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The Influence of Particle Size Sediment on Macrozoobenthos Abundance in Dumai Waters, Rupat Strait

Pengaruh Ukuran Partikel Sedimen terhadap Kelimpahan Makrozoobentos di Perairan Dumai, Selat Rupat

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ABSTRACT

The purpose of this study was to determine the effect of sediment texture on macrozoobenthos abundance in Dumai Waters, Rupat Strait. This study, conducted from February to March 2023, used a survey method. Stations were selected purposively. The method used 4 stations to collect samples, which were then analyzed in the laboratory. Analysis carried out in the laboratory comprises sediment fractionation and particle size analysis, and the identification of species of macrozoobenthos. The results of this study show that sediment texture accounts for 77.9% of the variation in macrozoobenthos abundance, while other environmental factors, including physical and chemical factors, account for the remaining 22.1%. The macrozoobenthos species found were *Barbatia* sp., *Marcia hiantina*, *Nerita articulata*, *Hiatula* sp., and *Clypeomorus* sp.

Keywords: Dumai Waters, Sediment Texture, Macrozoobenthos, Abundance

ABSTRAK

Tujuan penelitian ini adalah untuk mengetahui pengaruh tekstur sedimen terhadap kelimpahan makrozoobentos di Perairan Dumai, Selat Rupat. Penelitian ini, yang dilakukan pada bulan Februari hingga Maret 2023, menggunakan metode survei, dengan stasiun-stasiun yang dipilih berdasarkan purposive sampling. Metode ini menggunakan 4 stasiun untuk pengambilan sampel, dan sampel yang diperoleh kemudian dianalisis di laboratorium. Analisis yang dilakukan di laboratorium meliputi fraksi dan ukuran partikel sedimen, serta identifikasi spesies makrozoobentos. Hasil penelitian ini menunjukkan bahwa tekstur sedimen memiliki pengaruh sebesar 77,9% terhadap kelimpahan makrozoobentos, sedangkan 22,1% sisanya dipengaruhi oleh faktor lingkungan lain seperti faktor fisik dan kimia. Spesies makrozoobentos yang ditemukan adalah *Barbatia* sp., *Marcia hiantina*, *Nerita articulata*, *Hiatula* sp., dan *Clypeomorus* sp.

Kata Kunci: Perairan Dumai, Tekstur Sedimen, Makrozoobentos, Kepadatan

INTRODUCTION

The Rupat Strait is a small strait in the Strait of Malacca, located between the coast of Dumai city and Rupat Island, Riau Province. Rupat Island still has few activities beyond small plantations, but anthropogenic activities in Dumai City have significantly affected the environmental conditions in the Rupat Strait. Dumai waters in the Rupat Strait are a strategic transportation route vulnerable to oil pollution. The waters of Dumai and Rupat Strait are semi-enclosed, and in this area there are two high tides and two low tides within 24 hours (Nedi et al., 2010).

Anthropogenic activities can cause water pollution, leading to shallowing of river mouths, a process called sedimentation (Simanjuntak et al., 2018). Sedimentation is one of the most important problems in water. Sedimentation is a process in which sediment is transported by runoff water that is deposited where water velocity slows or stops, such as in reservoir channels, lakes, rivers, or coastal or bay areas (Arsyad, 2009). The high degree of sedimentation that occurs in wetlands causes a decline in water quality in those waters. According to Wahyuningrum et al. (2016), the introduction of sediment into waters can cause changes in the ecosystem, including changes in sediment texture, total sediment organic matter content, and the abundance of macrozoobenthic biota. Aulia et al. (2020) stated that the more activities that take place in river areas, the more waste will generally be produced, which can pollute the river. One attempt to determine the status of a water body is to use macrozoobenthos parameters as bioindicators. Macrozoobenthos plays an important role in the food web

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cycle because its life tends to be sedentary and it can survive (Rizka et al., 2016).

The sediment texture consists of sand, gravel, and mud fractions. Texture is the appearance of sediment related to the size, shape, and arrangement of sediment grains. A sediment deposit is composed of sediment particles of different sizes, originating from different sources. Sediment or base substrate that continually accumulates, and the presence of nutrients from living things and waste constitutes an organic matter content. The nutrient content in sediment is used by macrozoobenthos as one of the food requirements for their survival. In addition, macrozoobenthos were found living in sediments. The type of sediment texture and fraction content influences the abundance of macrozoobenthos (Putri et al., 2016).

The relationship between sediment texture and macrozoobenthos abundance in a water body is believed to have differences in abundance between each station due to differences in environmental characteristics where macrozoobenthos live around Dumai Waters, Rupat Strait. Therefore, researchers are interested in investigating the relationship between sediment particle size and macrozoobenthos abundance in Dumai Waters, Rupat Strait, and in determining macrozoobenthos abundance at each research station.

MATERIALS AND METHODS

Time and place

This survey was conducted in February-March 2023 and took place in Dumai Waters, Rupat Strait. The data analysis was carried out at the Physical Oceanography Laboratory, Faculty of Fisheries and Marine, Universitas Riau.

Methods

The method used in this study is a survey method and determining research stations through purposeful sampling by determining 4 stations, station 1 is located in the Masjid River estuary area, station 2 is located in a area close to the mangrove area of Pangkalan Sesai Village, station 3 is located in the TPI Pattimura port area, and station 4 is located in the Dumai-Melaka shipping area, which is expected to describe the condition of the Rupat Strait Dumai waters. Identification of macrozoobenthos samples was performed in the Physical Oceanography Laboratory.

Sediment sampling

Sediment sampling was conducted using an Eckman grab and repeated three times per station. The Eckman grab, with an opening area of 30 cm x 26 cm, is lowered to the bottom of the water to collect sediment; the collected sediment is then placed in a plastic bag labeled with the station point and repeat point. The sample is then placed in a refrigerator and taken to the laboratory for analysis. Sediment fractions and sediment organic matter are analyzed with these sediment samples. Use the following formula to calculate the percentage of sediment particles:

$$\text{Mean Size (Mz)} = \frac{Ø16 + Ø50 + Ø84}{3}$$

Classification: Ø1: coarse sand; Ø2: medium sand; Ø3: fine sand; Ø4: very fine sand; Ø5: coarse silt; Ø6: medium silt; Ø7: fine silt; Ø8: very fine silt; >Ø8: clay. To determine the sediment organic matter content, calculate with the following formula: Sediment organic matter (%) = $\frac{a-c}{a-b} \times 100\%$

Information: a = Weight of cup and sediment sample after drying or before combustion (g); b = Cup weight (g); c = Weight of cup and sample after combustion (g)

Macrozoobenthos sampling in the sediment was performed three times per station using an eckman grab. The eckman grab with an opening area of 30 cm x 26 cm is lowered to the bottom of the water to collect sediment, after which the collected sample is filtered through a 1 mm sieve. The collected macrozoobenthos is placed in a container in the form of a plastic bag and labeled with the station point and repeat point. Then the sample was placed in a refrigerator and taken to the laboratory, after which a 10% formalin solution was applied to prevent it from rotting. The type was then identified and its abundance analyzed.

Abundance of macro zoobenthos

To calculate the abundance of macrozoobenthos based on the number of individuals per unit area using the formula according to Odum (1993), as follows: Di = $\frac{N}{A}$

Information: Di = Abundance of macrozoobenthos (indi/m^2); N = number of macrozoobenthos individuals

captured in A (ind); A= Eckman gripper opening area (m^2)

Water quality

Measurement of physical and chemical parameters of water, including temperature and depth using an echo sounder measured at the bottom of the water, and then other parameters such as salinity using a hand refractometer, pH using pH paper, current speed using a current drogue, clarity using a secchi disk, measurements at the water surface and all parameters, this is done on site. In situ measurements are water-quality measurements taken directly at the sampling location. Meanwhile, testing for dissolved oxygen and sediment organic matter is carried out ex situ by taking samples in the form of water and sediment for analysis in the laboratory.

RESULT AND DISCUSSION

Water quality

Measuring water quality parameters aims to determine whether the environmental conditions of a water body are good or not. Water, as a place of residence or habitat for most aquatic biota, must have conditions suitable for their survival. Therefore, water quality measurements are necessary to determine the optimal conditions for waters inhabited by macrozoobenthos (aquatic biota), which can affect their lives. The results of the water quality parameter measurements are shown in Table 1.

Table 1. Water quality parameters of Dumai Waters

Parameter	Station I	Station II	Station III	Station IV
pH	6,7	6,3	7,2	7,1
Temperature (ºC)	27,3	29,3	29,5	29,9
Salinity (ppt)	8	17	24	23
Brightness (cm)	72,5	50	52,5	85
Current speed (m/s)	0,17	0,18	0,09	0,40
DO (mg/L)	7,3	8,16	6,12	6,5
Sediment organic matter (%)	10,57	8,15	4,78	3,98
Depth (m)	2,9	3	2,8	8,1

The results of measurements of water quality parameters in the Dumai Waters and Rupat Strait showed that the pH ranged from 6.3 to 7.2. The water temperature is between 27.3 ˚C and 29.9 ˚C. Lusianingsih (2011) stated that the optimal temperature for life in macrozoobenthos is around 28°C–30°C and is still within the tolerance limits of macrozoobenthos. The salinity varies from 8 to 24 ppt. According to PP (2021), the appropriate salinity for marine biota is a natural condition; in this case, it varies during the day (day vs. night) or with the season, and in mangrove areas, it can reach up to 34 ppt. The current speed ranges from 0.09 to 0.40 m/s. Water clarity ranges from 50 to 85 cm, while water depth ranges from 2.8 to 8.1 m. According to Gultom et al. (2018), macrozoobenthos in shallow areas exhibit different habitat characteristics because sunlight penetrates to the bottom in shallow waters. The depth of a body of water is one of the factors that limit its clarity. The dissolved oxygen content ranges from 6.5 to 8.16 mg/L. According to PP (2021), a good dissolved oxygen concentration for marine biota (macrozoobenthos) is greater than 5 mg/L. According to Bai'un et al. (2021), the higher the DO value of a water body, the higher the level of macrozoobenthos life in the water. The organic material content ranges from 3.98% to 10.57%. The highest organic material content was found at station I and the lowest at station IV. According to Bai'un et al. (2021), a high organic matter content in sediment generally indicates a habitat rich in benthic animals.

Fraction and average diameter of sediment

The results of the sediment type analysis at each station at the study site are shown in Table 2. Based on sediment fraction analysis at all stations, it can be concluded that the Rupat Strait Dumai waters are dominated by mud sediment. The highest average mud fraction is at station I, and the lowest is at station IV. Meanwhile, the average sediment diameter at each station is shown in Table 3.

Table 2. Sediment types of Dumai Waters, Rupat Strait

Station	Average of Sediment Fractions (%)			Fraction
	Gravel	Sand	Mud	
I	0,92	9,74	89,18	Mud
II	0,3	13,17	86,5	Mud
III	0,55	16,3	83,11	Mud
IV	0,65	18,53	80,81	Mud

Table 3. Average diameter of sediment of Dumai Waters

Station	Sampling Point	Mz (Ø)	Classification
I	1	7,2	fine silt
	2	7,2	fine silt
	3	7,23	fine silt
II	1	7,2	fine silt
	2	7,2	fine silt
	3	7,2	fine silt
III	1	6,2	medium silt
	2	7,03	fine silt
	3	5,7	coarse silt
IV	1	5,2	coarse silt
	2	6,03	medium silt
	3	5,36	coarse silt

At sampling point 3 of station I and sampling points 1 and 2 of station IV, coarse silt is found with an average diameter value of sediment particles of 5.2–5.7 Ø. Medium silt is found at sampling point 1 of station III and sampling point 2 of station IV, with an average value of sediment particle diameter of 6.03–6.2 Ø. At stations I and II, and station III at sample point 2, fine silt is found with an average sediment particle diameter of 7.2-7.23 Ø. In estuary waters, the average diameter (Mz) obtained is finer than the average diameter (Mz) in waters that are far from the coast or protrude slightly into the sea. The results of the calculation of the average diameter (Mz) of sediment in the waters of the Dumai River estuary obtained values ranging from 7.2 to 7.23 Ø with the classification of fine silt. Then, the highest content of sediment organic matter is found at station I, which is 10.57%, this station is located at the mouth of the Dumai River. This is due to the frequent rotation of the flow at this station, whereby stirring, the sediment organic matter will rise to the top, and the flow speed will also influence its distribution. The high levels of sediment and organic matter entering the waters result from increased land-based activities such as oil pond filling, cultivation, industry, and domestic activities. In this way, it can be concluded that the finer the sediment substrate at the bottom of the water, the higher the amount of sediment organic matter produced.

Macrozoobenthos species

Five species of macrozoobenthos have been found in the Dumai waters of Rupat Strait, which are shown in Table 4.

Table 4. Macrozoobenthos Species of Dumai Waters

Class	Ordo	Family	Genus	Species
Bivalves	Arcida	Arcidae	*Barbatia*	*Barbatia* sp.
	Venerida	Veneridae	*Marcia*	*Marcia hiantina*
Gastropods	Cycloneritida	Neritidae	*Nerita*	*Nerita articulata*
	Pulmonata	Hiatulaedae	*Hiatula*	*Hiatula* sp.
	Cerithiida	Cherithiidae	*Clypeomorus*	*Clypeomorus* sp.

Based on data obtained in the Dumai waters of the Rupat Strait, 2 classes of 8 macrozoobenthos were obtained: the Bivalves class, namely *Barbatia* sp., *Marcia hiantina*, and the Gastropods class, namely *Nerita articulata*, *Hiatula* sp., and *Clypeomorus* sp. Bivalves and gastropods are part of the phylum Mollusca that can be used as bioindicators in aquatic ecosystems. In addition to playing a role in the food chain, mollusks are quite adaptable to different habitats, can accumulate heavy metals without dying, and have thick, strong shells that make them less easily preyed upon by predators. Furthermore, this mollusk lives as a filter feeder in intertidal waters with muddy or sandy substrates at depths of 2-20 m.

Macrozoobenthos Abundance

The abundance of macrozoobenthos in the Rupat Strait Dumai waters varies between 4.27 - 27.06 ind/m^2. The highest average density of macrozoobenthos was in station II, which was 27.06 ind/m^2, while the lowest average density was 4.27 ind/m^2 in station IV.

The abundance of macrozoobenthos is influenced by sediment at the research station (Bai'un et al., 2021). The sludge sediment contains a high content of sediment organic matter. According to Winarto (2014), the finer the texture of the base substrate, the greater its ability to capture sediment organic matter. The highest density was found at stations I and II, probably because these two stations had the highest sediment organic matter content, namely 10.57% and 8.15%, compared to station IV, which had the lowest sediment organic matter content of 3.98%. The high concentration of sedimentary organic matter in stations I and II is believed to be due to the muddy

substrate and the large amounts of litter and mangrove debris found at these two stations. Macrozoobenthos can live in stations I and II thanks to sufficient nutrition from mangrove forests (litter) and nutrients transported by currents from upstream or downstream to the river mouth.

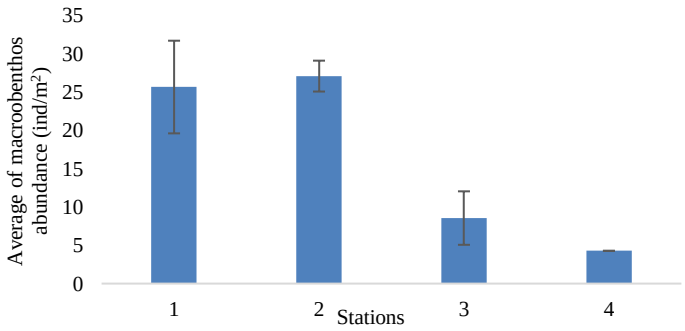

Figure 1. Average of macrozoobenthos abundance of Dumai Waters

The results of a simple linear regression analysis of sediment particle size (Mz) with the abundance of macrozoobenthos in the Dumai Waters, Rupat Strait yielded the regression equation Y = 12.267X-64.12, the coefficient of determination (R^2) was = 0.779, and the correlation coefficient (r) was 0.883. The obtained r value is adjusted to the proximity relationship according to Tanjung (2014), namely r = 0.71–0.90, indicating that particle size and macrozoobenthos abundance have a strong relationship.

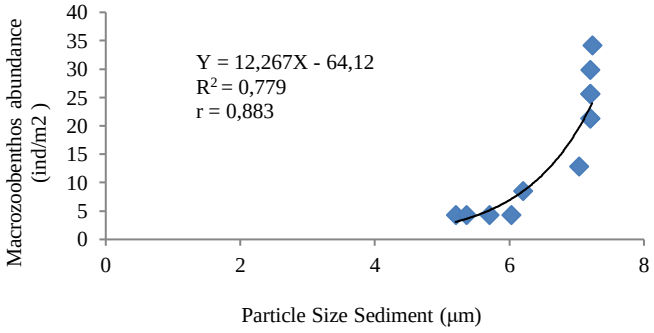

Figure 2. Relationship between sediment particle size and macrozoobenthos abundance of Dumai Waters

Based on these two variable relationships, it is known that the influence of sediment particle size on macrozoobenthos abundance in Rupat Strait Dumai waters is 77.9%. In contrast, the remaining 22.1% can be influenced by other environmental factors according to Simbolon et al. (2019), namely the physics and chemistry of the aquatic environment, including light penetration that affects water temperature, dissolved oxygen, food reserves, and the level of adaptation of macrozoobenthos, as well as anthropogenic activities in the surrounding waters.

Particle size is related to sediment organic matter: the finer the sediment particle size, the greater the sediment grains' ability to bind sediment organic matter. Sediment organic matter itself plays a role in determining the distribution of macrozoobenthos, and sediment organic matter is also a food source for macrozoobenthos animals. According to Gultom et al. (2018), sediment organic matter that settles at the bottom of water is food for benthic organisms, so the rate at which it is added to sediment has a major impact on bottom populations. In this way, it can be said that the silt substrate with a high sediment organic matter content has a significant influence on macrozoobenthos abundance. The smaller the particle size, the higher the sediment organic matter content, which allows macrozoobenthos animals to survive on the substrate.

CONCLUSION

The species of macrozoobenthos found in the Dumai waters of the Rupat Strait are from the Bivalves class and the Gastropods class. There are two species in the Bivalves class, namely *Barbatia* sp. and *Marcia hiantina*, while the Gastropods class has three species, namely *Nerita articulata*, *Hiatula* sp., and *Clypeomorus* sp. The highest macrozoobenthos abundance was found in the river mouth area (station I) and the lowest abundance in the

shipping area (station IV). The influence of sediment particle size on macrozoobenthos abundance was strong (r=0.883).

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