

# Macrozoobenthic community structure in the mangrove ecosystem of Teluk Bogam Village, Central Kalimantan

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**Abstract.** The mangrove ecosystem in Teluk Bogam Village plays an essential role in maintaining the balance of the coastal environment. Variations in the utilization of mangrove areas have the potential to cause differences in water quality conditions. To date, no study has specifically examined the macrozoobenthic community structure in Teluk Bogam Village. This study aims to analyze the macrozoobenthic community structure within the mangrove ecosystem of Teluk Bogam Village, Central Kalimantan. Sampling of macrozoobenthos and water quality observations were conducted in March, June, and September 2024, as well as in January 2025, at three observation stations. Data analyses included assessments of macrozoobenthic community structure and Principal Component Analysis (PCA). Macrozoobenthos in the study area consisted of the classes Gastropoda, Bivalvia, and Polychaeta, with the genus *Cerithium* being the most dominant. The community structure was categorized as stable, characterized by moderate diversity ( $H' = 2.04\text{--}2.06$ ), high evenness ( $E = 0.92\text{--}0.97$ ), and low dominance ( $D = 0.13\text{--}0.14$ ). The PCA results indicated that macrozoobenthic density exhibited a strong association with water quality parameters, particularly turbidity and total suspended solids (TSS).

## 1 Introduction

The coastal area of Teluk Bogam is located in Teluk Bogam Village, Kumai District, West Kotawaringin Regency, Central Kalimantan Province, and directly borders the Java Sea. Among the key ecosystems along the Teluk Bogam coastline is the mangrove ecosystem. Mangroves are one of the most important coastal ecosystems, providing essential ecological functions for both humans and aquatic biota. Mangrove forests protect shorelines from erosion, buffer strong winds and ocean waves, trap sediments, and retain fine particles carried

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by water flow. Furthermore, mangrove ecosystems serve as critical spawning, nursery, and feeding grounds for aquatic organisms such as fish and macrozoobenthos [1].

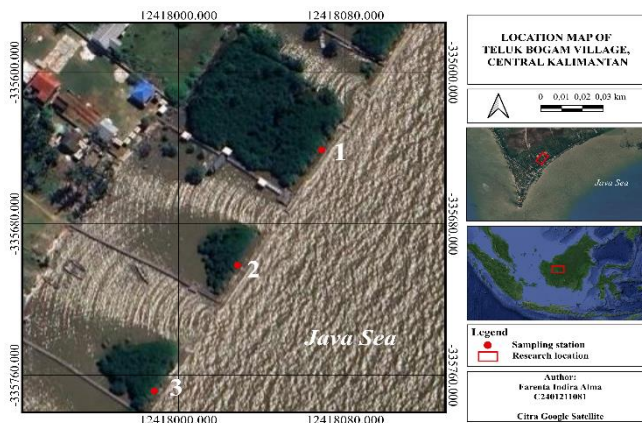
Macrozoobenthic organisms are generally sedentary and possess limited mobility. These organisms exhibit varying levels of sensitivity to environmental changes depending on their species. Therefore, the presence of specific macrozoobenthic taxa can be used as bioindicators to assess the ecological condition of aquatic environments. According to [2], the mangrove ecosystem in Teluk Bogam Village is located adjacent to residential areas, fishing activities, and tourism sites, which may lead to spatial variation in environmental conditions. Such variation can influence the structure of macrozoobenthic communities. Understanding the macrozoobenthic community structure in this mangrove ecosystem is thus essential for evaluating ecological balance and the quality of benthic habitats.

Previous studies on macrozoobenthic communities have been conducted in various coastal areas of Indonesia, including the Margagiri–Grenyang waters of Banten Bay [3] and the mangrove ecosystem of Pejarakan Village, Bali [4]. However, to date, no study has specifically examined the macrozoobenthic community structure within the mangrove ecosystem of Teluk Bogam Village. Therefore, this study aims to analyze the macrozoobenthic community structure in the mangrove ecosystem of Teluk Bogam Village, Central Kalimantan, as a basis for assessing aquatic environmental conditions and as reference data to support the sustainable management of mangrove ecosystems.

## 2 Research method

### 2.1 Time and location

The study was conducted in March, June, and September 2024, and January 2025 within the mangrove ecosystem of Teluk Bogam Village, Kumai District, West Kotawaringin Regency, Central Kalimantan (Figure 1). Three observation stations were established to represent the variation in environmental conditions and the local utilization of the mangrove area by the surrounding community. Station 1 was located near the coastal lodging area, Station 2 was situated around the fishing boat landing site and silvofishery area, and Station 3 was positioned adjacent to residential settlements and coastal tourism sites. Water quality parameters were analyzed both in the field and at the Environmental Laboratory, while macrozoobenthic analyses were carried out at the Macrobiology Laboratory I, Faculty of Fisheries and Marine Science, IPB University.



**Fig. 1.** Research location in Teluk Bogam Village, Central Kalimantan.

## 2.2 Data collection

Water quality sampling and measurements were conducted with four replications at each station, following the method outlined by APHA 2017 (Table 1). Sediment samples were collected simultaneously with macrozoobenthos sampling using 1 × 1 m quadrat transects and a Van Veen Grab sampler. Sediment grain size classification followed [5], which categorizes sediment fractions from gravel to clay based on particle diameter (mesh size). Macrozoobenthos samples were sorted and identified using the book *Recent and Fossil Indonesian Shells* by Dharma 2005 and the World Register of Marine Species (WoRMS: [www.marinespecies.org](http://www.marinespecies.org)), in the Macrobiology Laboratory I, Faculty of Fisheries and Marine Sciences, IPB University. Water quality parameters were analyzed both *in situ* (in the field) and *ex situ* (in the laboratory) at the Environmental Laboratory. The physical, chemical, and biological parameters of the water, along with the analytical methods and instruments used, are presented in Table 1.

**Table 1.** Parameters analyzed and observed.

Parameters	Unit	Instrument	Method
<b>Physical</b>			
Substrate	%	<i>Sieve Shaker</i>	Dry sieving
Temperature	°C	Multiparameter	<i>Electrometric method</i>
Depth	m	<i>Secchi disk</i>	Direct measurement
Turbidity	NTU	Multiparameter	<i>Nephelometric method</i>
Total Suspended Solid (TSS)	mg/L	Gravimetric scale	<i>Gravimetric method</i>
Total Dissolved Solid (TDS)	mg/L	Multiparameter	<i>Electrometric method</i>
<b>Chemical</b>			
pH	-	Multiparameter	<i>Electrometric method</i>
Dissolved Oxygen (DO)	mg/L	Multiparameter	<i>Electrometric method</i>
Salinity	ppt	Refractometer	Direct measurement
<b>Biological</b>			
Macrozoobenthos	-	<i>Van Veen Grab</i>	Ecological indices, PCA

## 2.3 Data analysis

### 2.3.1 Macrozoobenthos density

The formula used to calculate the density of macrozoobenthos at a given location is as follows [6]:

$$K_i = \frac{10000 \times N_i}{A} \tag{1}$$

Where,  $K_i$  = Density of macrozoobenthos species  $i$  (ind/m<sup>2</sup>),  $N_i$  = Number of individuals of macrozoobenthos species  $i$  (ind),  $A$  = Total sampling area for macrozoobenthos (m<sup>2</sup>), The value 10,000 is a conversion factor from cm<sup>2</sup> to m<sup>2</sup>.

### 2.3.2 Ecological index

The Shannon-Wiener diversity index was calculated using the following formula [7]:

$$H' = -\sum_{i=1}^n p_i \ln p_i \tag{2}$$

Where,  $H'$  = Shannon-Wiener diversity index,  $pi$  = Proportion of individuals of species  $i$  relative to the total number of individuals ( $ni/N$ ),  $ni$  = Number of individuals of species  $i$ .  $N$  = Total number of individuals across all species.

The evenness index ranges from 0 to 1 and is calculated based on the diversity index. The formula for the evenness index is as follows [8]:

$$E = \frac{H'}{H'_{max}} \quad (3)$$

Where,  $E$  = Evenness index,  $H'$  = Shannon-Wiener diversity index,  $s$  = Total number of macrozoobenthos species.  $H'_{max} = \ln S$

The dominance index ranges from 0 to 1 and is calculated using the Simpson's Dominance Index formula [8]:

$$D = \sum_{i=1}^n \left( \frac{n_i}{N} \right)^2 \quad (4)$$

Where,  $D$  = Dominance index,  $ni$  = Number of individuals of macrozoobenthos species  $i$ ,  $N$  = Total number of individuals of all macrozoobenthos species

### 2.3.3 Physicochemical water parameters

The values of water quality parameters were compared with water quality standards as stipulated in [9], specifically regarding water quality standards for marine biota, as well as [10], and supporting literature.

### 2.3.4 Sediment fraction classification

The total weight of filtered sediment was identified based on the Wentworth scale (1922) [5]. The dry sieving method was used to separate sediment into seven fractions: gravel (4 mm), granule gravel (2 mm), very coarse sand (1 mm), coarse sand (0.5 mm), medium sand (0.25 mm), fine sand (0.063 mm), and silt (<0.063 mm).

### 2.3.5 Relationship between macrozoobenthos density and physico-chemical water parameters

The relationship between macrozoobenthos density and water quality parameters was analyzed using Principal Component Analysis (PCA) with the assistance of XLSTAT2021 software. The relationship between the macrozoobenthos community and the physical and chemical parameters was further analyzed using Pearson correlation analysis. The correlation coefficient values range from 0.00 to 1.00, indicating a relationship that varies from very weak to very strong. The Pearson correlation coefficient can be calculated using the following formula [11].

$$r_{xy} = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2} \sqrt{n\sum y^2 - (\sum y)^2}} \quad (5)$$

Where,  $r$  = Pearson correlation coefficient between variables  $x$  and  $y$ ;  $x, y$  = Correlated variables;  $n$  = Number of data points used.

### 3 Results and discussion

#### 3.1 Results

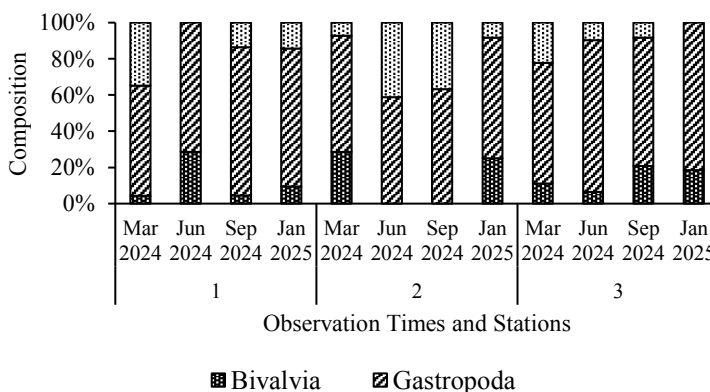
##### 3.1.1 Macrozoobenthos composition and density

The macrozoobenthos composition found in the mangrove ecosystem of Teluk Bogam Village consisted of three classes and 33 genera, including 7 genera from the class Bivalvia, 20 genera from Gastropoda, and 6 genera from Polychaeta (Table 2).

**Table 2.** Macrozoobenthos genera found in the Mangrove Ecosystem of Teluk Bogam Village.

Class	Genera				
Bivalvia	<i>Anadara</i>	<i>Donax</i>	<i>Lithophaga</i>	<i>Vasticardium</i>	
	<i>Antigona</i>	<i>Fimbria</i>	<i>Tellina</i>		
Gastropoda	<i>Aliculastrum</i>	<i>Conus</i>	<i>Nassaria</i>	<i>Pila</i>	<i>Terebra</i>
	<i>Cerithidea</i>	<i>Coralliophila</i>	<i>Nassarius</i>	<i>Pirenella</i>	<i>Terebralia</i>
	<i>Cerithium</i>	<i>Hemifusus</i>	<i>Nerita</i>	<i>Planaxis</i>	<i>Trochus</i>
	<i>Clypeomorus</i>	<i>Littoraria</i>	<i>Oliva</i>	<i>Strombus</i>	<i>Turitella</i>
Polychaeta	<i>Glycera</i>	<i>Nereis</i>	<i>Paraonis</i>		
	<i>Lumbrineris</i>	<i>Notomastus</i>	<i>Scoloplos</i>		

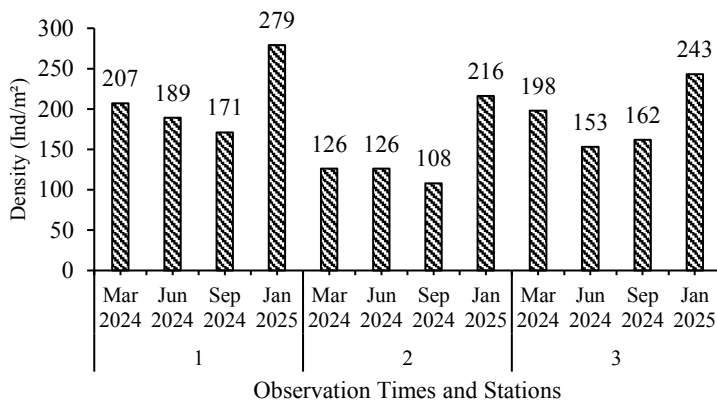
The composition of macrozoobenthic classes identified in the Teluk Bogam mangrove ecosystem, from the highest to the lowest percentage, was as follows: Gastropoda (71.90%), Polychaeta (16.12%), and Bivalvia (11.98%) (Figure 2). The dominance of Gastropoda indicates that the water conditions remain favorable for organisms with high tolerance to environmental fluctuations and elevated organic matter availability. Seasonal differences during sampling periods did not show a significant effect on the composition and distribution of macrozoobenthos within the Teluk Bogam mangrove ecosystem.



**Fig. 2.** Composition of macrozoobenthos found in the Mangrove Ecosystem of Teluk Bogam Village.

The density of macrozoobenthos across the three stations and four observation periods exhibited considerable variation. The highest density was recorded at Station 1 in January 2025, reaching 279 individuals/m<sup>2</sup>. The most abundant genus identified was *Cerithium*. The dominant composition and density of macrozoobenthos reflect the adaptive capacity of benthic organisms to environmental conditions, as well as the interactions between

environmental factors and anthropogenic activities within the ecosystem [12]. The variation in macrozoobenthos density is illustrated in Figure 3.



**Fig. 3.** Macrozoobenthos density in the Mangrove Ecosystem of Teluk Bogam Village.

### 3.1.2 Ecological index

An ecological index analysis, comprising diversity ( $H'$ ), evenness ( $E$ ), and dominance ( $D$ ), was conducted to describe the structure of the macrozoobenthic community and to assess the stability level of the mangrove ecosystem in Teluk Bogam Village. The results of these index calculations are presented in Table 3.

**Table 3.** Diversity index ( $H'$ ), evenness index ( $E$ ), and dominance index ( $D$ ) of macrozoobenthos in the mangrove ecosystem of Teluk Bogam Village.

Stations	Observation Periods	$H'$	$E$	$D$
1	March 2024	2,09	0,95	0,13
	June 2024	2,10	0,95	0,13
	September 2024	2,09	0,95	0,14
	January 2025	2,02	0,92	0,15
2	March 2024	2,01	0,97	0,14
	June 2024	2,11	0,96	0,13
	September 2024	2,02	0,97	0,14
	January 2025	2,13	0,92	0,14
3	March 2024	2,03	0,97	0,14
	June 2024	1,99	0,96	0,15
	September 2024	2,03	0,98	0,14
	January 2025	2,02	0,92	0,15

Based on Table 3, the diversity index ( $H'$ ) of macrozoobenthos in the mangrove ecosystem of Teluk Bogam Village ranged from 1.99 to 2.13 across the three stations during the four observation periods. The diversity of macrozoobenthos showed moderate variation, although it was lower than that reported by [4] in the mangrove ecosystem of Pejarakan Village, Bali. A moderate diversity index indicates that the ecosystem is in a relatively balanced ecological condition with a moderate level of environmental stress. The evenness index ( $E$ ) of macrozoobenthos in the Teluk Bogam mangrove waters ranged from 0.92 to 0.97, which is categorized as high since the calculated values approached 1. This suggests

that no single species dominated the community, and the distribution of individuals among species was relatively even [7].

The dominance index (D) of macrozoobenthos in the mangrove ecosystem of Teluk Bogam ranged from 0.13 to 0.15, indicating a low level of dominance, as the calculated values were close to 0. The dominance index reflects the tolerance or adaptive capacity of macrozoobenthos to dynamic environmental conditions within the aquatic ecosystem. Overall, the ecological index analysis revealed moderate diversity, high evenness, and low dominance. These findings are consistent with those reported by [13] in the mangrove ecosystem of Serangan Island, Bali, which exhibited similar ecological index values. Such conditions indicate that the macrozoobenthic community structure within the Teluk Bogam mangrove ecosystem is ecologically stable.

### 3.1.3 Physicochemical water parameters

The measurements of physicochemical parameters in the mangrove ecosystem waters of Teluk Bogam Village revealed that the Total Suspended Solids (TSS) and turbidity values at all three stations exceeded the established water quality standards. This condition indicates an increase in suspended particulate matter, which may be attributed to tidal activities and sediment resuspension within the mangrove area. Other parameters such as temperature, pH, dissolved oxygen (DO), and salinity remained within the acceptable range of marine water quality standards for aquatic organisms (Table 4). These findings suggest that the aquatic environment is still capable of supporting marine life, despite relatively high levels of turbidity and suspended solids. Turbidity can be influenced by various environmental factors, including rainfall, seasonal variation, and tidal dynamics. Strong wave action and rapid water currents can enhance sediment resuspension from the seabed, leading to an increase in suspended particle concentration within the water column.

**Table 4.** Mean and standard deviation of physical and chemical water parameters in the Mangrove Ecosystem of Teluk Bogam Village.

Parameters	units	Stations			Water Quality Standard
		1	2	3	
<b>Physical</b>					
Temperature	°C	28,58 ± 2,32	28,45 ± 1,79	28,93 ± 1,66	28-32*
Depth	m	0,51 ± 0,08	0,56 ± 0,06	0,55 ± 0,08	Natural
Turbidity	NTU	158,75 ± 85,06	85,23 ± 49,36	90 ± 59,78	<5**
TSS	mg/L	339 ± 287,26	222 ± 120,17	284 ± 120,83	80*
TDS	mg/L	15,90 ± 3,60	16,10 ± 4,10	15,32 ± 3,82	80***
<b>Chemical</b>					
pH	-	7,82 ± 0,21	7,84 ± 0,32	7,81 ± 0,19	7 - 8,5*
DO	mg/l	5,68 ± 0,33	5,43 ± 0,22	5,43 ± 0,29	>5*
Salinity	ppt	21,60 ± 1,23	21,25 ± 0,90	21,38 ± 0,95	up to 34*

Source: \*[9]; \*\*[10]; \*\*\*[14].

### 3.1.4 Substrate characteristics

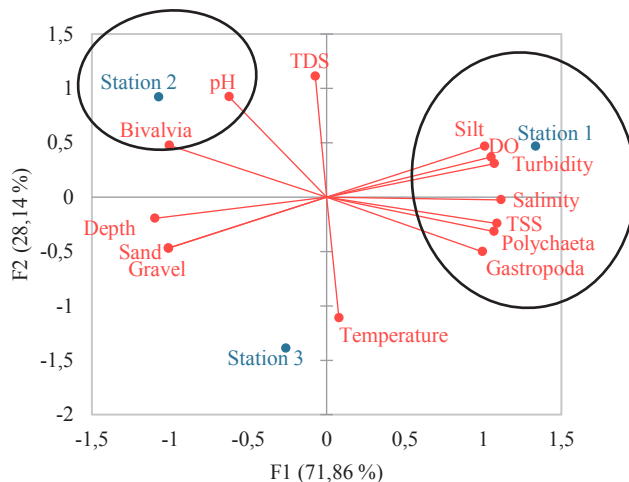
Differences in the percentage composition of sediment fractions were observed among the three sampling stations. Based on the analysis results, all stations were classified as having silty sand substrate types (Table 5). The Gastropoda group was the most abundant class across all stations. Silty sand substrates provide suitable habitats for the growth and survival of gastropods, thereby supporting higher levels of diversity and abundance within this group.

**Table 5.** Substrate composition of the Mangrove Ecosystem Waters in Teluk Bogam Village

Stations	Fraction Composition (%)							Substrate Types
	Gravel	Granule gravel	Very coarse sand	Coarse sand	Medium sand	Fine sand	Silt	
1	0,17	0,19	2,93	15,56	22,02	42,95	16,19	Silty sand
2	0,17	0,87	6,71	19,01	22,37	36,70	14,17	Silty sand
3	0,25	0,87	9,83	22,08	21,11	31,93	13,93	Silty sand

### 3.1.5 Relationship between macrozoobenthos and physico-chemical water parameters

The relationship between macrozoobenthos and the physico-chemical parameters of the water was analyzed using Principal Component Analysis (PCA). The results of the PCA are presented in the biplot shown in Figure 4.



**Fig. 4.** Biplot of the Relationship Between Macrozoobenthos and Physico-Chemical Water Parameters.

Based on the results of the Principal Component Analysis (PCA), the parameters TSS, salinity, turbidity, dissolved oxygen (DO), and mud substrate were found to be associated with the Gastropoda and Polychaeta groups. The relationships among these parameters exhibited strong to very strong positive correlations according to Pearson’s correlation analysis. This condition indicates that macrozoobenthos tend to be more abundant in waters with higher TSS and turbidity values, which may be attributed to greater availability of organic matter and nutrients, particularly in muddy substrates that are commonly found in mangrove ecosystems. These findings are consistent with those of [15], who reported that total suspended solids have a strong influence on macrozoobenthos density. High TSS and turbidity values can act as limiting factors for species that are sensitive to suspended sediments; however, they still support the presence of taxa with high environmental tolerance, such as Gastropoda and Polychaeta. The positive correlation between salinity and these two groups further indicates their strong adaptive capability to varying salinity levels. In addition, the positive correlation between DO and the abundance of Gastropoda and Polychaeta suggests that these organisms thrive under conditions with sufficient oxygen availability. Dissolved oxygen is an essential factor for the metabolic processes and survival of macrozoobenthos.

Meanwhile, *Bivalvia* exhibited a strong positive correlation with pH, indicating that this group tends to develop optimally within stable pH ranges. The pH parameter itself is an important indicator of water quality, as it influences the physiological processes of aquatic organisms and the availability of essential nutrients. The presence and abundance of macrozoobenthos may also be influenced by mangrove vegetation density. High mangrove density plays a significant role in enhancing litter production, which subsequently enriches sediments with organic matter. The accumulation and decomposition of litter contribute to the formation of nutrients and detritus, serving as a primary food source for macrozoobenthos. Consequently, mangrove ecosystems with dense vegetation tend to support higher abundances of benthic organisms [11].

The dominant mangrove species found in the Teluk Bogam mangrove ecosystem is *Rhizophora mucronata*, which typically grows in estuarine areas influenced by tidal fluctuations. Sandy to silty substrates support the adaptability of *R. mucronata* to its environment, facilitating optimal propagule dispersal and growth.

## 4 Conclusion

Based on a four-month study conducted in the mangrove ecosystem of Teluk Bogam Village, macrozoobenthos belonging to the classes Gastropoda, *Bivalvia*, and Polychaeta were identified across the three observation stations. The most dominant genus recorded was *Cerithium*. The highest macrozoobenthos density was observed in January 2025, reaching 279 individuals/m<sup>2</sup>. The community structure of macrozoobenthos was categorized as stable, characterized by moderate diversity, high evenness, and low dominance. The results of the Principal Component Analysis (PCA) indicated that turbidity and total suspended solids (TSS) were the primary environmental factors influencing the distribution of macrozoobenthos, particularly Gastropoda, within the Teluk Bogam mangrove ecosystem. These findings provide valuable insights and serve as a scientific basis for the sustainable management and conservation of mangrove ecosystems.

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