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Macrozoobenthic Diversity in the Coastal Peatland Ecosystem of Koneng Beach, Dumai, Indonesia

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ABSTRACT

Koneng Beach in Dumai City, Riau Province, is a coastal area located on a peatland ecosystem and is influenced by industrial and shipping activities, making it vulnerable to environmental pressures that affect benthic organisms. This study aims to analyze the diversity of macrozoobenthos in the coastal peatland ecosystem of Koneng Beach and was conducted on May 12, 2024. A purposive sampling method was employed, with three observation stations and line transects. Sampling was carried out during low tide using 1 × 1 m² quadrats. Macrozoobenthic community analysis included abundance calculation, the Shannon-Wiener diversity index (H'), and the dominance index (C). The identification results revealed only one species of macrozoobenthos, *Mysotella myosotis* (class Gastropoda). The diversity index (H') was 0, indicating very low diversity, while the dominance index (C) was 1, indicating high dominance by a single species. These conditions suggest that the aquatic ecosystem of Koneng Beach is experiencing ecological stress, likely related to anthropogenic activities and environmental pollution. Further research is needed to examine the relationship between pollution levels and the structure of the macrozoobenthos community in this area.

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1. Introduction

Indonesia is one of the countries with the largest peatland areas in Southeast Asia, accounting for 80% of the region's total 23 million hectares [1]. Peatland ecosystems are among the most ecologically rich terrestrial ecosystems and hold strategic importance in the context of global climate change. Peatlands are estimated to store enormous amounts of carbon [2]. In addition to their carbon storage function, peatlands provide diverse habitats for wildlife and support livelihoods for local communities [3].

Coastal peatland ecosystems have unique characteristics because they are located in the transition zone between land and sea, and are thus influenced by tidal dynamics, seawater inflow, and salinity [4]. Coastal peatlands are found along the seashore and in delta regions, where they have developed on marine sediments, such as clay and mud, at or slightly above sea level [4]. These conditions make coastal peatland ecosystems important habitats for various aquatic organisms, including benthic communities such as macrozoobenthos that live on the substrate and are strongly influenced by sediment characteristics and water quality [5]. Koneng Beach, Dumai City, Riau Province, in Sumatra, is one of the regions with peatlands that feature diverse habitats and organisms. Peatlands serve as habitats for benthic communities, including macrozoobenthos.

The coastal area of Dumai City, in the waters of the Rupat Strait in Riau Province, has developed rapidly as a hub for industry, trade, agriculture, and shipping [6]. Ecological pressures on the waters of the Rupat Strait are evident in the decline in coastal water quality, resulting from increased wastewater discharge [7].

Macrozoobenthos are aquatic organisms that live on the surface or within the sediment of water bodies. Macrozoobenthos are relatively sedentary on a specific substrate, making them more sensitive to environmental disturbances and changes in water and sediment quality. Macrozoobenthos is quite sensitive to changes in water quality, which affect its abundance, diversity, and distribution [8]. Macrozoobenthos has a relatively fixed habitat, is large enough to be easily identified, has limited mobility, and lives both within and on the bottom of water bodies [9]. These organisms play a role in the decomposition and mineralization of organic matter in water bodies and use it as an energy source. As detritivores, macrozoobenthos can serve as biological indicators for assessing the balance of aquatic ecosystems [10].

Koneng Beach, located in Dumai City, Riau Province, is a coastal area that ecologically lies atop a peatland and is surrounded by mangrove vegetation. Although this area possesses high biodiversity potential, as is typical of coastal peatland ecosystems, to date, research on the macrozoobenthos diversity in the peatlands along Koneng Beach has been scarce. Therefore, the objective of this study is to gather information on the biodiversity potential of this region, with a specific focus on macrozoobenthos.

2. Research Significance

Research on macrozoobenthos diversity at Koneng Beach, Dumai City, Riau Province, is important because the area is a coastal peat ecosystem located in a region with relatively high levels of industrial and shipping activity. Anthropogenic activities such as industry, maritime

transport, and the disposal of domestic and industrial waste have the potential to degrade water quality by increasing pollutant levels and accumulating organic matter in the coastal environment. These conditions can exert ecological pressure on benthic organisms, particularly macrozoobenthos that live sedentarily on aquatic substrates and are sensitive to environmental changes.

Macrozoobenthos plays a crucial role in aquatic ecosystems, both as decomposers of organic matter and as biological indicators of environmental quality. Changes in the structure of macrozoobenthos communities, such as declines in diversity and increases in the dominance of certain species, may reflect ecological disturbances in a water body. Therefore, this study is expected to provide information on the ecological conditions of Koneng Beach, based on the structure of the macrozoobenthos community there. Additionally, the results of this study can serve as baseline data for the sustainable management and monitoring of environmental quality in the Dumai coastal area.

3. Methods

Location and Time

This study was conducted on May 12, 2024, in the waters off Koneng Beach, Dumai City, Riau Province. Observation stations were selected using purposive sampling, which involves choosing locations deemed representative of the study area's general conditions. The observation stations were divided into three stations arranged from the shore toward the open water. At each station, three transects were established, drawn perpendicular from the shoreline toward the sea, with a distance of 10 meters between transects. Sampling was conducted along each transect to collect macrozoobenthos data at the study site. Subsequently, sample analysis and identification were conducted at the Marine Biology Laboratory, Faculty of Fisheries and Marine Sciences, University of Riau. The map of the study location is shown in Figure 1.

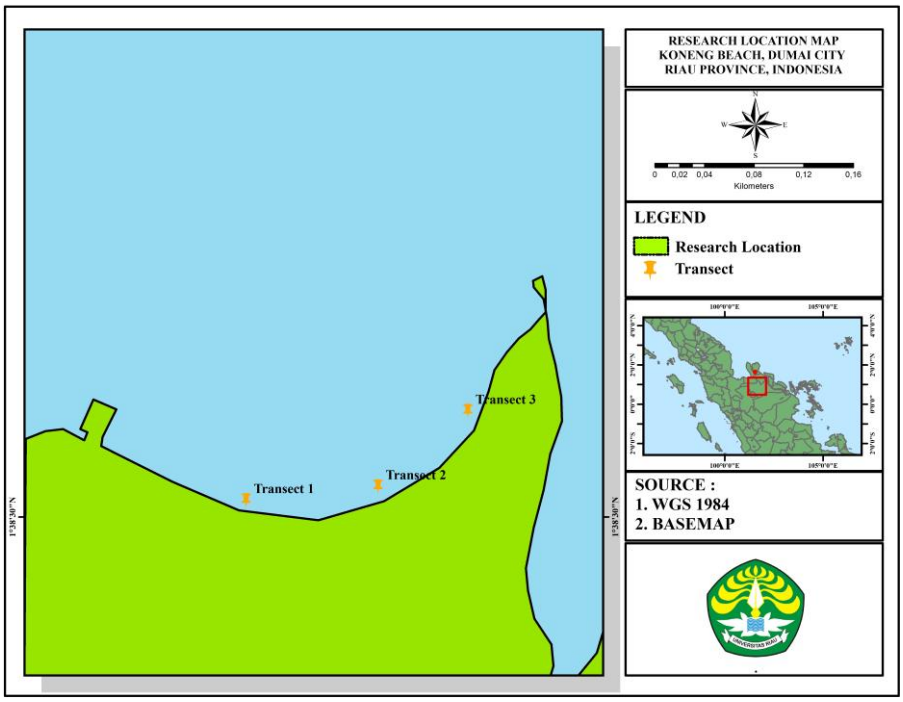

Fig 1. Research Location Map

Equipment and Materials

The equipment and materials used in this study included quadrant plots, transects of approximately 50 m, a hand refractometer, pH indicator paper, and a thermometer. Meanwhile, the materials used in this study included sample containers for storing macrozoobenthos samples and 10% formalin, which was used as a preservative to maintain sample condition during the research process and laboratory observations.

Water Quality Monitoring

Water quality measurements were conducted in the field, including temperature, salinity, and pH, to assess aquatic environmental conditions at the study site. Temperature was measured using a thermometer, salinity using a handheld refractometer, and pH using pH indicator paper, allowing water quality data to be obtained directly and accurately.

Sampling

Macrozoobenthos sampling was conducted during low tide using the line transect method, with transect lines approximately 50 m long extending from the shoreline out to sea. The purpose of this approach was to systematically collect data on the distribution and abundance of macrozoobenthic organisms in this marine environment. The samples were collected at each 1 x 1 m^2 plot. The macrozoobenthos collected were larger than 1 mm.

Identification and Analysis of Macrozoobenthos

The macrozoobenthos samples collected were cleaned and identified in the laboratory using a macrozoobenthos identification guide. Community structure analysis was conducted by calculating abundance, the Shannon-Wiener diversity index, the evenness index, and the dominance index.

Analysis of the Structure of the Macrozoobenthos Community

Abundance of Macrozoobenthos

The macrozoobenthos abundance equation according to Brower & Zar (1990) in [11]:

$$K = \frac{ni}{A}$$

Notes:

K :The abundance of the i-th individual (ind/m^2)
ni : The number of individuals of type i obtained
A : The area of the i-th plot is found (m^2)

Diversity of Macrozoobenthos Species

Diversity is calculated using the Shannon-Weaver (H') index from 1949, as described in [9]:

$$\boldsymbol{H' = -\sum_{i=0}^{S} pi \log_2 pi}$$

Notes :

H' : Shannon-Wiener Diversity Indexc
Pi : ni /N (proportion of species i)
Ni : Number of individuals of species i
N : Total number of individuals
S : Number of species

Table 1. Macrozoobenthos Diversity Index Categories

H'	Category
$H' < 1$	Low
$1 \leq H' \geq 3$	Medium
$H' > 3$	High

Uniformity of Macrozoobenthic Species

Species uniformity is used to assess the evenness of a macrozoobenthos population or community using the equation [11]:

$$E = \frac{H'}{InS}$$

Notes :

E : Uniformity index
H' : Diversity index
S : Number of species

Table 2. Categories of the Macrozoobenthos Species Uniformity Index

E	Category
0 ≤ E < 0,4	Low
0,4 ≤ E < 0,6	Medium
0,6 ≤ E ≤ 1,0	High

Dominance of Macrozoobenthos Species

The dominance index (C) describes the patterns of concentration and distribution of species dominance within a stand. The dominance index (C) is used to determine the extent to which one group of organisms dominates another :

$$C = \sum_{i=0}^{s} \frac{ni}{N} \; 2$$

Notes :
C : Simpson's Dominance Index
ni : Number of individuals of each species
N : Total number of individuals of all species
s : The sum of 1, 2, 3, and so on

Table 3. Dominance Index Categories for Macrozoobenthos Species

C	Category
0 ≤ C < 0,5	Low
0,5 ≤ C < 0,75	Medium
0,75 ≤ C ≤ 1	High

4. Results and Discussion

Physical and Chemical Parameters

Physical and chemical parameters, such as temperature, salinity, and pH, are critical to the health of aquatic ecosystems, particularly for macrozoobenthic organisms [9]. Measurements of these physical and chemical parameters were conducted directly in the waters off Koneng Beach, yielding the data presented in Table 4.

Table 4. Water Quality Parameter Values at Koneng Beach

Parameter	Value
Temperatur (ºC)	30 ºC
Salinity (ppt)	33 ppt
pH	7

Temperature is one of the physical parameters that plays a crucial role in the metabolism of aquatic organisms. In this study, the temperature measured was sea surface temperature. Sea

surface temperature is greatly influenced by weather conditions, solar radiation, cloud cover, and wind speed. The measured sea surface temperature at Koneng Beach was 30°C. This temperature is still considered normal for macrozoobenthos. Sea surface temperatures in Indonesia generally range from 27-32 °C [9].

The pH level in the waters off Koneng Beach is 7. This value indicates that the pH in the waters off Koneng Beach is within the normal range. Water quality is classified as acceptable when the pH level ranges between 7 and 8.5. In the life cycle of benthic organisms, pH levels play a crucial role; this is because a decrease in pH levels in a body of water can disrupt metabolism, ultimately leading to the death of benthic organisms.

The salinity value measured in the waters off Koneng Beach was 33 ppt. Koneng Beach is located directly in the waters facing the Rupat Strait. The salinity value obtained indicates favorable conditions for macrozoobenthos; according to Nontji (2007) in [9], the salinity range for these waters is 24-35 ppt.

Classification of Macrozoobenthos

Based on the identification results, the macrozoobenthos found in the waters off Koneng Beach belong to the phylum Mollusca, class Gastropoda. Observations indicate that only one species, Mysotella myosotis, was present. This aligns with a related study conducted by [12], which states that the class Gastropoda dominates the waters of Dumai. This species was found in every transect and observation plot presented in Table 5.

Table 5. Distribution of Macrozoobenthos Species in the Waters off Koneng Beach

Spesies	Transect 1			Transect 2			Transect 3		
	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Mysotella myosotis	-	✓	-	✓	-	-	✓	-	✓

Fig 2. *Mysotella myosotis*

Macrozoobenthos Abundance

Macrozoobenthos abundance reflects the overall abundance within a community, yielding a density value that represents the number of individuals per unit area [9]. Based on the results of data collection and analysis, macrozoobenthos abundance in transect 1 of plot 2 was 3 ind/m², in transect 2 of plot 1 it was 3 ind/m², and in transects 3 of plots 1 and 3, macrozoobenthos abundance was 1 ind/m².

The abundance of macrozoobenthos is greatly influenced by water quality parameters such as temperature. A temperature of 30°C falls within the optimal range for the metabolic activity and growth of benthic organisms in tropical regions. However, excessively high temperatures can also reduce dissolved oxygen levels, meaning that only organisms capable of adapting can survive. In this dataset, a temperature of 30°C remains sufficiently stable to support several macrozoobenthic species. Sea surface temperatures themselves are considered normal for aquatic life, ranging between 27-32°C [9], so the macrozoobenthos in the waters off Koneng Beach can thrive.

A salinity level of 33 ppt indicates normal seawater conditions that are quite favorable for marine benthic organisms [9]. Many macrozoobenthos species have a high tolerance for this salinity level, so abundance in some plots remains relatively high. However, differences in abundance between transects may indicate the presence of other factors, such as substrate type, organic matter, or water currents, that also influence the distribution of organisms.

A pH of 7 indicates neutral conditions, which remain suitable for macrozoobenthos. A stable pH supports physiological processes in organisms, such as respiration and shell formation in some benthic species [9]. Benthic organisms prefer a pH of around 7-8.5 in their habitat; if the pH is < 7, a decline in the benthic population has occurred. If the pH is too low or too high, organisms will experience stress, which can lead to a decrease in population size [13]. Therefore, the pH conditions at the study site can be considered sufficiently favorable to support the survival of macrozoobenthos.

Several related studies, such as the one cited in [10], have found a correlation between sediment grain size and macrozoobenthos abundance: the finer the sediment grain size, the greater the abundance of macrozoobenthos. Conversely, the coarser the sediment grain size, the lower the abundance of macrozoobenthos.

Macrozoobenthos Diversity Index (H')

A diversity index refers to a measure or value used to determine the level of species diversity within an ecosystem [8]. This index reflects the number of species as well as the balance of the number of individuals of each species found at a given location. The diversity index value obtained for the Koneng coastal waters was 0. This value falls into the low category. The macrozoobenthos diversity index values for all sampling points are shown in Table 6.

Table 6. Macrozoobenthos Diversity Index in the Waters off Koneng Beach

Transect	Plot	Diversity (H')	Category
1	1	0	Low
	2	0	Low
	3	0	Low

2	1	0	Low
	2	0	Low
	3	0	Low
3	1	0	Low
	2	0	Low
	3	0	Low

The macrozoobenthos diversity index at Koneng Beach, which falls into the low category, indicates that few macrozoobenthos species were found and that the benthic community at that location tends to be dominated by only certain species. As shown in Table 6, the diversity index for Koneng Beach received a score of 0, placing it in the low category. This condition indicates that the structure of the macrozoobenthos community is not yet stable, as a healthy ecosystem generally has higher species diversity and a more even distribution of individuals.

In addition, low biodiversity can also indicate the presence of ecological pressures in aquatic environments, such as pollution, sedimentation, or disturbances from coastal activities. If an aquatic environment is subjected to environmental pressures, less tolerant organisms will decline or disappear, while more tolerant organisms will survive. This results in a smaller number of species and a decrease in the diversity index.

Macrozoobenthos Dominance Index (C)

The dominance index (C) describes the patterns of concentration and distribution of species dominance within a stand [12]. The dominance index (C) is used to determine the extent to which one group of biota dominates another. The dominance index value for macrozoobenthos in the waters off Koneng Beach, obtained from all transects and plots, was 1, which falls into the high category. The dominance index values are shown in Table 7.

Table 7. Macrozoobenthos Dominance Index in the Waters off Koneng Beach

Transect	Plot	Dominance(C)	Category
1	1	-	Low
	2	1	High
	3	-	Low
2	1	1	High
	2	-	Low
	3	-	Low
3	1	1	High
	2	-	Low
	3	1	High

The macrozoobenthos dominance index at Koneng Beach, which falls into the high category in transect 1, plot 2; transect 2, plot 1; and transect 3, plots 1 and 3, indicates that the macrozoobenthos community at these locations is dominated by a single species, namely the gastropod Mysotella myosotis. The high dominance of this species indicates that the number of Mysotella myosotis individuals is greater than that of other macrozoobenthos species.

The high dominance of Mysotella myosotis indicates that this species is better adapted to the environmental conditions at Koneng Beach in Dumai. Environmental parameters obtained during the study, such as a temperature of 30°C, salinity of 33 ppt, and a pH of 7, remain within ranges that support gastropod life. These conditions allow Mysotella myosotis to survive, reproduce, and utilize food sources more effectively than other species.

According to a study by [14], the rapid growth of the oil industry in the Dumai region has increased pressure on water resources from waste, causing numerous problems, particularly for the health of living organisms and humans. This aligns with the high dominance value, indicating that the coastal waters of Koneng, Dumai, can be classified as polluted. In addition to oil industry activities, anthropogenic activities that discharge domestic waste have caused high levels of dissolved organic matter; as shown in the study [12], this indicates high concentrations of organic matter around Dumai's waters. High levels of dissolved organic matter are highly beneficial for macrozoobenthos [15]. Furthermore, several studies on pollution have also identified organisms such as epipelagic diatoms, whose presence indicates changes in water conditions or the occurrence of pollution in those waters [16].

5. Conclusions

Based on the results of a study conducted in the waters off Koneng Beach, Dumai City, it was found that the level of macrozoobenthos diversity was very low, with a diversity index value of 0. Identification results showed that only one species of macrozoobenthos, Mysotella myosotis of the class Gastropoda, dominated all observation sites. The low diversity value and the high dominance of a specific species indicate that the aquatic ecosystem is under significant environmental stress.

These conditions are believed to be influenced by anthropogenic activities in the coastal area, such as industrial activities, shipping, and waste disposal, which have the potential to degrade water quality. The imbalanced structure of the macrozoobenthos community indicates that the waters off Koneng Beach are polluted, thereby affecting the survival of the benthic organisms living there. Therefore, environmental management efforts and further research are needed to investigate the relationship between pollution levels and the condition of the macrozoobenthos community in the Koneng Coastal Waters in greater depth.

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