relationship is as follows: 0.00 - 0.199 = Very weak relationship; 0.20 - 0.399 = Low relationship; 0.40 - 0.599 = Moderate relationship; 0.60 - 0.799 = Strong relationship; and 0.80 - 1.000 = Very strong relationship

Data Analysis

The data were presented in graphs and tables and analyzed descriptively. An ANOVA was used to analyze the effect of detergent content on diatom abundance. In addition, a linear regression test was applied to evaluate the relationship between detergent content and diatom abundance in the waters of Pakning Asal Village, Bukit Batu Subdistrict, Bengkalis Regency, Riau Province.

3. RESULT AND DISCUSSION

Detergent content in the waters of Pakning Asal Village

Detergents are one of the pollutants found in water, especially in residential areas, mangrove forests, and industrial areas. The water content in Pakning Asal Village, Bukit Batu District, Bengkalis Regency, is shown in Table 1. The highest detergent content was observed at station 1 (1.3) at 2.8676 mg/L, while the lowest was observed at station 3 (3.2) at 0.5152 mg/L

Types of Diatoms and Diatom Abundance in the Waters of Pakning Asal Village

Diatoms are single-celled microalgae with a very high diversity of forms. Diatoms can also be grouped by habitat. In this study, the types of diatoms found in the waters of Pakning Asal Village, Bukit Batu District, Bengkalis Regency, are presented in Table 2.

The diatom species found in the waters of Bukit Batu, Bukit Batu District, Bengkalis Regency, varied greatly among stations. As shown in Table 2, the most abundant species at Station I (1.1) and (1.2) are 6 species at (1.1) (*Pleurosigma* sp., *Coscinodiscus* sp., *Closterium* sp., *Ulotrix* sp., *Nitzschia* sp., *Rhizosolenia* sp) and 5 species at (1.2) (*Coscinodiscus* sp., *Nitzschia* sp., *Rhizosolenia* sp., *Bacillaria paxilifer.*, *Istmia* sp.). The species with the lowest abundance were found at Stations I (1.3), II (2.2), III (3.1), and IV (3.3), with 2 species at each station. Among the diatom species obtained, the most dominant species at each station was *Rhizosolenia* sp., which was present at every sampling point.

The diatom abundance in this study, from the waters of Bukit Batu, Bengkalis District, showed a high diversity of species, with *Rhizosolenia* sp. being the most abundant, found at every station. The abundance of diatoms is shown in Table 3.

Table 1. Results of detergent content analysis in the waters of Pakning Asal Village

Station	Repetition	Absorbance	Concentration (mg/L)
	1	0,307	2,8390
I	2	0,254	2,3343
Settlements	3	0,310	2,8676
	Average		2,6803
II	1	0,234	2,1438
Mangrove forests	2	0,162	1,4581
	3	0,211	1,9248
	Average		1,8422
III	1	0,072	0,6010
Industry	2	0,063	0,5152
	3	0,069	0,5724
	Average		0,5628

Table 2. Types of diatoms found in the waters of Pakning Asal Village

No	Species	Station								
		1.1	1.2	1.3	1.1	1.2	1.3	1.1	1.2	1.3
1	*Pleurosigma* sp	*					*			
2	*Coscinodiscus* sp	*	*							
3	*Closterium* sp	*								
4	*Ulotrix* sp	*								
5	*Nitzschia* sp	*	*		*		*	*	*	
6	*Rhizosolenia* sp	*	*	*		*	*		*	*
7	*Bacillaria paxillifera*		*							
8	*Istmia* sp		*							*
9	*Synedra* sp			*						
10	*Thalassionema* sp				*					
11	*Rhabdonema* sp				*					
12	*Proboscia alata*				*					
13	*Guinardia* sp					*				
14	*Grammatophora*							*	*	
	Total Species	6	5	2	4	2	3	2	3	2

Table 3. Abundance of diatoms in the waters of Pakning Asal Village

Station	Repetition	Type	Abundance Value (ind/L)
		Pleurosigma sp	312,5
		Closterium sp	156,25
	1.1	*Ulothrix* sp	156,25
		Nitzschia sp	156,25
		Rhizosolenia sp	312,5
		Coscinodiscus sp	312,5
I		*Bacillaria paxillifer*	156,25
	1.2	*Nitzschia* sp	156,25
		Rhizosolenia sp	156,25
		Istmia sp	156,25
	1.3	*Synedra* sp	156,25

		Rhizosolenia sp	457,95
II	2.1	*Rhabdonema* sp	457,95
		Thalassionema sp	156,25
		Nitzschia	156,25
		Proboscia alata	156,25
	2.2	*Guinardia* sp	156,25
		Rhizosolenia sp	312,5
	2.3	*Pleurosigma* sp	156,25
		Rhizosolenia sp	156,25
		Nitzschia sp	457,95
III	3.1	*Nitzschia* sp	156,25
		Grammatophora sp	312,5
	3.2	*Nitzschia* sp	312,5
		Grammatophora sp	156,25
		Rhizosolenia sp	312,5
	3.3	*Rhizosolenia* sp	625
		Isthmia sp	156,25

Diatoms are a group of phytoplankton that play an important role as primary producers in aquatic environments and are sensitive to changes in environmental quality. Diatoms are single-celled microalgae with a high diversity of shapes and types, and can also be classified by habitat. Planktonic Diatoms: Live suspended in the water column, such as species in the order Centrales. Benthic diatoms: Attached to the bottom substrate, such as species in the order Pennales, planktonic diatoms are commonly found in tropical and subtropical marine waters (Suwartimah et al., 2011).

The diversity and abundance of diatoms reflect the condition of aquatic ecosystems, including productivity and pollution levels. Based on identification results, 15 diatom species were found in the waters of Bukit Batu, originating from several stations: *Pleurosigma* sp., *Coscinodiscus* sp., *Closterium* sp., *Ulothrix* sp., *Nitzschia* sp., *Rhizosolenia* sp., *Bacillaria paxilifer*, *Istmia* sp., *Synedra* sp., *Thalassionema* sp., *Rhabdonema* sp., *Proboscia alata*, *Guinardia* sp., *Grammatophora* sp. The most dominant species was *Rhizosolenia* sp., which was found in all observation stations (Stations I, II, and III), indicating its ability to adapt to various environmental conditions.

The abundance of diatom species varied between stations. Stations 1 (1.1) and 1.2 showed the highest abundance, with 6 species each. The types found included *Pleurosigma* sp., *Nitzschia* sp., *Coscinodiscus* sp., *Rhizosolenia* sp., *Ulothrix* sp., and *Bacillaria paxilifer*. The dominance of *Rhizosolenia* sp. indicates tolerance to water affected by domestic activities. Station II (2.2) has the fewest species (2), indicating relatively stable water conditions slightly disturbed by waste; at some points, only *Nitzschia* sp. and *Rhizosolenia* sp. were found. Stations III (3.1) and (3.3) also showed low diversity, with only 2–3 species, suggesting that industrial pollution may affect plankton abundance and diversity.

Rhizosolenia sp., the dominant species, is an indicator of productive water but also tolerant of mild eutrophic conditions. Meanwhile, *Nitzschia* sp. and *Grammatophora* sp. are often found in waters with high organic content and serve as early indicators of water quality degradation (Yuliana et al., 2022). The presence of *Coscinodiscus* sp. and *Thalassionema* sp. also characterizes an environment that is still naturally productive. Conversely, the decline in species numbers at industrial and mangrove stations indicates environmental disturbance that suppresses diversity.

Bukit Batu waters show a fairly high level of diatom diversity, with *Rhizosolenia* sp. as the dominant species at all stations. The highest abundance was observed at Station I, likely due to elevated nutrient levels from domestic activities. Lower diversity was observed in industrial and mangrove areas, reflecting higher environmental pressures (Hidayati & Martono, 2020).

Relationship between Detergent Content and Diatom Abundance in Pakning Village

The relationship between detergent content and diatom abundance in the waters of Pakning Asal Village, Bukit Batu District, Bengkalis Regency, Riau Province, shows a comparative value between detergent content and diatom abundance, as shown in Table 4.

Table 4. The relationship between detergent content and diatom abundance

Station	Repetition	Detergent (mg/L)	Diatom (ind/L)
	1	2,8390	218,75
I	2	2,3343	218,75
Settlements	3	2,8676	307,1
II	1	2,1438	231,675
Mangrove forests	2	1,4581	234,375
	3	1,9248	256,816
III	1	0,6010	234,375
Industry	2	0,5152	260,416
	3	0,5724	390,625

Based on the comparison of detergent content and diatom abundance between stations, Station III has the lowest detergent content (0.5628 mg/L) and the highest diatom abundance (295.1 ind/L). At Station I, the detergent content is the highest at 2.6803 mg/L, and the diatom abundance is the lowest at 240.9 ind/L.

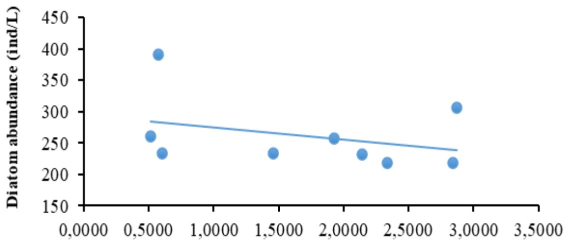

Figure 1. The relationship between detergent content and diatom abundance

Research conducted in three different types of locations, namely residential areas, mangrove forests, and industrial areas in the Pakning Asal Village area, aimed to determine the effect of detergent levels on diatom abundance as a bioindicator of water quality. Data in Table 4 show variations in detergent content and diatom abundance at each station. The correlation coefficient (r) of 0.342 indicates that the relationship between detergent levels and diatom abundance is weak and not significant. The coefficient of determination (R^2) of 0.117 indicates that only 11.7% of the variation in diatom abundance is explained by detergent levels. In comparison, the remaining 88.3% is influenced by other factors, such as nutrient availability (nitrate, phosphate, silicate), salinity, temperature, and light intensity.

Although the results show a negative correlation (decreasing diatom abundance with increasing detergent concentration), the correlation is very weak. This is evident from the data at Station III, which had the lowest detergent concentration (0.5628 mg/L) and the highest diatom abundance (295.1 ind/L), compared with Station I, which had the highest detergent concentration (2.6803 mg/L) and the lowest diatom abundance (248.2 ind/L). High detergent concentrations can disrupt diatom physiological processes, such as cell membrane damage and inhibition of photosynthesis (Chapman, 2021).

However, the weak, non-significant relationship indicates that detergent pollution levels in the study area have not yet reached levels of acute toxicity for the diatom community. Overall, the study results indicate that the relationship between detergent concentration and diatom abundance is weak and statistically insignificant. This suggests that other environmental parameters, such as nutrients, salinity, or light intensity, may contribute more significantly to diatom population fluctuations in the water. Therefore, high detergent content has not directly affected diatom abundance in the water of Pakning Asal Village. Further studies are needed on other physical and chemical parameters that may play a more significant role in regulating phytoplankton abundance, including diatoms.

4. CONCLUSION

Based on the research results, the highest detergent content was observed at station I (2.8676 mg/L), located in a residential area, and the lowest at station III (0.5152 mg/L), located in an industrial area. The most dominant diatom species at all locations was *Rhizosolenia* sp., which showed high tolerance to pollution. The relationship between detergent content and diatom abundance showed a weak and insignificant negative correlation (r = 0.342), suggesting that detergent is not the sole factor influencing diatom abundance. Other factors, such as nutrients, light, temperature, and salinity, are likely to play a more dominant role. Further studies are needed to assess the Influence of other environmental factors on diatom community structure.

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