

BIOASSESSMENT OF COASTAL WATER QUALITY IN PENYENGAT ISLAND BASED ON MACROZOOBENTHIC COMMUNITY STRUCTURE

Pendugaan Kualitas Perairan Pesisir Pulau Penyengat Berdasarkan Komunitas Makrozoobenthos

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ABSTRACT

The coastal ecosystem of Penyengat Island in Tanjungpinang City is an area with high ecological and economic value, however, various anthropogenic activities such as settlements, sea transportation, tourism, and reclamation around the Tanjungpinang coast are suspected to put pressure on water quality. This study aims to determine the abundance and ecological index of macrozoobenthos, water quality conditions based on the Azti's Marine Biotic Index (AMBI), and the relationship between macrozoobenthos abundance and water physicochemical parameters in Penyengat Island waters. The study was conducted in February 2026 using a survey method with a systematic random sampling technique. Sampling used an Ekman grab measuring 30 × 30 cm. Data were analyzed using diversity, evenness, dominance, AMBI index, and Spearman correlation tests. The results showed that 24 genera of macrozoobenthos were found consisting of the classes Gastropoda (12 genera), Bivalvia (8 genera), Malacostraca (1 genus), Polychaeta (2 genera), and Oligochaeta (1 genus) with an abundance of 42.22 ind/m². The diversity index (H') value is classified as moderate (2.67), uniformity (E) is high (0.84), and dominance (C) is low (0.10). In general, the water quality still meets the quality standards. Based on the AMBI value, the quality of the coastal waters of Penyengat Island is classified as slightly polluted, which indicates environmental pressure due to the input of organic materials. The results of the Spearman correlation test indicate that the physicochemical parameters have a very weak and insignificant relationship.

Key words: Bioindicators, Macrozoobenthos, Penyengat Island, Water Quality.

ABSTRAK

Ekosistem perairan pesisir Pulau Penyengat di Kota Tanjungpinang merupakan kawasan yang memiliki nilai ekologis dan ekonomis tinggi, namun berbagai aktivitas antropogenik seperti

permukiman, transportasi laut, pariwisata, serta reklamasi di sekitar pesisir Tanjungpinang diduga memberikan tekanan terhadap kualitas perairan. Penelitian ini bertujuan untuk mengetahui kelimpahan dan indeks ekologi makrozoobentos, kondisi kualitas perairan berdasarkan *Azti's Marine Biotic Index* (AMBI), serta hubungan antara kelimpahan makrozoobentos dengan parameter fisika-kimia perairan Pesisir Pulau Penyengat. Penelitian dilaksanakan pada Februari 2026 menggunakan metode survei dengan teknik sistematis random sampling. Pengambilan sampel menggunakan Ekman grab berukuran 30×30 cm. Data dianalisis menggunakan indeks keanekaragaman, keseragaman, dominansi, indeks AMBI, dan uji korelasi Spearman. Hasil penelitian menunjukkan ditemukan 24 genera makrozoobentos yang terdiri atas kelas Gastropoda (12 genera), Bivalvia (8 genera), Malacostraca (1 genus), Polychaeta (2 genera), dan Oligochaeta (1 genus) dengan kelimpahan sebesar 42,22 ind/m². Nilai indeks keanekaragaman (H') tergolong sedang (2,67), keseragaman (E) tinggi (0,84), dan dominansi (C) rendah (0,10). secara umum kualitas perairan masih memenuhi baku mutu. Berdasarkan nilai AMBI, kualitas perairan pesisir Pulau Penyengat tergolong sedikit tercemar, yang menunjukkan adanya tekanan lingkungan akibat masukan bahan organik. Hasil uji korelasi Spearman menunjukkan bahwa parameter fisika-kimia memiliki hubungan sangat lemah dan tidak signifikan.

Kata Kunci: Bioindikator, Kualitas Perairan, Makrozoobentos, Pulau Penyengat

INTRODUCTION

Penyengat Island is a coastal area located in Penyengat Urban Village, Tanjungpinang Kota District, Riau Islands Province. Geographically, Riau Islands Province is situated between coordinates 0°40' S – 07°19' N and 103°30' E – 110°00' E (Ramelan *et al.*, 2017). This area possesses significant coastal resource potential, including seagrass beds, mangrove ecosystems, coral reefs, fish, and various mollusk species that provide both ecological and economic benefits. As human activities such as settlements, port operations, marine transportation, and tourism increase, so does the pressure on the aquatic environment. Furthermore, the island's proximity to the coast of Tanjungpinang City exposes it to the influence of the Gurindam 12 reclamation project, which has been underway since 2018; this project has the potential to alter water morphology, sedimentation patterns, and substrate characteristics factors that constitute the primary habitat for macrozoobenthos. Such conditions are suspected of affecting water quality and the balance of the coastal ecosystem.

According to Rosdatina *et al.* (2019), the physicochemical water quality around Penyengat Island remains good; however, macrozoobenthos diversity is relatively low, indicating ecological stress resulting from coastal activities. Macrozoobenthos are benthic organisms that reside on the seabed and possess low mobility, allowing them to respond to environmental changes over relatively long periods. Consequently, the presence and community structure of macrozoobenthos are frequently utilized as bioindicators to assess water quality.

Environmental condition assessments can be conducted not only through ecological indices but also by using Azti's Marine Biotic Index (AMBI), which categorizes macrozoobenthos based on their tolerance levels to environmental disturbances, thereby illustrating the degree of water pollution. Based on this, this study was conducted with the aim of analyzing the abundance and ecological indices of macrozoobenthos, determining the coastal water quality of Penyengat Island using AMBI, and analyzing the relationship between macrozoobenthos abundance and physicochemical water parameters.

RESEARCH METHODS

Time and Place

This study was conducted in February 2026 in the coastal waters of Penyengat Island, Tanjungpinang City, Riau Islands Province. Sample and data analyses were performed at the Marine Biology Laboratory of the Faculty of Marine Science and Fisheries, Raja Ali Haji Maritime University. A map of the study site is presented in Figure 1.

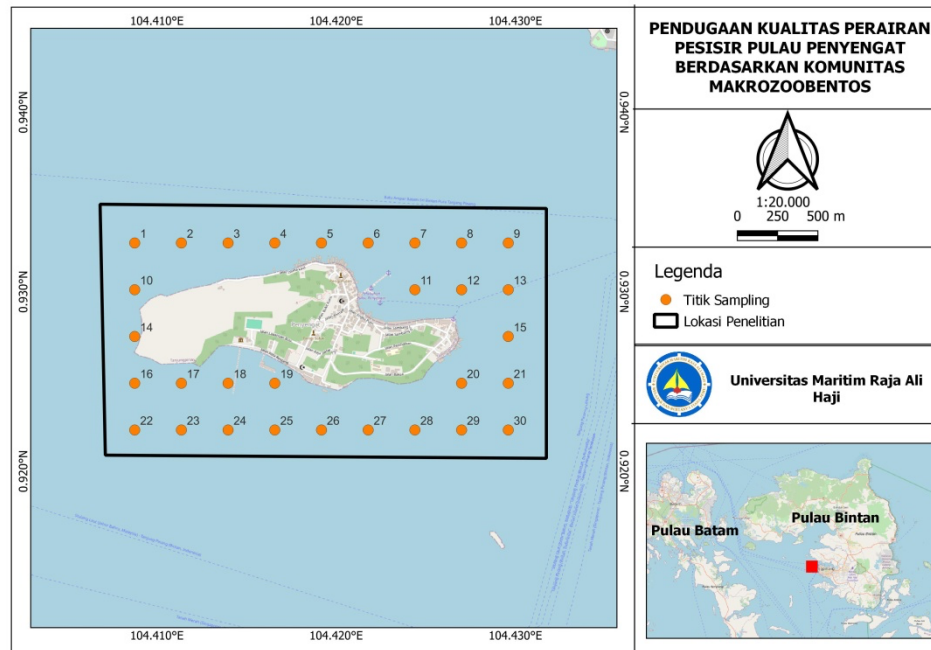


Figure 1. Map of Penyengat Island

Tools and Materials

The equipment used in this study included a GPS (for determining coordinates), a 30x30 cm Ekman grab (for sample collection), a 100 μ m sieve (for sample filtering), a camera (for documentation), writing instruments (for recording observations), a tray (for sample sorting), tweezers (for handling/separating samples), a DO meter (for measuring dissolved oxygen), a water quality tester (for measuring salinity, pH, and temperature), a Petri dish (for observing sorted samples), a spoon (for sorting samples), a digital scale (for weighing substrate samples), a sieve net (for sifting substrate), a furnace (for high-temperature substrate drying), a stereo microscope (for sample observation and identification), and a cool box (for sample storage).

The materials used during the study included 70% alcohol (for sample preservation), label paper (for marking sample containers), ziplock bags (as sample containers), Rose Bengal (for staining benthic samples), tissues (for drying equipment), distilled water (for cleaning equipment and samples), the identification book *The Book of Shells* (Harasewych & Moretzsohn, 2010) (for identifying benthic samples), and aluminum foil (as a container for weighing substrate).

Methods and Procedures

The study location was determined using a survey method, while the sampling technique employed Systematic Random Sampling (Marcelino *et al.*, 2023). This involved establishing 30 sampling points using QGIS 3.36.0 software; the initial point was randomized within the sampling area, and subsequent points were determined systematically at 300-meter

intervals. A GPS (Global Positioning System) device was used to navigate to each coordinate point. The research data comprised both primary and secondary data. Primary data were obtained through the collection of macrozoobenthos, substrate, and water samples, alongside *in situ* measurements of physicochemical parameters. All samples were subsequently analyzed at the Marine Biology and Chemistry Laboratory of FIKP UMRAH. Secondary data were sourced from scientific journals, websites, and research findings related to macrozoobenthos.

Macrozoobenthos sampling was conducted at the 30 points using a 30×30 cm Ekman grab. The grab was lowered until it touched the substrate; a slight jerk was then applied to ensure the grab clamped onto the sediment and closed tightly before being hoisted to the surface. Live macrozoobenthos were separated from the substrate, placed in ziplock bags, and filtered using a 100 µm mesh sieve. Samples were cleaned carefully to avoid damaging delicate macrozoobenthos such as worms and larvae; the cleaned samples were then placed in ziplock bags and preserved with a 70% alcohol solution. Remaining organic debris was placed in separate ziplock bags and treated with 70% alcohol and Rose Bengal stain to color the macrozoobenthos, thereby facilitating sorting from the debris in the laboratory (APHA, 2017). Each sample container was labeled for identification and transported to the Marine Biology Laboratory at FIKP Raja Ali Haji Maritime University for further sorting, observation, and identification.

A 100 g substrate sample was collected at each observation point using the Ekman grab and stored in a ziplock bag. The samples were subsequently dried and sieved using a stacked sieve set for substrate type analysis, then processed using the GRADISTAT (Grain Size Distribution and Statistics Package) software. Total organic matter (TOM) content analysis was performed using the Loss on Ignition (LOI) method by combusting the samples at 550°C for 2 hours.

Data Analysis

Macrozoobenthos Abundance

The abundance of the identified macrozoobenthos was then calculated based on the species found, using the formula by Krebs (2014):

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

Information:

K = Macrozoobenthos abundance (individuals/cm²)

ni = Number of individuals per species

A = kman grab opening area (30×30 cm = 900 cm² = 0,09 m²)

Ecological Index

Diversity Index (H')

The macrozoobenthos diversity index was calculated using the Shannon-Wiener formula as follows (Krebs, 2014):

$$H' = - \sum p_i \ln p_i$$

Information:

H': Diversity index

ni : Number of individuals of each species

pi : ni/N

N : Total number of individuals

Evenness Index (E)

The evenness of a species within a community can be determined using the Shannon-Wiener evenness index, calculated with the following formula (Krebs, 2014):

$$E = \frac{H'}{H_{max}} = \frac{H'}{\ln S}$$

Information:

E : Evenness index

H' : Shannon-Wiener diversity index

Hmax : lnS (S is the number of macrozoobenthos species)

Dominance Index (C)

The dominance of a species within a community can be calculated using the Simpson's Dominance Index formula (Krebs, 2014):

$$C = \sum_{i=1}^S \left(\frac{n_i}{N} \right)^2$$

Information:

C = Simpson's dominance index

ni = Number of individuals of each species

N = Total number of individuals

AMBI Index (A Marine Biotic Index)

The formula used to calculate the AMBI index uses (Borja *et al.*, 2000) the following formula:

$$AMBI = \{(0 \times \%GI) + (1,5 \times \%GII) + (3 \times \%GIII) + (4,5 \times \%GIV) + (6 \times \%GV)\} / 100$$

Information:

(G I) "Sensitive species" group

(G II) "Indifferent species" group

(G III) "Tolerant species" group

(G IV) "Second-order opportunistic species" group

(G V) "First-order opportunistic species" group

Pollution classification categories based on the AMBI index are presented in Table 1.

Table 1. AMBI Categories (Borja *et al.*, 2020)

Pollution Classification	Biotic coefficient	Biotic Index	Dominance of the ecological group	Benthic Community
Unpolluted	$0,0 < BC \leq 0,2$	0	I	Good
Unpolluted	$0,2 < BC \leq 1,2$	1		Poor
Slightly polluted	$1,2 < BC \leq 3,3$	2	III	Unbalanced
Moderately polluted	$3,3 < BC \leq 4,3$	3		Transition to polluted
Moderately polluted	$4,3 < BC \leq 5,0$	4	IV – V	Polluted
Heavily polluted	$5,0 < BC \leq 5,5$	5		Transition to heavily polluted
Heavily polluted	$5,5 < BC \leq 6,0$	6	V	Heavily polluted
Severely polluted	Azoic	7	Azoic	Azoic

TOM (*Total Organic Matter*)

The organic matter content in the sediment is calculated based on the following formula (Indriani *et al.*, 2017).

$$\% TOM = \frac{b - a}{b} \times 100\%$$

Information:

% TOM = Organic matter content

a = Ash weight (g)

b = Sample weight (g)

Depth

Water depth was measured using a graduated line equipped with a weight. The measuring device was lowered to the bottom, and the length of the submerged line was recorded as the depth data for each point. The collected depth data was subsequently processed using QGIS version 3.34.0 to generate a bathymetric map. An interpolation method was employed during processing to create a depth contour map, facilitating the observation of morphological variations in the seabed at the study site.

Correlation Analysis

An analysis of the relationship between macrozoobenthos abundance and physicochemical water parameters was conducted using the Spearman correlation test to determine the strength and direction of the relationship between the variables. Data processing was performed using Jamovi software (version 2.7.12) to obtain the correlation coefficient (r) and significance value (p-value). A correlation coefficient approaching -1 indicates a strong negative relationship, a value approaching 0 indicates a weak relationship or no relationship, and a value approaching +1 indicates a strong positive relationship. The guidelines for interpreting the correlation coefficient are based on Sugiyono (2018), as follows.

1. A coefficient interval of 0.00–0.19 indicates a very weak level of correlation.
2. A coefficient interval of 0.20–0.39 indicates a weak level of correlation.
3. A coefficient interval of 0.40–0.59 indicates a moderate level of correlation.
4. A coefficient interval of 0.60–0.79 indicates a strong level of correlation.
5. A coefficient interval of 0.80–1.000 indicates a very strong level of correlation.

RESULTS

Physicochemical Parameters of Water Bodies

The results of environmental parameter measurements in the coastal waters of Penyengat Island are presented in Table 2.

Table 2. Average values of environmental parameters in the coastal waters of Penyengat Island.

No.	Parameters	Unit	Average	Quality standards*
1.	Physical			
	Temperature	°C	27.9 ± 3.67	28-30
	Turbidity	NTU	1.80 ± 1.73	<5
	Salinity	ppt	29 ± 0.61	33-34
	Depth	m	4.37 ± 1.84	-
	Substrate	-	Slightly gravelly muddy sand	-

No.	Parameters	Unit	Average	Quality standards*
2.	Chemical			
	pH	-	8.50 ± 0.43	7-8.5
	DO	mg/L	7.52 ± 0.73	>5
	TOM	%	14.61 ± 4.14	-

*Quality standards based on Government Regulation No. 22 of 2021, Appendix VIII, for marine biota.

*± (Standard Deviation).

Macrozoobenthos Taxa Found and Their Tolerance Characteristics (AMBI Index)

Based on the results of observations, 24 genera and their indicator characteristics were presented in Table 3.

Table 3. Tolerance Characteristics of Macrozoobenthos

No	Class	Genus	Category
1	Gastropoda	<i>Nassarius</i> sp.	Indifferent (AMBI Index GII)
		<i>Cerithium</i> sp.	Tolerant (AMBI Index GIII)
		<i>Muricodraropa</i> sp.	Tolerant (AMBI Index GIII)
		<i>Laevistrombus</i> sp.	Tolerant (AMBI Index GIII)
		<i>Rhinoclavis</i> sp.	Tolerant (AMBI Index GIII)
		<i>Voluta</i> sp.	Indifferent (AMBI Index GII)
		<i>Luria</i> sp.	Tolerant (AMBI Index GIII)
		<i>Latirus</i> sp.	Tolerant (AMBI Index GIII)
		<i>Tonna</i> sp.	Indifferent (AMBI Index GII)
		<i>Pleuroploca</i> sp.	Tolerant (AMBI Index GIII)
		<i>Cerithidae</i> sp.	Sensitive (AMBI Index GI)
		<i>Littorina</i> sp.	Indifferent (AMBI Index GII)
2	Bivalvia	<i>Pitar</i> sp.	Tolerant (AMBI Index GIII)
		<i>Tellina</i> sp.	Sensitive (AMBI Index GI)
		<i>Astarte</i> sp.	Sensitive (AMBI Index GI)
		<i>Paratapes</i> sp.	Indifferent (AMBI Index GII)
		<i>Gafrarium</i> sp.	Indifferent (AMBI Index GII)
		<i>Corbula</i> sp.	Sensitive (AMBI Index GI)
		<i>Meretrix</i> sp.	Tolerant (AMBI Index GIII)
		<i>Anomarocardia</i> sp.	Tolerant (AMBI Index GIII)
3	Malacostraca	<i>Macrophtalmus</i> sp.	Tolerant (AMBI Index GIII)
4	Polychaeta	<i>Lysidice</i> sp.	Indifferent (AMBI Index GII)
		<i>Sternaspis</i> sp.	Tolerant (AMBI Index GIII)
5	Oligochaeta	<i>Clitellio</i> sp.	Second-order opportunistic (AMBI Index GIV)

Macrozoobenthos Abundance

The abundance of macrozoobenthos in the coastal waters of Penyengat Island is presented in Figure 2.

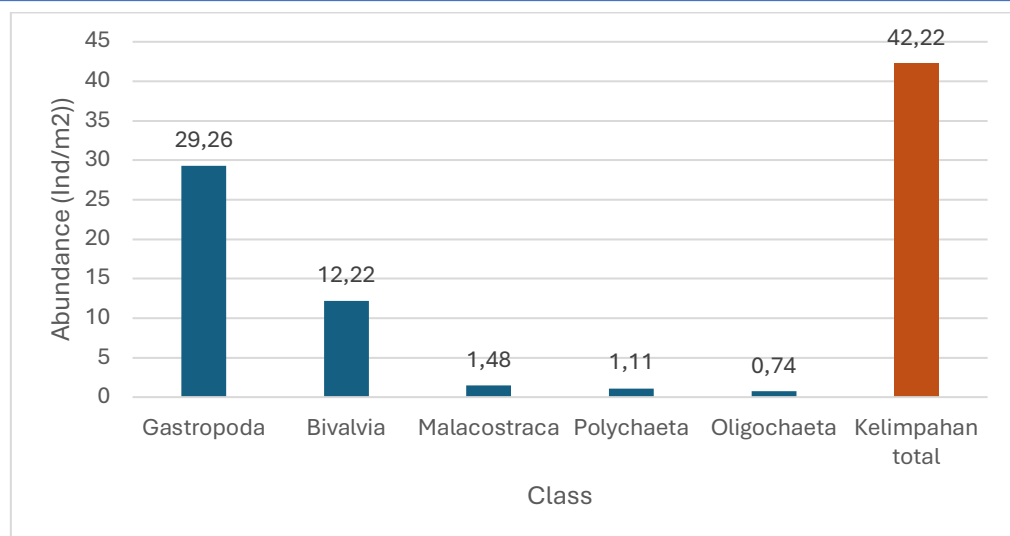


Figure 2. Graph of macrozoobenthos abundance by class

Macrozoobenthos Ecological Index

The results of the ecological index calculations for macrozoobenthos in the coastal waters of Penyengat Island are presented in Table 4.

Table 4. Macrozoobenthos Ecological Indices in the Coastal Waters of Penyengat Island

Index	Average	Category
Diversity (H')	2,67	Medium
Evenness (E)	0,84	High
Dominance (C)	0,10	Low

AMBI Index

Based on the AMBI Index classification (Borja *et al.*, 2020), the genera listed in Table 3 are categorized as follows: 4 sensitive genera (GI), 7 indifferent genera (GII), 12 tolerant genera (GIII), and 1 first-order opportunistic genus (GIV). The category most frequently encountered in the coastal waters of Penyengat Island is the tolerant category.

The AMBI Index is a biological index used to assess the environmental quality status of the coastal waters of Penyengat Island specifically the level of disturbance caused by organic matter enrichment or pollution based on the classification of biota according to their tolerance levels. This process yielded water quality values using macrozoobenthos as bioindicators, as presented in Table 5.

Table 5. AMBI index values

No	Group	Amount	Proportion	Weight	Product	AMBI
1	Sensitive (GI)	4	16,67	0	0	2.13 (Slightly Polluted)
2	Indifferent (GII)	7	29,17	1,5	43,75	
3	Tolerant (GIII)	12	50	3	150	
4	Opportunistic sequence ISI (GIV)	1	4,17	4,5	18,75	
5	Order opportunistic (GV)	0	0	6	0	
Total		24			212,5	

Relationship Between Macrozoobenthos Abundance and Physicochemical Water Parameters

The relationship between macrozoobenthos abundance and water parameters was analyzed using the Spearman correlation test. The results of the Spearman correlation analysis for the coastal waters of Penyengat Island are presented in Table 6.

Table 6. Spearman Correlation Analysis

Parameters	Macrozoobenthos Abundance		
	Correlation coefficient (ρ)	Sig. (p-value)	Strength of Relationship
pH	-0,264	0,159	Weak (not significant)
Temperature	0,044	0,818	Very weak (not significant)
Salinity	-0,245	0,192	Weak (not significant)
DO	0,255	0,174	Weak (not significant)
Turbidity	0,194	0,305	Very weak (not significant)
Depth	-0,281	0,132	Weak (not significant)
TOM	-0,13	0,494	Very weak (not significant)
Gravel	-0,214	0,257	Weak (not significant)
Sand	-0,085	0,653	Very weak (not significant)
Mud	0,062	0,746	Very weak (not significant)

Note. * $<0,05$; ** $p < 0,01$; *** $P < 0,001$

DISCUSSION

Physicochemical Parameters of Water Bodies

Based on the measurement of physicochemical parameters, the coastal waters of Penyengat Island generally meet the quality standards for marine biota as stipulated in Government Regulation of the Republic of Indonesia Number 22 of 2021, Attachment VIII. The measured parameters including temperature, pH, salinity, DO, turbidity, depth, substrate, and Total Organic Matter (TOM) play a crucial role in determining water quality and influencing macrozoobenthos life.

The average measured temperature was 27.9°C. This value falls within a range relatively close to the standard for marine biota (28–30°C) set by Government Regulation Number 22 of 2021, Attachment VIII. Although the average temperature was slightly below the standard range, the difference was minor and the conditions remain suitable for supporting benthic organisms, particularly macrozoobenthos. Temperature is a physical parameter that plays a vital role in regulating various processes in aquatic organisms such as metabolism, growth, and reproduction within the aquatic environment (Deldicq *et al.*, 2021). According to Sofiyani *et al.* (2021), the optimal temperature range for the survival of macrozoobenthos is between 25°C and 30°C.

Turbidity measurements yielded an average value of 1.80 NTU, indicating that the coastal waters of Penyengat Island possess good clarity and remain within the quality standards for marine biota specifically the limit of <5 NTU—as stipulated by Government Regulation of the Republic of Indonesia Number 22 of 2021. This condition allows for optimal sunlight penetration, thereby supporting various ecological processes. High levels of total suspended solids (TSS) are known to affect macrozoobenthos (Mustofa, 2018); therefore, the low turbidity value indicates that the coastal waters of Penyengat Island are in good condition and capable of providing a suitable habitat for macrozoobenthos.

Dissolved oxygen (DO) measurements in the coastal waters of Penyengat Island showed an average value of 7.52 mg/L. This value meets the seawater quality standard for marine biota (>5 mg/L) as set forth in Government Regulation of the Republic of Indonesia Number 22 of 2021, Appendix VIII. The high dissolved oxygen concentration indicates that the water quality remains good and is capable of supporting the biological activities of aquatic organisms, including macrozoobenthos. According to Bai'un *et al.* (2020), a decrease in dissolved oxygen concentration can negatively impact macrozoobenthos particularly species with low tolerance for oxygen-depleted conditions potentially leading to reduced abundance or even mortality. Telaumbanua (2025) states that dissolved oxygen is a critical factor for the survival of aquatic organisms, as it plays a direct role in respiration and energy production. Thus, this study demonstrates that the oxygen requirements of macrozoobenthos are adequately met, thereby supporting the survival, growth, and development of the macrozoobenthic community.

The average pH measurement obtained was 8.50, which falls within the water quality standard range of 7.0–8.5 specified in Government Regulation of the Republic of Indonesia Number 22 of 2021, Appendix VIII. This condition indicates that the acidity level of the waters remains within the normal range and is capable of supporting aquatic life. According to Sofiyani *et al.* (2021), pH levels influence the survival and growth of macrozoobenthos; thus, suitable pH conditions support the presence of these organisms in a body of water.

The average salinity measured was 29 ppt, a value that does not meet the quality standards set out in Government Regulation (PP RI) No. 22 of 2021, Attachment VIII. This low salinity is likely attributable to the influx of freshwater mixing with the seawater mass, resulting in the dilution of salt concentrations. Salinity plays a crucial role in influencing the dynamics of aquatic biotic communities. The spatial distribution and abundance of macrozoobenthos are also influenced by the salinity of the waters (Hariawansyah *et al.*, 2019).

The average Total Organic Matter (TOM) value recorded in the coastal waters of Penyengat Island was 14.61%. Based on the classification by Hartoko *et al.* (2013), sediment organic matter content is categorized as follows: <3.5% (very low), 3.5–7% (low), 7–17% (moderate), 17–35% (high), and >35% (very high). Consequently, the organic matter content at the study site falls into the moderate category, indicating that the sediment retains sufficient organic matter to support macrozoobenthos life. The availability of organic matter is essential for the development and growth of benthic organisms such as macrozoobenthos (Putri *et al.*, 2021). The moderate level of organic matter is likely influenced by the substrate characteristic specifically, slightly gravelly muddy sand which allows for the retention of organic matter derived from organism remains, plant litter, and organic particles settling from the water column (Putri *et al.*, 2016).

The substrate type in the coastal waters of Penyengat Island is dominated by slightly gravelly muddy sand; substrate characteristics are crucial factors determining distribution and abundance, as they serve as habitats, refuges, and food sources for macrozoobenthos. The fine sediments within the substrate provide a more stable habitat and shelter from predators, while also aiding macrozoobenthos in withstanding environmental conditions. Finer sediment fractions are associated with greater accumulation of organic matter; high levels of organic matter provide ample food for macrozoobenthos, thereby increasing their abundance on the seabed (Putri *et al.*, 2024). Measurements indicate an average water depth of 4.37 m along the coast of Penyengat Island. This depth classifies the study site as shallow water, allowing sunlight to penetrate to the seabed. According to Mahestro *et al.* (2023), shallow waters generally range from 0 to 20 m in depth. Macrozoobenthos communities in shallow waters tend to exhibit greater species diversity; this is supported by Minggawati (2013), who noted that shallow waters typically possess higher diversity compared to deeper waters. In shallow waters, sunlight penetrates the entire water column to the bottom; these areas usually offer greater

habitat variation than deeper zones, fostering diverse macrozoobenthos communities and interspecies interactions. These findings align with research by Simanjuntak *et al.* (2018), which states that water depth influences the number of species and individuals, as well as the distribution patterns of macrozoobenthos.

Identification of Macrozoobenthos Types and Abundance

Based on the identification of macrozoobenthos along the coast of Penyengat Island, five classes and 24 genera were recorded. These classes were Gastropoda (12 genera), Bivalvia (8 genera), Malacostraca (1 genus), Polychaeta (2 genera), and Oligochaeta (1 genus). The results indicated an average macrozoobenthos abundance of 42.22 ind/m² in the coastal waters of Penyengat Island. Gastropoda and Bivalvia were the dominant classes, with abundances of 29.26 ind/m² and 12.22 ind/m², respectively. The dominance of these two classes is likely linked to their adaptability to environmental conditions and the suitability of the substrate as both a habitat and a food source. According to Putra *et al.* (2020), gastropods possess high resilience aided by hard shells that protect their bodies allowing them to survive better than certain other macrozoobenthos groups.

The dominance of *Nassarius* sp. in this study is thought to be influenced by the suitability of the muddy-sand substrate and the organism's adaptability to the coastal habitat. As a member of the Nassariidae family, *Nassarius* sp. typically inhabits areas ranging from the intertidal to the sublittoral zones; it is an active forager that uses a siphon to detect food sources within the sediment and is capable of burying itself in sandy or muddy substrates, thereby facilitating easier access to food and protection from environmental stressors (Armiani *et al.*, 2025). Furthermore, the water quality characterized by a dissolved oxygen (DO) level of 7.52 mg/L, a pH of 8.50, and low turbidity (1.80 NTU) likely supported the feeding activity, growth, and survival of *Nassarius* sp. in this habitat.tersebut.

Macrozoobenthos Ecological Index

The diversity index (H') of macrozoobenthos in the coastal waters of Penyengat Island was 2.67, falling into the moderate category. This value indicates that the macrozoobenthos community possesses a sufficiently diverse genus composition, reflecting environmental conditions capable of supporting the life of various macrozoobenthos types. According to Magfirah *et al.* (2014), favorable water conditions are generally characterized by high diversity and evenness indices alongside a low dominance index.

The evenness index (E) of 0.84 falls into the high category, indicating that the distribution of individuals across genera is relatively uniform and no single genus dominates the community. According to Odum (1993), a high evenness value reflects a relatively uniform distribution of individuals among the various genera. This condition indicates that environmental resources and habitats in the coastal waters of Penyengat Island are capable of supporting a balanced existence for various macrozoobenthos genera.

The dominance index (C) value of 0.10 falls into the low category, indicating that no single genus dominates the macrozoobenthos community. According to Rosdatina *et al.* (2019), evenness and dominance indices are inversely related; a high evenness index corresponds to low dominance. This condition demonstrates that the macrozoobenthos community in the coastal waters of Penyengat Island is composed of various genera with relatively balanced individual counts.

Macrozoobenthos Types Based on Tolerance (AMBI Index)

Based on the AMBI index analysis results presented in Table 5, the coastal water quality of Penyengat Island falls into the "slightly polluted" category, with an AMBI value of 2.13. This value indicates environmental stress caused by organic matter input, leading to an

emerging imbalance in the benthic community structure. However, the level of organic pollution remains low, meaning the water conditions generally remain capable of supporting the life and development of macrozoobenthic communities. Gupta & Singh (2011) state that gastropods are a macrozoobenthic group with a high tolerance for changing environmental conditions, enabling them to adapt better than other benthic groups. This capability is supported by their wide distribution, ability to survive in various water conditions, and tolerance to specific pollutants.

Relationship Between Macrozoobenthos Abundance and Physicochemical Water Parameters

Based on the Spearman correlation analysis, all physicochemical water parameters showed weak to very weak relationships with macrozoobenthos abundance, with significance values (p-values) greater than 0.05. These results indicate no significant relationship between environmental parameters and macrozoobenthos abundance in the coastal waters of Penyengat Island. This is likely because water quality parameter values were relatively uniform across stations and remained within the tolerance range of the macrozoobenthos, meaning they did not act as the primary factors influencing abundance.

CONCLUSION

Based on the research findings, the macrozoobenthos community in the coastal waters of Penyengat Island comprises 24 genera with a mean abundance of 42.22 individuals/m². The diversity index (H') of 2.67 is classified as moderate, the evenness index (E) of 0.84 is high, and the dominance index (C) of 0.10 is low. The Azti's Marine Biotic Index (AMBI) value of 2.13 indicates that the coastal waters of Penyengat Island fall into the "slightly polluted" category. Spearman correlation results show that macrozoobenthos abundance has a weak to very weak and non-significant relationship with all analyzed physicochemical parameters ($p > 0.05$). Thus, variations in these physicochemical parameters do not yet show a significant influence on macrozoobenthos abundance at the study site. Management of the coastal waters of Penyengat Island should focus on preventing increased pollution and conducting periodic water quality monitoring to maintain the ecosystem's current status as slightly polluted.

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