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Distributions of Silicate and Nitrate in Tirang Beach, Semarang

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A B S T R A C T

Tirang Beach is located near the estuary of Silandak River, surrounded by mangrove forests, aquaculture ponds, residential areas, industrial zones, tourism areas, and spots for fishing activities. These various activities may affect the concentration of silicate and nitrate in the local waters. The objective of this research is to study the distribution of silicate and nitrate in Tirang Beach, Semarang. Quantitative research method with descriptive analysis is the research method used for this study. The research method used to analyse the silicate is Grasshof method and to analyse the nitrate the method that is used is the method that is developed by Pearson. The result of this research shows that the average concentration of silicate is 2,2024 µMol, and for the nitrate the average concentration is 0,6402 µMol. The result of this research shows that the concentration of silicate is higher than the previous researches, while the nitrate concentration is lower than the previous researches. The farther the distribution of the 2 nutrients from the beach the lower the concentration is, while the concentration will be higher when it's closest to the beach. So, the distribution of the two nutrients is more affected by dispersion and dilution processes than by the direction of the current.

Keywords: Silicate, Nitrate, Distribution, Tirang Beach, Brightness

1. Introduction

Rivers are the main media to distribute organic material from the land to the sea. A high concentration of organic material into the waters can cause the water to become turbid thereby blocking sunlight from penetrating the waters. Nitrate and silicate come from the processes of decomposition, weathering, or the breakdown of plants, remains of dead organisms, and waste discharges from land-based sources such as domestic, industrial, agricultural, or livestock waste including leftover feed from the pond with the help of bacteria and these materials will breakdown and become nutrients. These can affect the concentration of silicate and nitrate. The input of nutrients into marine waters has a positive impact by supporting the primary productivity of the ecosystem. However, at certain levels, these nutrients can lead to negative impacts by accelerating the rate of primary productivity which may disrupt the balance of the aquatic ecosystem.

Studying nitrate and silicate concentration in marine waters is essential to assess pollution levels. Water quality parameters such as salinity, temperature, pH, dissolved oxygen (DO), and brightness can influence nitrate and silicate concentrations. Tirang Beach is located near the estuary of Silandak River, surrounded by mangrove forests, aquaculture ponds, residential areas, industrial zones, tourism areas, and spots for fishing activities. The tourism at Tirang Beach in Semarang has been growing rapidly. These various activities may affect the concentration of silicate and nitrate in the local waters. Based on this, it is necessary to do research on the distribution of silicate and nitrate concentration.

2. Material and Method

This research used purposive sampling to determine the station and each station represent specific environmental conditions. There is 9 sampling points were selected for this study. Point 1 represents the estuary, points 2 and 3 represent the beach, points 4, 5, 6, and 7 represent the open sea, point 8 and 9 represents the fishpond and mangrove area.

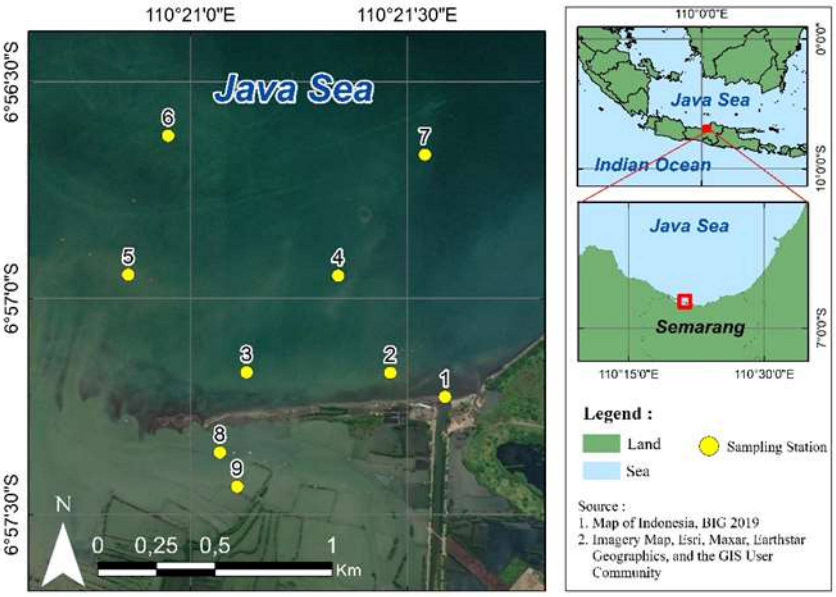

Figure 1. Sampling Station

2.1 Silicate Analysis

The analysis of silicate concentration in this study is based on the method developed by Grasshoff (1999). The first step is the preparation of calibration curve using standard silicate solutions (Na_2SiF_6) with various concentrations: 3 µM, 5 µM, 10 µM, 15 µM, 20 µM, 25 µM, 30 µM, and 35 µM. For each concentration, take 25 mL of solution and mix with 0.05 mL of sulfuric acid reagent and 0.10 mL of bromine water. The mixture was homogenized and wait for 5 minutes. Then, add 1 mL of molybdate reagent, homogenized and wait for 5–10 minutes. After that, add 1 mL of oxalic acid reagent and add 0.5 mL of ascorbic acid, homogenized, and wait for 30–60 minutes. The final result was measured using a spectrophotometer at a wavelength of 810 nm. The absorbance data obtained from the measurements were processed using Microsoft Excel to create a calibration curve, which was considered valid if the coefficient of determination (r^2) was close to 0.99. After obtaining a valid calibration curve, the next step was to analyze the silicate concentration in seawater samples. Add 25 mL seawater sample and placed in a plastic bottle. Then, add 0.05 mL of sulfuric acid reagent and add 0.10 mL of bromine water, homogenized, and then wait for 5 minutes. Next, add 1 mL of molybdate reagent, homogenized, and wait for 5–10 minutes. Then, add 1 mL of oxalic acid reagent and add 0.5 mL of ascorbic acid, homogenized, and wait for 30–60 minutes. After the sample preparation was completed, measure using a spectrophotometer at 810 nm and each measurement was repeated three times to ensure the accuracy.

2.2 Nitrate Analysis

The analysis of silicate concentration in this study is based on the method developed Pearsons (1984). To determine the nitrate concentration, the first step was to analyse nitrite. Before analysing nitrite in seawater samples, a calibration curve was prepared using standard nitrite solutions ($NaNO_2$) to determine the regression value and linear equation that would be used to calculate nitrite concentrations. The concentrations used for the nitrite calibration curve were 0.5 µM, 1 µM, 1.5 µM, 2 µM, and 2.5 µM. After that, nitrite content in the seawater samples was analysed. A 25 mL sample of seawater placed into an Erlenmeyer flask, and add 0.5 mL of sulfanilamide reagent and wait for 2–8 minutes. Then, add 0.5 mL of NED reagent and wait for 10–120 minutes. The absorbance was measured using a spectrophotometer at a wavelength of 543 nm. The absorbance results then used in the linear equation obtained from the calibration curve to calculate the nitrite concentration.

The analysis of nitrate concentration starts by making a calibration curve using standard nitrate solutions (KNO_3) with different concentrations: 0.5 µM, 1 µM, 1.5 µM, 2 µM, and 2.5 µM. These solutions are diluted using synthetic seawater. Then, take 20 mL of each standard solution and passed through the reduction column. Before doing this, the NH_4Cl solution inside the column is drained until it nearly reaches the copper wool. The standard solution with the lowest concentration is added first and allowed to fully pass through the column, and the liquid that comes out is collected. After this, NH_4Cl can be added back into the column. The same steps are repeated for the next standard solutions, from the lowest to the highest concentration. Next, 20 mL of the collected liquid from each concentration is placed into an Erlenmeyer flask. Sulfanilamide reagent is added and left to react for 2–8 minutes. Then, add NED reagent and wait the mixture for 10–120 minutes. After that, the absorbance is measured using a spectrophotometer at a wavelength of 543 nm. The absorbance data is processed using Microsoft Excel to make a calibration curve. This curve is considered valid if it shows a straight line (linear) and has a determination coefficient (r^2) close to 0.99. After obtaining a valid calibration curve, the next step was to analyse the nitrate concentration in seawater samples. A 25 mL sample of seawater is taken and mixed with 25 mL of NH_4Cl solution. This mixture is then passed through a reduction column that has already been cleaned using NH_4Cl. NH_4Cl solution is also used to rinse the reduction column between samples to prevent contamination. This process is repeated for all samples. From each sample, 20 mL of the solution coming out of the column is collected. Then, 0.5 mL of Sulfanilamide reagent is added and left to react for 2–8 minutes. After that, add 0.5 mL of NED reagent and wait for 10–120 minutes. After that, the absorbance is measured using a spectrophotometer at a wavelength of 543 nm. The measurement is repeated three times for each sample to ensure accuracy. The absorbance values obtained are then used in the calibration curve equation to calculate the nitrate concentration in the seawater sample. Finally, the nitrate concentration is processed using a correction formula: nitrate - (nitrite*0.95), to get the final, accurate nitrate concentration result.

2.3 Water Quality Analysis

Temperature was measured using a digital thermometer, which was placed on the surface of the seawater. Salinity was analyse using a refractometer by placing a drop of seawater onto the device and observe where the blue line is at. pH was measured with a pH meter, which was inserted into the seawater and left until the reading stabilized. The same procedure was used for measuring dissolved oxygen (DO), using a DO meter. Brightness was measured using a Secchi disk, which was lowered into the water until it was no longer visible and note the depth at which the disk disappeared. Current measurements were carried out using a float (drifter ball) attached to a 5-meter rope and a hand compass to determine the current direction. Current speed and direction were determined by observing the movement of the float using the compass and timing how long it took from the moment the float was released into the water until the rope was fully extended. The current speed was then calculated using a current speed formula.

3. Results and Discussion

The concentrations of silicate and nitrate in the waters of Tirang Beach vary at each station. Silicate concentrations range from 1.187 - 4.4381 µMol, with an average of 2.2024 µMol. Nitrate concentrations range from 0.2137 to 1.467 µMol, with an average of 0.6402 µMol. The details are shown in **Table 1**

Table 1. Concentration of silicate and nitrate in Tirang Beach, Semarang

STATION	COORDINATES		SILICATE	NITRATE
	Latitude	Longitude	(µMol)	(µMol)
1	6° 57' 13.7"	110° 21' 35.24"	2,3818	0,7943
2	6° 57' 10.36"	110° 21' 27.67"	2,7022	0,7208
3	6° 57' 10.3"	110° 21' 7.08"	1,5333	0,2616
4	6° 56' 56.9"	110° 21' 20.48"	1,2000	0,2379
5	6° 56' 56.76"	110° 20' 51.43"	1,7108	0,587
6	6° 56' 37.49"	110° 20' 56.95"	1,200	0,2889
7	6° 56' 40.13"	110° 21' 32.46"	1,187	0,2137
8	6° 57' 21.41"	110° 21' 4.11"	3,4684	1,467
9	6° 57' 26.13"	110° 21' 6.48"	4,4381	1,1904
	Average		2,2024	0,6402

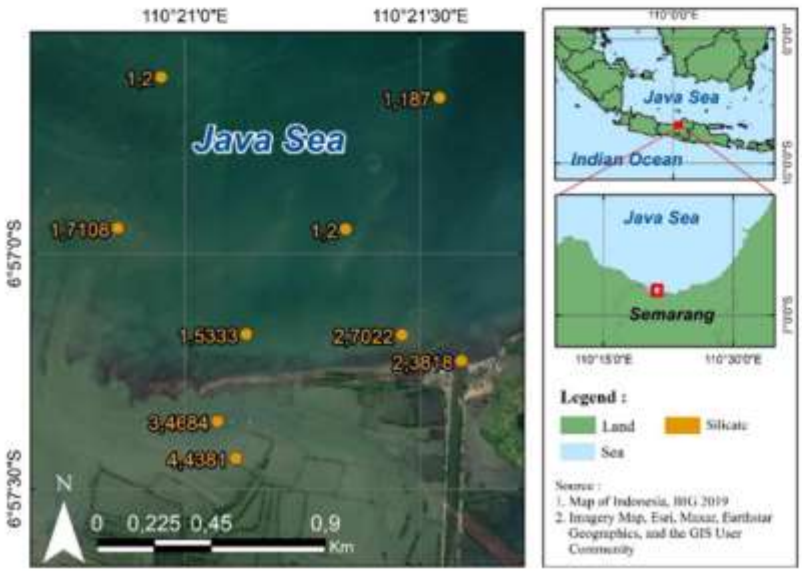

Figure 2. Silicate Concentration Distribution

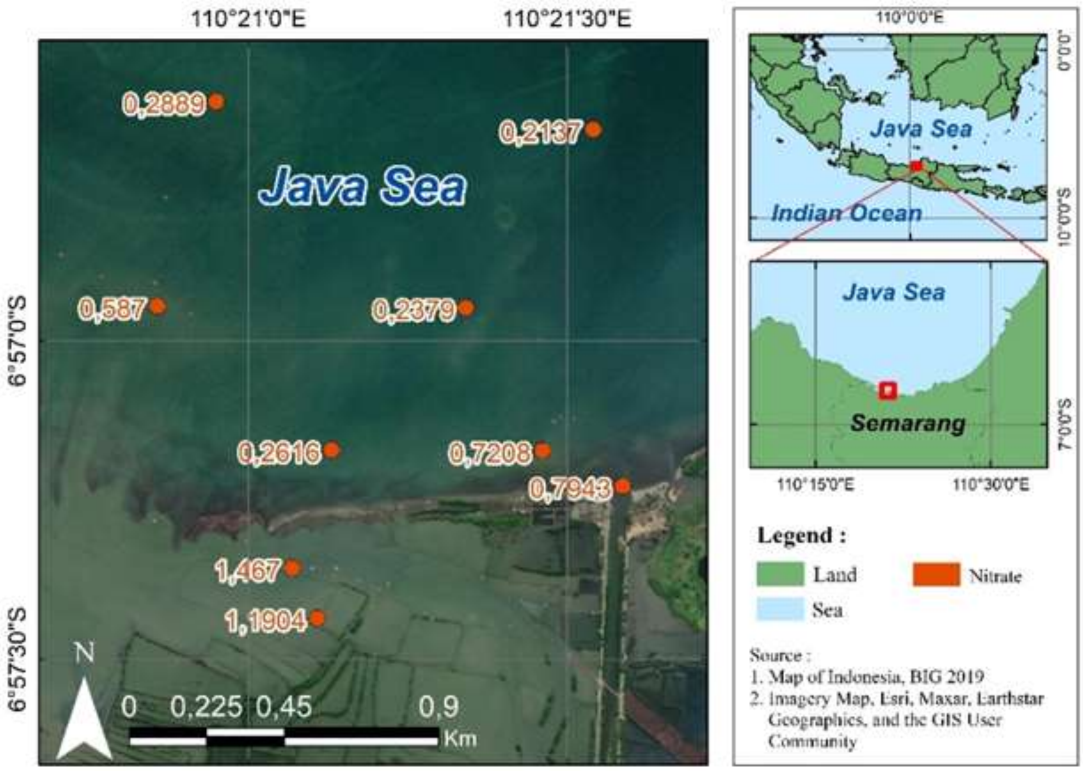

Figure 3. Nitrate Concentration Distribution

The measured water quality parameters include pH, dissolved oxygen (DO), temperature, salinity, and brightness with the following respective ranges and averages: pH ranged from 4.633 to 5.560 with an average of 4.916; DO ranged from 4.057 to 9.240 mg/L with an average of 6.681 mg/L; temperature ranged from 31.167 to 33.6 °C with an average of 31.789 °C; salinity ranged from 28.667 to 33 ‰ with an average of 31.370 ‰; and brightness ranged from 0.32 to 1 meter with an average of 0.602 meters. The details are shown in **Table 2**

Table 2. Water Quality Concentration

Station	**pH**	**DO (mg/L)**	**TEMPERATURE (°C)**	**SALINITY (‰)**	**BRIGHTNESS (m)**
1	6,887	7,020	33,600	31,667	0,320
2	6,633	9,240	32,300	32,000	0,490
3	6,737	7,507	31,400	33,000	0,650
4	6,633	7,823	31,400	32,667	0,600
5	6,897	6,540	31,500	32,333	0,690
6	6,770	6,693	31,333	31,000	1,000
7	6,750	6,513	31,167	30,000	1,000
8	7,380	4,740	31,600	31,000	0,320
9	7,560	4,057	31,800	28,667	0,350
Average	6,916	6,681	31,789	31,370	0,602

The current speed at Tirang Beach shows significant variation and it range from 0.0357 - 0.2208 m/s, with an average of 0.1288 m/s. The current direction at Tirang Beach also varies within a certain range. The details are shown in **Table 3**

Table 3. Current Speed and Current Direction

Station	Current Speed (m/s)	Current Direction (°)	Current Direction
1	0,1810	294	West
2	0,1190	163	South
3	0,0562	190	South
4	0,1454	120	South
5	0,1783	184	South
6	0,1369	184	South
7	0,0864	185	South
8	0,2208	180	South
9	0,0357	192	South
Average	0,1288	188	South

The average concentration of silicate during the study was 2.2024 µMol, which is much higher compared to a previous study conducted in September 2022, where the average concentration was much lower at 0.5833 µMol (Astuti et al., 2024). This increase may be caused by the accumulation of silicate over time, which settles and is later released back into the water during mixing events either from human activities such as dredging or natural processes like cyclones and rainfall (Muslim and Jones, 2003). Rainfall had occurred before sampling resulting in increased turbidity, with an average brightness of 60.2 cm. This is lower than the transparency measured in the previous study, which was 93.0556 cm (Astuti et al., 2024), showing that the water more turbid in this study. The influence between water quality parameters and nutrient distribution can be significant, particularly in relatively shallow waters that are easily mixed by current, affecting turbidity levels (Muslim et al., 2017). The average pH during this study was 6.916 (**Table 2**), which is slightly lower than the concentration in the previous study which is 7.01 (Astuti et al., 2024). A lower pH level or increased acidity is one of the factors that can influence the release of chemical elements from sediments into the water. Furthermore, the farther from the coast and river, the lower the silicate concentration tends to be, while concentrations are higher closer to coastal and river areas due to runoff from the land (Marlian, 2016).

The average silicate concentration in the Tirang Beach was 2.2024 µMol (**Table 1**). This average is higher than the concentration in the previous study, which was 0.5833 µMol (Astuti et al., 2024). The highest concentration was recorded at Station 9 (**Table 1**), while the lowest was recorded at Station 7 (**Table 1**). The high concentration at Station 9 is likely due to its close location to fishponds and a river, while Station 7 is located farthest point from the river mouth and coastline, resulting in a lower silicate concentration. The distribution of silicate concentrations shows a decreasing trend as the distance from the coast increases. This pattern is not aligned with the direction of water currents, which mostly flow southward (**Table 3**). This is likely because the distribution of chemical substances, especially nutrients, is strongly influenced by processes such as dispersion and dissolution (Daniel et al., 2024).

The average nitrate concentration during the study was 0.6402 µMol (**Table 1**). This concentration is lower compared to previous studies conducted in the waters of the Jajar River estuary, Demak (Yusuf et al., 2023) and in Morodemak (Adellio et al., 2024) in 2020, which reported to have higher average concentrations of 3.055 µMol and 2.1497 µMol. This difference is likely due to the lower population density and human activity around Tirang Beach compared to the Demak coastal area. The sampling locations in the previous studies were located near areas with high human activity, such as fish auction centers, which contribute to higher nitrate levels in the surrounding waters. According to Triyaningsih et al. (2021), the Morodemak waters are used for domestic and industrial waste disposal, boat traffic, tourism, and fishing activities, all of which can affect water quality.

The highest nitrate concentration was found at Station 8 (**Table 1**), while the lowest concentration was recorded at Station 7 (**Table 1**). Nitrate levels in seawater tend to be higher closer to the coastline due to runoff from the land (Farihah et al., 2016). Waters near river mouths typically have higher nitrate concentrations, which decrease as the distance from the shore increases toward the open sea (Simajuntak, 2009; Wahyuni et al., 2021). Other water quality parameters such as temperature, salinity, and dissolved oxygen (DO) (Table 2) do not show a direct correlation with silicate and nitrate concentrations. If any correlation exists, it is generally relative rather than direct, as these parameters are more influenced by water depth and turbidity or brightness (Muslim et al., 2017).

4. Conclusion

Based on the results of this study, silicate concentrations ranged from 1.187- 4.4381 µMol, while nitrate concentrations ranged from 0.2137 - 1.467 µMol. The distribution of both nutrients decreased with distance from the shore. This pattern was not affected by the direction of the currents but was mainly influenced by dispersion and dilution. Compared to previous research at the same location, silicate concentrations have increased, which is likely related to lower water transparency indicating mixing, as well as a decrease in pH.

References

Adellio, M. A., Wulandari, S. Y., & Muslim. (2024). Correlation between Nitrate and Chlorophyll-A Concentration in Morodemak Waters, Demak District, Central Java, Indonesia. *International Journal of Research Publication and Reviews, 5(6)*, 176-179.

Astuti, R.D., Muslim, M. & Ismanto, A. (2024). Sebaran Horizontal Silikat dan Hubungannya Dengan Klorofil-A Di Perairan Pesisir Pantai Tirang Semarang. *Indonesian Journal of Oceanography, 6(4),* 357-367.

Daniel, R.M., Satriadi, A., & Muslim. (2024). Horizontal Distribution of Total Suspended Solids (TSS) and Chlorophyll-a at Tirang Beach Semarang. *International Journal of Research Publication and Reviews, 5(12),* 203-210.

Farihah, R.A., Maslukah, L. & Wulandari, S.Y. (2016). Sebaran Horizontal Konsentrasi Nitrat Dan Nitrit Pada Kondisi Pasang Surut di Perairan Cilauteureun, Garut. *Journal of Oceanography*, *5(3),* 378-389.

Marlian, N. (2016). Analisis Variasi Konsentrasi Unsur Hara Nitrogen, Fosfat dan Silikat (N, P dan Si) di Perairan Teluk Meulaboh Aceh Barat. *Acta Aquatica: Aquatic Sciences Journal, 3(1),*1-6.

Muslim. Ir & Jones, G. (2003). The Seasonal Variation of Dissolved Nutrients, Chlorophyll A and Suspended Sediments at Nelly Bay, Magnetic Island. *Estuarine, Coastal and Shelf Science*, *57(3),* 445-455.

Muslim., Prihatiningsih, W.R., dan Nugroho, A. B. (2017). Relative Effect of Water Quality on 137Cs Activity in Larangan Water, Tegal. *Jurnal Sains Nuklear Malaysia, 29(1),* 45-61.

Simanjuntak, M. (2009). Hubungan Faktor Lingkungan Kimia, Fisika terhadap Distribusi Plankton di Perairan Belitung Timur, Bangka Belitung. *Jurnal Perikanan*, *11(1),* 31-45.

Triyaningsih, N.N.W., Munasik, M. & Setyati, W.A. (2021). Total Bahan Organik dan Kualitas Air di Perairan Morodemak, Kabupaten Demak. *Journal of Marine Research*, *10(2),* 205-212.

Wahyuni, W.I., Amin, B. & Siregar, S.H. (2021). Analysis of Nitrate, Phosphate, and Silicate Content and Their Effects on Planktonic Abundance in the Estuary Waters of Batang Arau or Padang City West Sumatra Province. *Asian Journal of Aquatic Sciences*, *4(1),* 1-12.

Yusuf, M., Rizkiana, A.A., Wulandari, S.Y., & Muslim. (2023). Horizontal Distribution of Nitrate Concentration in the Estuary of Jajar River, Demak Regency, Indonesia. *Eur. Chem. Bull*, *12(5)*, 4602-4610