

## MACROZOOBENTHOS DIVERSITY AS A BIOINDICATOR OF WATER CONDITIONS IN TANETE RILAU SUBDISTRICT, BARRU REGENCY: A STUDY OF COMMUNITIES, SEDIMENTS, AND ENVIRONMENTAL PARAMETERS

Muh. Fahreza Suryadi<sup>1</sup>, Lintang Aprilya<sup>1</sup>, Muhammad Alfa Rizki Nawawi<sup>1</sup>, Kamaruddin<sup>2</sup> Muhammad Farid Samawi<sup>3</sup>, Amir Hamzah Muhiddin<sup>3</sup>

Submitted: 10 April 2026 Accepted: April 29, 2026

<sup>1</sup>Student of the Marine Science Study Program, Faculty of Marine Science and Fisheries, University Hasanuddin.

<sup>2</sup>National Research and Innovation Agency, (BRIN)

<sup>3</sup>Marine Science Study Program, Faculty of Marine Science and Fisheries, University Hasanuddin.

Corresponding Author:

\*Muh. Fahreza Suryadi

E-mail: rezfaa6328@gmail.com

### ABSTRACT

Tanete Rilau Subdistrict in Barru Regency is a coastal area facing environmental pressures due to anthropogenic activities such as settlements, fishponds, and coastal development. This study aims to analyze the diversity of macrozoobenthos as a bioindicator of water conditions in the area. The research was conducted in March 2026 at three observation stations: the fishpond area (Station 1), mangrove ecosystem (Station 2), and settlement area (Station 3). The results found 8 species of macrozoobenthos from the phylum Mollusca (7 species of Gastropods and 1 species of Bivalvia), with a total of 61 individuals. The abundance of individuals ranged from 3–28 ind/m<sup>2</sup>, with the highest abundance at Station 1 (28 ind/m<sup>2</sup>) and the lowest at Station 3 (3 ind/m<sup>2</sup>). The diversity index (H') ranged from 0 to 1.32, categorizing the water quality as low to moderate. Station 2 showed the highest diversity (1.32), while Station 3 showed single species dominance by *Clypeomorus pellucida* with a dominance index (C) of 1. Sediment analysis showed dominance of fine to very fine sand fractions with total organic matter content (TOM) ranging from 5.01% to 34.88%. PCA analysis confirmed that variation in environmental conditions is controlled by the interaction of temperature, salinity, pH, DO, and TOM, which directly affect the macrozoobenthos community structure at the research sites.

Keywords: Macrozoobenthos, Bioindicator, Tanete Rilau, Diversity, Water Conditions.

### INTRODUCTION

Coastal areas are beach ecosystems that play a strategic role as transitional zones between terrestrial and marine environments, and they contain the potential of natural resources and ecosystem services known as coastal resources (Hanibe et al., 2022). Coastal regions are dynamic areas, which makes them highly vulnerable to various factors that can cause disturbances or damage. These factors may originate from natural processes such as natural disasters, or from exploitative anthropogenic activities (Sulastriningrum et al., 2024). Benthic organisms are groups of organisms that live on the bottom of water bodies and have high sensitivity to changes in water quality, making them frequently used as indicators of aquatic environmental conditions. The composition and distribution of benthos are greatly influenced by the dynamics of water conditions, so their presence can reflect changes in environmental factors over time as a result of continuous exposure to fluctuating water quality (Nurhia et al., 2021).

Macrozoobenthos are groups of organisms that are highly dependent on aquatic environmental conditions as their habitat. These organisms utilize

the substrate at the bottom as a place to live, search for food, and reproduce. In addition, macrozoobenthos are characterized by relatively slow movement and a sessile (settled) lifestyle, making them highly sensitive to changes in environmental conditions. According to Poedjirahajoe (2019), macrozoobenthos play an important role in the decomposition of organic matter into nutrients that can be reused by other organisms in the aquatic ecosystem.

It is important to understand the structure of the macrozoobenthos community in a body of water, considering its role as a biological indicator for assessing environmental quality. The diversity of macrozoobenthos can reflect the condition of the water, where a high level of diversity indicates a relatively stable and unpolluted environment, while low diversity suggests environmental stress or disturbance. Aryanti et al. (2021) reported that changes in aquatic environmental conditions will have a direct impact on the composition and abundance of macrozoobenthos.

The decline in water quality in coastal areas can be caused by both natural and anthropogenic factors (Nuzullah et al., 2025). Natural factors include tidal

dynamics, currents, and waves, while anthropogenic factors include pollution from domestic waste, fishing activities, and changes in land use in coastal areas. The pressure from these various activities can lead to changes in the physical, chemical, and biological characteristics of the water, which ultimately affects the presence of macrozoobenthos. One effort that can be undertaken to monitor water conditions is the use of bioindicators, such as macrozoobenthos, as they are able to provide an accurate and continuous depiction of environmental conditions.

However, information regarding the diversity of macrozoobenthos as an indicator of water conditions in Tanete Rilau District, Barru Regency is still limited and has not been widely reported. Therefore, this study was conducted to analyze the diversity of macrozoobenthos as a bioindicator of water conditions in the area. This research proposes the hypothesis that differences in environmental

conditions at each observation station will affect the structure of the macrozoobenthos community, in terms of abundance, diversity, and dominance.

## MATERIALS AND METHODS

### Time and Location of Research

This Research will be conducted in March 2026 in the coastal area of Tanete Rilau District, Barru Regency, South Sulawesi Province, which borders directly with the sea to the west, as well as fishpond areas, the Makassar-Parepare main road, and residential zones to the east. The research will be carried out at three observation stations representing different aquatic conditions: Station 1 in the fishpond area, Station 2 in the mangrove ecosystem, and Station 3 in the residential area. The research location and position of the stations can be seen in Figure 1.

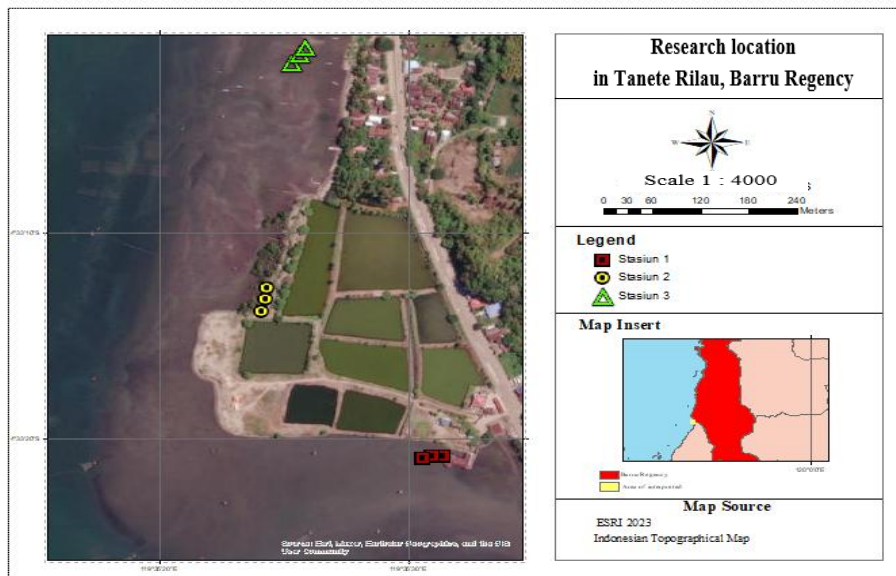


Figure 1. Research Location

## Data Collection Techniques

### Sampling

Sampling included macrozoobenthos, sediment, and aquatic environmental parameters, all conducted during low tide conditions. Macrozoobenthos samples were collected using the transect method with  $1 \times 1$  meter plots laid parallel to the shoreline, with three replicates at each observation station. Organisms found were then collected and preserved for identification in the laboratory. Meanwhile, sediment sampling at each station was carried out using a sediment core inserted into the substrate to obtain sediment

samples, which were then stored and taken to the laboratory for further analysis.

### Morphometrics of Macrozoobenthos

Macrozoobenthos morphometric measurements include the length, width, and body weight of the organisms. Length and width are measured using a measuring board with an accuracy of 1 cm, while weight is measured using a digital scale with an accuracy of 0.01 grams. All measurements are conducted carefully to ensure data accuracy, so that the results accurately represent the morphological condition of the organisms.

### Temperature

The temperature is measured using a thermometer by immersing it in water and observing it for several minutes until the indicator on the scale stabilizes. After that, record the result on the thermometer scale.

### Salinity

Salinity is measured directly in the field using a hand refractometer. The salinity measurement is carried out by collecting water samples at each station, then placing a drop of the sample onto the surface of the prism glass using a dropper pipette. Carefully close the glass with the cover plate, then point the hand refractometer towards the light source. Next, look through the end of the hand refractometer to view the salinity scale. The salinity reading will appear at the boundary line between the blue and white areas on the scale.

### pH

pH measurement is carried out using a pH meter. Before use, the device must first be calibrated with distilled water, after which the pH meter is immersed in the water. The displayed pH value is then recorded.

### Dissolved Oxygen (DO)

DO measurement is carried out using a DO meter. Before use, the DO meter is first calibrated, after which the DO meter probe is slowly inserted into the water. Wait a moment until the reading on the DO meter display stabilizes, then record the result that appears.

## Data Analysis

### Macrozoobenthos Abundance Index

The abundance of macrozoobenthos individuals is calculated using the following formula (Alwi et al., 2020):

$$Y = \frac{a}{b}$$

Where:

Y = Number of Macrozoobenthos Organisms (Ind/m<sup>2</sup>)  
a = Number of Macrozoobenthos Individuals (ind) b = Transect Area (m<sup>2</sup>)

### Diversity and Evenness Index

According to Alwi et al., 2020, to calculate the species diversity index (H'), it is calculated as follows:

$$H' = - \sum \left( \frac{ni}{N} \right) \times \ln \left( \frac{ni}{N} \right)$$

$$E = \frac{H'}{\ln(S)}$$

Where:

H' = Diversity Index  
ni = Number of individuals of each species  
N = Total number of individuals of all species  
E = Evenness Index  
S = Number of species  
Ln = Natural Logarithm

### Dominance Index (C)

The dominance index value of macrozoobenthos organisms is calculated using the dominance index/Simpson's index formula (Nuridayanti, 2021):

$$C = \sum_{k=0}^n \left( \frac{ni}{N} \right)^2$$

Where:

C = Dominance index  
Ni = Number of individuals of each species  
N = Total number of individuals

### Sediment grain size

Sediment analysis to determine grain size was carried out using the dry sieving method. The procedure began with drying the sample in an oven at 105°C for approximately 16 hours until it reached a dry condition. After that, each sample was weighed at 100 grams for further analysis. The sieving process referred to the method by Eleftheriou and McIntyre (2005), which uses a sieve shaker with sieve sizes ranging from 2.36 mm to 0.075 mm for about 15 minutes with constant motion. After the sieving process was completed, samples from each size fraction were carefully transferred into containers to prevent loss of sediment particles. Next, each fraction was weighed using a digital scale and labeled to ensure accurate identification. For sediment fractions smaller than 0.075 mm, further analysis was conducted using the pipette method. These fine samples were mixed with water until homogeneous, then the pipette process was carried out based on the standard procedure for settling time and particle fall distance. The results of the grain size analysis were then classified according to the Wentworth scale (1922), and presented in the form of a table as well as calculated using the following formula (Rahimah, 2022):

$$Li = \frac{\text{Weight of sieve fractions}}{\text{Total weight of sieve fractions}} \times 100$$

Which is then classified according to the Wentworth scale of 1922 as referenced in Latief (2020) as follows:

Table 1. Wentworth's Grain Size Classification (1922)

	Grade Name	Particle Size (mm)
Gravel	Boulders	>256
	Cobbles	64 - 256
	Pebbles	4 - 64
	Granules	2 - 4
	Very coarse sand	1 - 2
Sand	Coarse sand	0.5 - 1
	Medium sand	0.25 - 0.5
	Fine sand	0.125 - 0.25
	Very fine sand	0.0625 - 0.125
Silt		0.0004 - 0.0625 (1/256 - 1/16)
Clay		< 0.004 (< 1/256)

#### Total Organic Material in Sediment

Analysis of total organic matter content using the Loss On Ignition (LOI) method. The LOI method aims to determine the total organic matter content in sediment in order to identify the depositional environment. The stages of total organic matter (organic carbon) content analysis using the LOI method are based on the laboratory procedures of the University of Pittsburgh and the guidelines

established by Allen et al. (1974) in Sari, et al. (2014).

$$Li = \frac{Wo - Wt}{Wo} \times 100\%$$

Where:

Li = Loss on Ignition (%)

Wo = Initial Weight (grams)

Wt = Final Weight (grams)

According to Simanjuntak, et al (2020), the organic matter content of sediment is classified into five categories:

>35% = Very high organic matter content

17-35% = High organic matter content

7-17% = Moderate organic matter content

3.5-7% = Low organic matter content

<3.5% = Organic matter content is very low

## RESULTS AND DISCUSSION

Based on the research conducted, the macrozoobenthos found at the study site consist of one phylum, two classes, six orders, eight families, eight species, and 61 individuals. The classes identified include seven species from the class Gastropoda and one species from the class Bivalvia. The composition of the macrozoobenthos obtained can be seen in Table 2.

Table 2. Species of Macrozoobentos Found in Research Locations.

Phylum	Class	Order	Family	Species	Amount
Mollusca	Gastropoda	Neogastropoda	Muricidae	<i>Orania pallary</i>	3
			Pisaniidae	<i>Engina alveolata</i>	18
			Nassariidae	<i>Nassarius livescens</i>	3
		Littorinimorpha	Planaxidae	<i>Planaxis sulcatus</i>	4
		Cerithiodea	Potamididae	<i>Pirenella cingulata</i>	1
		Cerithiimorpha	Cerithiidae	<i>Clypeomorus pellucida</i>	8
		Cerithiodea	Potamididae	<i>Terebralia sulcata</i>	16
	Bivalvia	Cardiida	Cardiidae	<i>Trachycardium rugosum</i>	8

#### Individual Abundance

The abundance of macrozoobenthos indicates the number of individuals found in a particular area,

expressed in units of individuals per square meter (ind/m<sup>2</sup>). The value of macrozoobenthos abundance at the research location is presented in Table 3. Based on Table 3, the abundance of macrozoobenthos at the research site ranged from 3 to 28 ind/m<sup>2</sup>. The highest abundance was found in the pond area (Station 1) at 28 ind/m<sup>2</sup>, while the lowest abundance was recorded in the residential

area (Station 3), with a value of 3 ind/m<sup>2</sup>. The class Gastropoda was the group of macrozoobenthos with the highest abundance at the study site. This high abundance is thought to be related to the relatively high adaptability of Gastropods to changes in environmental conditions. In addition, the presence of a hard shell as protection and their ability to withstand various environmental pressures also support the dominance of this group compared to others. According to Yollanda et al. (2021),

Table 2. Macrozoobenthos Abundance

Phylum	Class	Species	Observation Station		
			1	2	3
Mollusca	Gastropoda	<i>Orania pallary</i>	3	1	-
		<i>Engina alveolata</i>	18	-	-
		<i>Nassarius livescens</i>	3	-	-
		<i>Planaxis sulcatus</i>	4	-	-
		<i>Pirenella cingulata</i>	-	1	-
		<i>Clypeomorus pellucida</i>	-	5	3
		<i>Terebralia sulcata</i>	-	16	-
	Bivalvia	<i>Trachycardium rugosum</i>	-	8	-
Amount			28	30	3

Gastropods have a wide distribution, a high level of adaptability, and a good ability to survive various changes in environmental conditions. Meanwhile, Yunita et al. (2023) stated that Gastropods have relatively low mobility and tend to be sedentary, which directly exposes them to and makes them responsive to changes in their surrounding environment. In the class Bivalvia, the species *Trachycardium rugosum* showed the lowest abundance value. This is suspected because the species is an infaunal organism that lives by burrowing and resides quite deep within the sediment, making it harder to detect and resulting in relatively low numbers. The findings of Handrayani et al. (2025) also reported similar results, indicating that burrowing organisms such as bivalves tend to have low abundance because of their habit of creating deep burrows in the substrate, as well as possible limitations during field observation.

### Diversity Index

The diversity index describes the number and variety of organism types in an ecosystem. The values of the macrozoobenthos diversity index at the research site are presented in Figure 2. Based on the graph, the macrozoobenthos diversity index values at the research location range from 0 to 1.32. Referring to Odum's criteria (1993), a diversity index value in the range of  $0 < H' < 1$  is considered low,  $1 < H' < 3$  is considered moderate, and  $H' > 3$  is considered high. Thus, the level of macrozoobenthos diversity at the research site falls into the low to moderate category.

Based on the research results presented in Figure 2, the highest diversity index value was found in the mangrove ecosystem (Station 2), which was 1.32, indicating a moderate diversity category. This condition suggests that there is a relatively even

distribution of macrozoobenthos individuals from various species.

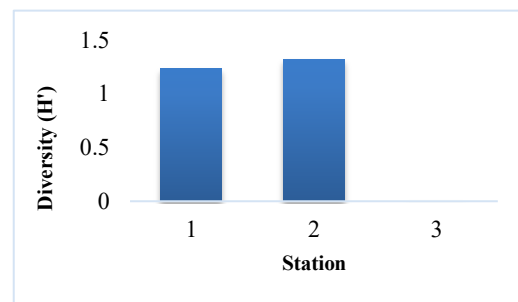


Figure 2. Diversity between stations

This finding is consistent with Akbar et al., (2022), who stated that moderate diversity reflects a fairly even distribution of organisms as well as a relatively stable community condition. Conversely, the lowest diversity index value was found in the residential area (Station 3), with a value close to 0. This condition indicates that only one type of macrozoobenthos was found, with a dominant number of individuals. Such a situation reflects an imbalance in the ecosystem, which is likely influenced by specific environmental pressures. According to Abidin (2023), low community diversity can be caused by several factors, such as the availability of food resources, substrate type, presence of predators, and the ability of species to adapt to less supportive environmental conditions.

### Dominance Index

The dominance index is used to determine whether or not there is a dominant species in an ecosystem. A high dominance index value can affect the diversity level of a community. The dominance index values at the research site are presented in Figure 3, ranging from 0.38 to 1. According to Odum (1993), a dominance index value close to 0

indicates the absence of a dominant species, while a value close to 1 indicates domination by a particular species.

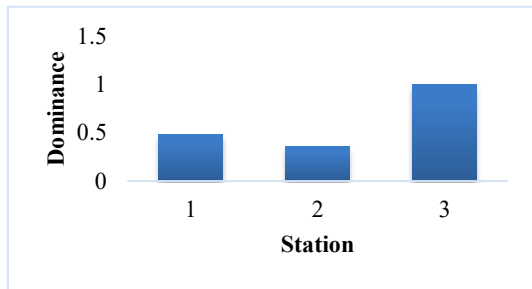


Figure 3. Dominance index

Based on the research results, the highest dominance index value was found in the residential area (Station 3), at 1, which indicates the dominance of the species *Clypeomorus pellucida*. Conversely, the lowest dominance index value was found in the mangrove ecosystem (Station 2), at 0.38, indicating that no single species dominates at that station. A relatively low dominance value was also found in the pond area (Station 1), at around 0.48. The conditions at Station 2 and Station 1 show that the distribution of individuals among species is relatively even, so there is no dominant species. Meanwhile, the high dominance at Station 3 indicates low species richness and an uneven distribution of individuals. This is in line with Munandar et al. (2016), who stated that a high dominance value reflects low species diversity and an unbalanced community structure.

### Morphometrics of Macrozoobenthos

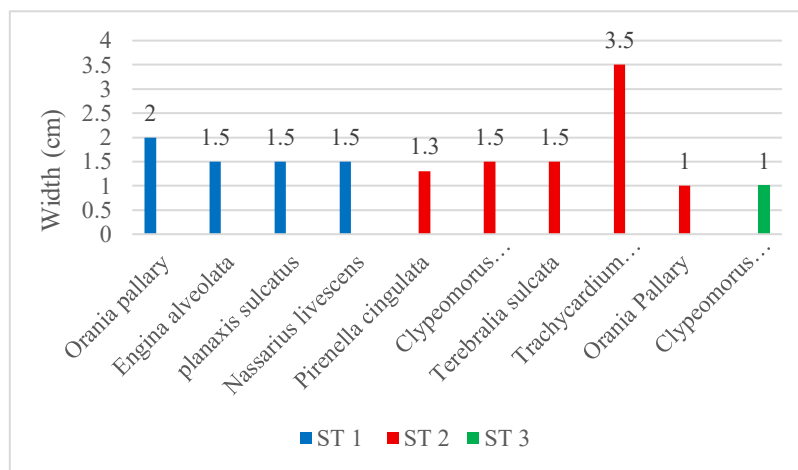


Figure 4. Width of macrozoobenthos

The measurements of macrozoobenthos length at the three stations, as presented in Figure 5, show variations in size that reflect differences in aquatic environmental conditions. In the pond area (Station 1), macrozoobenthos length ranges from 2 to 3 cm.

Morphometric analysis was conducted to determine the body size characteristics of macrozoobenthos in each species found. Morphometric measurements included parameters such as the organism's body length, width, and weight. Calculations were carried out using three samples for each species, and the measurement results were then averaged to obtain a representative value that reflects the morphological condition of each species.

The results of the study in Figure 3 show that the body width of macrozoobenthos varies between observation stations. At Station 1, the body width of macrozoobenthos ranges from 1.5–2 cm, with the largest size found in the species *Orania pallary* (2 cm), while other species such as *Engina alveolata*, *Planaxis sulcatus*, and *Nassarius livescens* have relatively uniform body widths of about 1.5 cm. At Station 2, the range of body sizes is more diverse, between 1–3.5 cm. The species with the largest size is *Trachycardium rugosum* (3.5 cm), followed by *Terebralia sulcata* and *Clypeomorus pellucida* (1.5 cm), as well as *Pirenella cingulata* (1.3 cm). Meanwhile, *Orania pallary* has the smallest body size at this station, about 1 cm. At Station 3, the macrozoobenthos found have relatively small and homogeneous body sizes, which are around 1 cm, dominated by *Clypeomorus pellucida*. Overall, Station 2 exhibited the greatest variety and largest size of macrozoobenthos, while Station 3 had the smallest and most uniform body sizes. These differences indicate variations in environmental conditions that influence the growth of macrozoobenthos at each station.

The largest sizes were found in *Orania pallary* and *Planaxis sulcatus*, which reached 3 cm, while *Engina alveolata* measured 2.5 cm and *Nassarius livescens* about 2 cm. This indicates that the organisms at this station are dominated by small to medium sizes. In the mangrove ecosystem (Station

2), there is a wider range in size, from 1.5 to 3.1 cm. The largest species is *Terebralia sulcata* (3.1 cm), followed by *Clypeomorus pellucida* (3 cm) and *Trachycardium rugosum* (2.5 cm). Meanwhile, *Pirenella cingulata* and *Orania pallary* are smaller, measuring around 1.5 cm. In the residential area (Station 3), macrozoobenthos length is relatively

uniform and smaller, at about 2.1 cm, represented by *Clypeomorus pellucida*. Overall, Station 2 exhibits macrozoobenthos lengths that tend to be larger and more varied compared to Stations 1 and 3. This variation indicates that environmental factors such as substrate, salinity, pH, and dissolved oxygen play a role in influencing macrozoobenthos growth at each station.

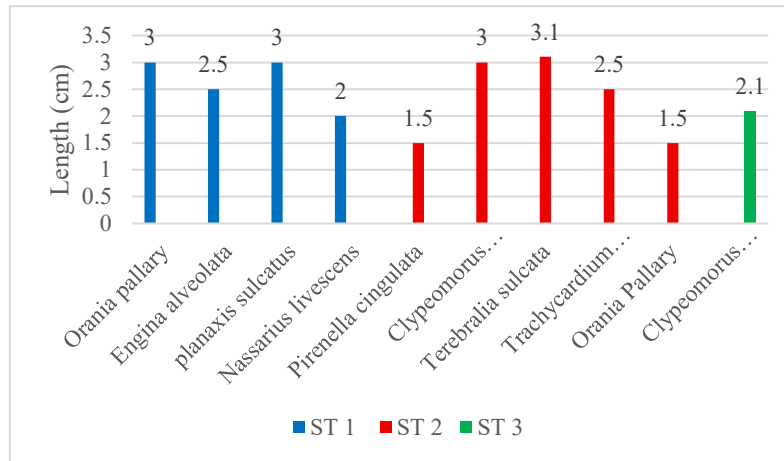


Figure 5. Length of macrozoobenthos

The results of the research in Figure 6 show that the biomass of macrozoobenthos varies between observation stations. In the pond area (Station 1), the biomass is relatively higher compared to the other stations, with the largest contribution coming from *Orania pallary* (4.14 grams), followed by *Nassarius livescens* (3.235 grams) and *Engina alveolata* (3.143 grams). Meanwhile, *Planaxis sulcata* had the lowest biomass at this station, at just 0.715 grams. In the mangrove ecosystem (Station 2), macrozoobenthos biomass is dominated by *Trachycardium rugosum*, which has the highest value at 12.408 grams. Other species, such as

*Terebralia sulcata* (3.16 grams) and *Clypeomorus pellucida* (1.424 grams), also contributed, albeit to a lesser extent. Meanwhile, *Pirenella cingulata* (0.468 grams) and *Orania pallary* (0.504 grams) exhibited relatively low biomass. In the residential area (Station 3), macrozoobenthos biomass tended to be low and was represented only by *Clypeomorus pellucida* with a value of 0.601 grams. Overall, Station 2 recorded the highest macrozoobenthos biomass due to the strong dominance of a single species, while Station 3 had the lowest biomass. This variation indicates that the environmental conditions at each station influence the productivity and distribution of macrozoobenthos biomass.

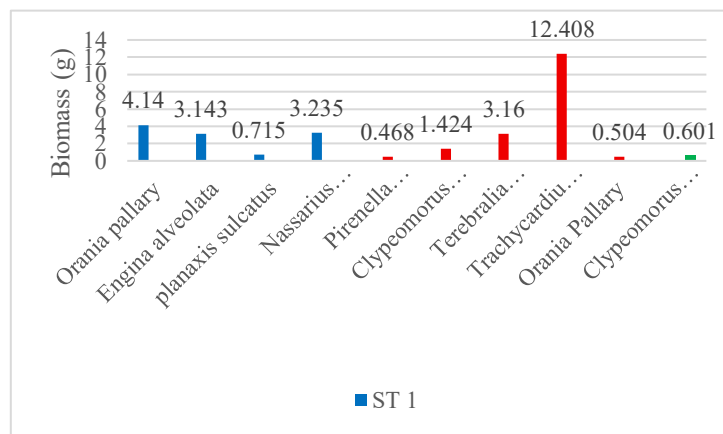


Figure 6. Biomass of macrozoobenthos

Based on the results of morphometric measurements—specifically the length and width of

macrozoobenthic bodies—at the three observation stations, variations in size were observed, reflecting

differences in aquatic environmental conditions. In the pond area (Station 1), the body sizes of macrozoobenthos were generally medium, with length ranging around 2–3 cm and width 1.5–2 cm. Species such as *Orania pallary* and *Planaxis sulcatus* showed relatively larger sizes compared to other species at this station. This suggests that the environment at Station 1 is sufficiently supportive for organism growth, although it does not yet present extremely large maximum sizes. This supports Verhaegen et al. (2018), who state that the body size of gastropods reflects habitat stability and nutrient availability, whereby environments with adequate organic matter content can support optimal growth and the formation of sturdier morphologies. In the mangrove ecosystem (Station 2), the range of body sizes was broader, both in terms of length and width. The macrozoobenthos length ranged between 1.5–3.1 cm, with widths reaching up to 3.5 cm. The species *Trachycardium rugosum* had the greatest width (3.5 cm), while *Terebralia sulcata* had the maximum length (3.1 cm). This higher variability in size indicates the presence of dynamic environmental conditions, yet these still support the growth of larger organisms. It reflects the adaptive capacity of macrozoobenthos to environmental fluctuations such as changes in salinity, temperature, and pH. According to Krug et al. (2021), benthic organisms possess adaptation

mechanisms such as osmoregulation and thicker shell development to survive in the variable conditions of the intertidal zone. Meanwhile, the residential area (Station 3) showed macrozoobenthos body sizes that were relatively small and uniform. The length was approximately 2.1 cm with a width of about 1 cm, dominated by *Clypeomorus pellucida*. The low variation and size suggest that environmental conditions at Station 3 are less than optimal for organism growth. Factors such as low dissolved oxygen, high turbidity, or anthropogenic pressure are thought to be responsible for the limited growth. Wijayanti et al. (2018) state that under stressed environmental conditions, an organism's energy is used more for survival than for morphological growth. In addition to morphometric parameters, biomass measurements also showed clear differences among the stations. Station 2 had the highest biomass, dominated by *Trachycardium rugosum* (12.408 grams), followed by *Terebralia sulcata* (3.16 grams) and *Clypeomorus pellucida* (1.424 grams). The high biomass at this station indicates an ample energy supply and sufficiently supportive sediment conditions for benthic organisms. According to Soto et al. (2017), macrozoobenthic biomass is positively correlated with organic matter content and sediment stability. Station 1 displayed a

moderate biomass, primarily contributed by *Orania pallary* (4.14 grams), *Nassarius livescens* (3.235 grams), and *Engina alveolata* (3.143 grams). This suggests that Station 1 has a reasonably productive habitat, though not as productive as Station 2. Meanwhile, Station 3 had the lowest biomass, approximately 0.601 grams, represented by *Clypeomorus pellucida*. This low biomass indicates higher ecological pressure, whether due to natural factors like high sedimentation or human activities in the coastal area. Ardani et al. (2020) stated that anthropogenic pressure can significantly reduce macrozoobenthic biomass and diversity. Overall, the variations in morphometric size and macrozoobenthic biomass at the three stations demonstrate ecological responses to aquatic environmental conditions. Physicochemical parameters such as temperature, salinity, pH, dissolved oxygen, as well as substrate characteristics and organic matter content, play important roles in determining the patterns of growth, distribution, and productivity of macrozoobenthos at each observation station.

#### Characteristics of Sediment Grain Size

Based on the results of the sediment grain size distribution analysis at three observation stations—fishpond area (Station 1), mangrove ecosystem (Station 2), and residential area (Station 3)—it was found that the sediments at the research locations are dominated by fine-sized fractions. In the fishpond area (Station 1), the dominant fraction is generally sized at 63  $\mu\text{m}$ , with percentages of 71.699% and 71.49% in replications 1 and 2, which fall into the very fine sand category according to the Wentworth classification. Nevertheless, in the third replication, the 125  $\mu\text{m}$  fraction dominates with a percentage of 19.832%, classified as fine sand. This indicates a variation in grain size distribution; however, it still generally shows a dominance of fine sediment. In the mangrove ecosystem (Station 2), the sediment grain size distribution shows a more consistent pattern, with all replications dominated by fractions sized around 64–66  $\mu\text{m}$ . The percentage of the dominant fraction at this station is quite high, at 60.791%, 67.387%, and 66.061%, all categorized as very fine sand. This condition indicates that the depositional environment in S2 is relatively stable, with a dominance of fine material. Meanwhile, in the residential area (Station 3), the sediments are dominated by larger size fractions compared to the other two stations, ranging between 125–127  $\mu\text{m}$  with respective percentages of 58.559%, 53.663%, and 59.952%. According to the Wentworth classification, this size falls into the fine sand category. These grain size distribution characteristics reflect the energy conditions of the depositional environment. Referring to Elake et al.

(2025), the dominance of fine fractions is an indicator that the hydrodynamic dynamics in these waters are relatively low. The weak current energy limits the transport capacity of larger particles, making it easier for fine materials to accumulate and settle on the seafloor. This phenomenon usually

occurs in sheltered coastal areas or areas that receive a high supply of suspended material from the land. This is consistent with the findings of Bila and Ardhani (2025), who stated that low-energy environments are the main sites for the deposition of fine sediments such as silt and clay.

Table 3. Graph of the Percentage Distribution of Sediment Grain Size at Each Observation Station.

Station	Repetition	Fraction Dominance	Wentworth Classification
1	1	63 $\mu\text{m}$ (71.699%)	very fine sand
	2	63 $\mu\text{m}$ (71.49%)	very fine sand
	3	125 $\mu\text{m}$ (19.832%)	fine sand
2	1	64 $\mu\text{m}$ (60.791%)	very fine sand
	2	65 $\mu\text{m}$ (67.387%)	very fine sand
	3	66 $\mu\text{m}$ (66.061%)	very fine sand
3	1	125 $\mu\text{m}$ (58.559%)	fine sand
	2	126 $\mu\text{m}$ (53.663%)	fine sand
	3	127 $\mu\text{m}$ (59.952%)	fine sand

Analysis of sediment fraction grouping based on the Shepard classification shows that all research locations are significantly dominated by the sand fraction. Data in Table 5 confirm that the pond area (Station 1) has a sand percentage ranging from 90.4% to 94.7%, with a relatively low contribution of fine fractions (silt + clay) at 5.3% to 9.6%. Similar characteristics are observed in the mangrove ecosystem (Station 2), with sand content between 90.2% and 91.1%. Meanwhile, the residential area (Station 3) displays the strongest sand fraction dominance compared to other stations, reaching 98.6%, with a very minimal proportion of fine sediment (1.3% to 1.6%). Although the sand fraction is the main component, the presence of fine material still found, particularly at S1 and S2, indicates a supply of suspended material from the land or the result of resuspension of bottom

sediments that settle under certain energy conditions. This dominance of the sand fraction reflects hydrodynamic conditions with moderate to high intensity. In environments with strong current energy, fine particles tend to remain suspended and transported, so only coarser particles can undergo deposition on the seabed. Conversely, the accumulation of fine fractions usually only occurs under calmer energy conditions. This is in line with the theory put forward by Siregar et al., (2014) that sediment distribution in coastal areas is the result of complex interactions between currents, waves, and terrestrial material supply. Thus, sedimentation dynamics at the research locations are largely influenced by the strength of water hydrodynamics and the contribution of material from land, which together determine the overall characteristics of the bottom sediments.

Table 4 Composition of Sediment Fractions and Shepard Classification at Each Observation Station

Station	Repetition	%Sand	%Silt+Clay	Types of Sediment
1	1	94.7	5.3	sand
	2	90.4	9.6	sand
	3	94.4	5.6	sand
2	1	91.1	8.9	sand
	2	90.2	9.8	sand
	3	90.8	9.2	sand
3	1	98.4	1.6	sand
	2	98.7	1.3	sand
	3	98.6	1.4	sand

### Total Organic Material (TOM)

Based on the results of Total Organic Matter (TOM) measurements in the sediment, it was found that TOM values at the research sites ranged from 5.01% to 34.88%. These values indicate a significant variation among the observation stations. The pond area (Station 1) had a TOM content of 13.78%, which falls into the moderate category, while the mangrove ecosystem (Station 2) showed the highest value at 34.88%, considered high. Meanwhile, the residential area (Station 3) had the lowest TOM value at 5.01%, classified as low. This analysis shows that the organic matter content in the sediment varies from low to high. The high TOM content at Station 2 indicates a greater accumulation of organic material compared to the other stations. This condition may be caused by a higher supply of organic material from land, biological activity, or more intensive deposition processes in environments with relatively low hydrodynamic energy. An increase in organic matter content in the sediment plays an important role in geochemical processes, particularly in the binding of heavy metals. Organic matter is a component capable of binding metals through organic-metal complex formation or chelation processes, allowing heavy metals to accumulate and be retained in the sediment. According to Maslukah (2013), high organic matter content will increase the sediment's ability to accumulate heavy metals.

Thus, the higher the organic matter content, the greater the sediment's potential to bind and store heavy metals. This condition has implications for the quality of the aquatic environment, as the accumulation of heavy metals in the sediment can affect benthic organisms, including the macrozoobenthos community.

Table 5. Total Organic Matter Analysis Results (TOM)

Station	%Weight
Fishpond area	13.78
Mangrove ecosystem	34.88
Residential area	5.01

### The relationship between the abundance and diversity of macrozoobenthos as bioindicators of water quality

Principal Component Analysis (PCA) in this study was conducted by including five main environmental variables: temperature, salinity, pH, dissolved oxygen (DO), and total organic matter (TOM). Before analysis, the data was transformed through a standardization process to equalize the scale between variables prior to PCA analysis. This approach aims to improve the accuracy of interpreting the relationships between environmental variables and their influence on the structure of the macrozoobenthos community.

The results of the PCA analysis show that two principal components, namely PC1 and PC2, are able to explain the majority of data variation, with contributions of 61.79% (PC1) and 35.65% (PC2), respectively, resulting in a total explained variation of 97.44%. This indicates that the environmental variables analyzed have been optimally represented in the two-dimensional biplot (Figure 7). According to Lever et al. (2017), PCA is an effective multivariate method for reducing data complexity and comprehensively identifying patterns of relationships among environmental variables. As shown in Figure 7, the PC1 axis depicts the main gradient that separates aquatic environmental conditions based on physico-chemical parameters. Positive PC1 values are strongly associated with temperature and salinity, indicating the dominance of physical factors in water characteristics. Conversely, negative PC1 values are influenced by pH, dissolved oxygen (DO), and total organic matter (TOM), which indicate waters with more intensive biological activity and biogeochemical processes. This is consistent with Paerl et al. (2016), who state that temperature and salinity are the main controllers of aquatic physical dynamics, while DO and organic matter reflect the metabolic processes of aquatic ecosystems. In Figure 7, it is also evident that the PC2 axis represents secondary variation related to the interaction between organic matter and the chemical conditions of the water. Positive PC2 values are dominated by TOM, pH, and salinity, indicating waters with relatively high organic matter content. Meanwhile, negative PC2 values are associated with DO and temperature, reflecting increased oxygen consumption due to the decomposition of organic matter. According to Zhang et al. (2017), an increase in organic matter in sediment and the water column can enhance microbial activity, which leads to a decrease in dissolved oxygen.

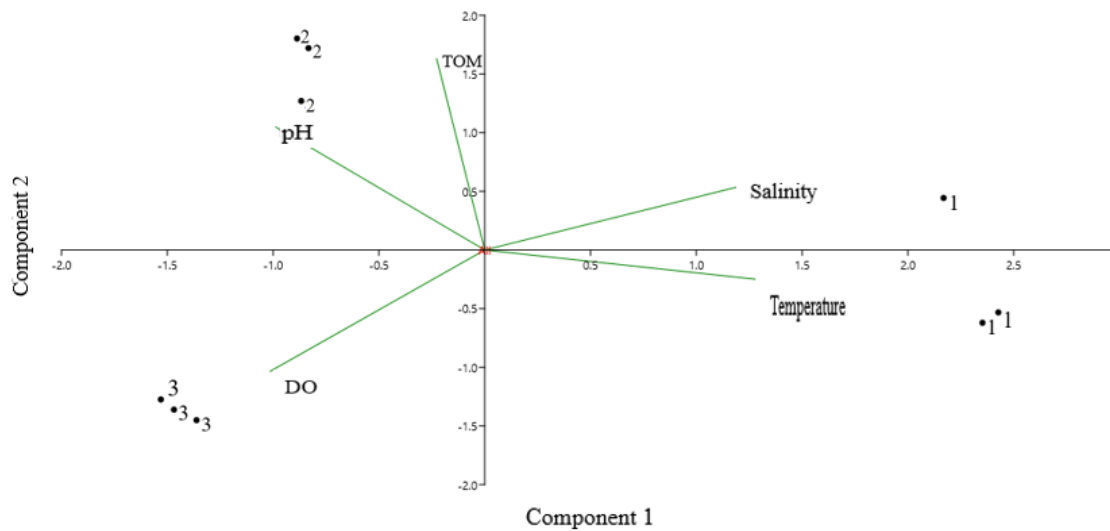


Figure 7. The relationship between the abundance and diversity of macrozoobenthos and water quality

The relationships between variables depicted in Figure 7 indicate that temperature and salinity have a positive correlation, so an increase in temperature tends to be followed by an increase in salinity due to evaporation processes and water mass dynamics. In contrast, DO shows an inverse relationship with TOM, indicating that the higher the organic matter content, the greater the consumption of dissolved oxygen. This is supported by Xiao et al. (2019), who state that the decomposition of organic matter is one of the main factors causing decreases in DO in coastal waters. Additionally, pH is also related to biogeochemical processes influenced by respiration and photosynthesis activities. The distribution of observation points on the biplot (Figure 7) shows a separation of characteristics between observation stations. Stations on the positive side of PC1 are

characterized by the dominance of temperature and salinity, while stations on the negative side of PC1 are more influenced by DO and pH. Along the PC2 axis, stations with positive values indicate a strong influence of organic matter (TOM), while negative values reflect a dominance of dissolved oxygen. This pattern highlights significant spatial variation in environmental conditions among the study sites. Overall, as shown in Figure 7, the PCA results reveal that variations in aquatic environmental conditions at the study locations are controlled by the interaction between temperature, salinity, dissolved oxygen, pH, and total organic matter. The combination of these factors plays an important role in determining water quality and has the potential to influence the structure of benthic organism communities. This is consistent with Kadim et al. (2024), who state that changes in the physico-chemical parameters of the waters directly affect

habitat conditions and the distribution of benthic organisms.

## CONCLUSION

Based on the research results, it can be concluded that the macrozoobenthos community in the coastal waters of Tanete Rilau District, Barru Regency, consists of 8 species dominated by the class Gastropoda, with a total of 61 individuals. The structure of this community shows significant spatial variation, with the highest abundance found in the fishpond area (Station 1) at 28 ind/m<sup>2</sup> and the lowest in the residential area (Station 3) at 3 ind/m<sup>2</sup>. Overall, the condition of the waters falls into the low to moderate category, with diversity index ( $H'$ ) values ranging from 0 to 1.32. The low diversity and high dominance index at Station 3 indicate stronger environmental pressure in residential areas compared to the mangrove and fishpond ecosystems. The habitat characteristics at the study site are dominated by fine to very fine sand sediment fractions, with Total Organic Matter (TOM) content varying from 5.01% to 34.88%. The highest TOM content, found in the mangrove ecosystem (Station 2), correlates with greater macrozoobenthos biomass compared to the other stations. Overall, PCA analysis confirms that the distribution and productivity of macrozoobenthos in this area are controlled in a complex manner by the interaction of physico-chemical parameters such as temperature, salinity, pH, dissolved oxygen (DO), as well as substrate characteristics. This underscores the important role of macrozoobenthos as effective bioindicators for monitoring ecosystem health and coastal water quality. These findings recommend designating the mangrove ecosystem as a priority conservation zone to maintain coastal

biodiversity stability. The low environmental quality in residential areas highlights the urgency of controlling domestic waste and monitoring anthropogenic activities. In addition, the use of macrozoobenthos as bioindicators can be implemented as a periodic monitoring instrument for early detection of environmental degradation in Barru Regency.

#### ACKNOWLEDGMENT

The author extends their deepest gratitude to Dr. Ir. Muhammad Farid Samawi, M.Si., as the

#### REFERENCES

- Abidin, M. A. I. (2023). Monitoring keanekaragaman jenis Echinodermata di Pantai Kondang Merak Kecamatan Bantur Kabupaten Malang [Doctoral Dissertation], Universitas Islam Negeri Maulana Malik Ibrahim
- Akbar, R. T. M., Setiyowati, Y., Widiana, A., & Cahyanto, T. (2022). Keanekaragaman dan kelimpahan makrozoobentos sebagai bioindikator kualitas air di Situ Patengan, Kabupaten Bandung, Jawa Barat. *Jurnal Ilmiah Biosaintropis (Bioscience-Tropic)*, 8(1), 74-86.
- Alwi, D., Muhammad, S. H., & Herat, H. 2020. Keanekaragaman Dan Kelimpahan Makrozoobentos Pada Ekosistem Mangrove Desa Daruba Pantai Kabupaten Pulau Morotai. *Jurnal Enggano*, 5(1), 64-77.
- Ardani, A., Hidayat, T., & Arifin, M. (2020). Respon makrozoobentos terhadap tekanan antropogenik di perairan pesisir utara Jawa. *Jurnal Kelautan Nasional*, 15(1), 55-67.
- Aryanti, N. A., Wibowo, F. A. C., Mahidi, M., Wardhani, F. K., & Kusuma, I. K. T. W. (2021). Hubungan Faktor Biotik dan Abiotik Terhadap Keanekaragaman Makrobentos di Hutan Mangrove Kabupaten Lombok Barat. *Jurnal Kelautan Tropis*, 24(2), 185-194.
- Bila, E. S., & Ardhani, N. (2025). Analisis Jenis Ukuran Butir Sedimen Dasar Perairan Situbondo Menggunakan Metode Pengayakan Basah: Analysis of Grain Size Types of Sediments in Situbondo Waters using The Wet Sieving Method. *Jurnal Hidrografi Indonesia*, 7(2), 83-90.
- Elake, A., Asa, B., Akyuwen, F., Nanlohy, P., & Awayal, D. D. (2025). Analisis ukuran butiran sedimen dan batuan serta distribusinya di muara sungai wae yame desa wayame kecamatan teluk ambon kota ambon. *Journal online of physics*, 11(1), 1-6.
- Handrayani, H., Al Idrus, A., & Jamaluddin, J. (2025). Diversity of Mollusks (Gastropods and Bivalves) in The Bagek Kembar Mangrove Ecosystem Essential Area, Sekotong. *Jurnal Biologi Tropis*, 25(3), 2465-2476.
- Hanibe, J. J., Mamangkey, N. G., Manembu, I. S., Boneka, F. B., Ompi, M., & Pangemanan, N. P. (2022). Kepadatan dan keanekaragaman jenis fauna bentos (> 1mm) pada daerah pecahan karang di perairan kelurahan molas teluk manado. *Jurnal pesisir dan laut tropis*, 10(2), 24-32.
- Kadim, M. K., & Pasingi, N. (2024). Kondisi habitat fisik dan keanekaragaman makroinvertebrata sebagai indikator pencemaran di sungai Bone Gorontalo. *Jurnal Kesehatan Lingkungan Indonesia*, 23(3), 301-310.
- Krug, P. J., Shimer, E., & Rodriguez, V. A. (2021). Differential tolerance and seasonal adaptation to temperature and salinity stress at a dynamic range boundary between estuarine gastropods. *The Biological Bulletin*, 241(2), 89-103.
- Lever, J., Krzywinski, M., & Altman, N. (2017). Principal component analysis. *Nature Methods*, 14, 641-642.
- Latief, A. S. (2020). Karakteristik Sedimen Berdasarkan Sebaran Ukuran Butir Dan Mekanisme Transportasi Di Pantai Galesong Kabupaten Takalar Provinsi Sulawesi Selatan (Doctoral dissertation, Universitas Hasanuddin).

- Maslukah, L. 2013. Hubungan antara konsentrasi logam berat Pb, Cd, Cu, Zn dengan bahan organik dan ukuran butir dalam sedimen di Estuari Banjir Kanal Barat, Semarang. *Buletin Oseanografi Marina* 2(3):55-62.
- Munandar, A., Ali, Ms., Karina, S., Studi Ilmu Kelautan Fakultas Kelautan dan Perikanan Universitas Syiah Kuala Darussalam, P., Aceh, B., & Studi Ilmu Biologi Fakultas Keguruan dan Ilmu Pengetahuan Universitas Syiah Kuala Darussalam, P. (2016). Struktur Komunitas Makrozoobenthos Di Estuari Kuala Rigaih Kecamatan Setia Bakti Kabupaten Aceh Jaya Community Structure Macrozoobenthos Estuari Kuala Rigaih District District of Setia Bakti Aceh Jaya. *Jurnal Ilmiah Mahasiswa Kelautan Dan Perikanan Unsyiah*, 1(November), 331–336.
- Nurhia. I. R. 2021. Kelimpahan Dan Pola Sebaran Makrozoobentos Di Perairan Desa Ollo Selatan Kabupaten Wakatobi. *Jurnal Sapa Laut* Maret 2021. Vol.6(1): 49-54.
- Nuzullah, R. R. (2024). Redesain Lanskap Pantai Molino Sebagai Kawasan Eduwisata di Desa Sorowako, Kecamatan Nuha, Kabupaten Luwu Timur (Redesigning the Molino Beach Landscape as an Edu-tourism Area in Sorowako Village, Nuha District, East Luwu Regency (Doctoral dissertation, Universitas Hasanuddin).
- Odum, E. (1993). *Dasar-dasar Ekologi Umum* (Gadjah Mad).
- Paerl, H. W., Hall, N. S., & Calandrino, E. S. (2016). Controlling harmful cyanobacterial blooms in a world experiencing anthropogenic and climatic-induced change. *Science of the Total Environment*, 551–552, 1–12.
- Sari, T. A., Atmodjo, W., & Zuraida, R. (2014). Studi bahan organik total (bot) sedimen dasar laut di Perairan Nabire, Teluk Cendrawasih, Papua. *Journal of Oceanography*, 3(1), 81-86.
- Simanjuntak, N., Rifardi, R., & Tanjung, A. (2020). Hubungan karakteristik sedimen dan bahan organik sedimen dengan kelimpahan kerang darah (*Anadara granosa*) di perairan Tanjung Balai Asahan Provinsi Sumatera Utara. *Jurnal Perikanan dan Kelautan*, 25(1), 6-17.
- Siregar, C. R. E., Handoyo, G., & Rifai, A. (2014). Studi pengaruh faktor arus dan gelombang Terhadap sebaran sedimen dasar di perairan Pelabuhan kaliwungu Kendal. *Journal of Oceanography*, 3(3), 338-346.
- Sulistyaningrum, E., & Murthy, T. W. (2024). Studi Identifikasi Kerusakan Wilayah Pesisir dengan Metode Matriks Penilaian Indeks Kerentanan Pantai (IKP) di Kabupaten Bantul, Daerah Istimewa Yogyakarta Studi Kasus Pantai Pelangi-Tallwolu dan Pantai Depok. In *Prosiding Seminar Nasional Teknik Lingkungan Kebumihan SATU BUMI* 6(1),1-3.
- Soto, E., Quiroga, E., Ganga, B., & Alarcón, G. (2017). Influence of organic matter inputs and grain size on soft-bottom macrobenthic biodiversity in the upwelling ecosystem of central Chile. *Marine Biodiversity*, 47, 517–529.
- Verhaegen, G., Neiman, M., & Haase, M. (2018). Ecomorphology of a generalist freshwater gastropod: Complex relations of shell morphology, habitat, and fecundity. *Organisms Diversity & Evolution*, 18, 425–438.
- Wijayanti, S., Nugraha, W. A., & Fitriani, N. (2018). Hubungan antara parameter fisika kimia air terhadap morfometri Gastropoda di Pantai Krakal, Gunungkidul. *Jurnal Oseanografi Tropis*, 4(1), 32–40.
- Yolanda, R., Maharani, H. W., Diantari, R., & Yudha, I. G. (2021). Pollution Status of Raman River, Metro City Based on the Macrozoobenthos Community. *Aquasains* 10(1):1041-1048.
- Yunita, N., Hutasuhut, M. A., & Idami, Z. (2023). Abundance and Dominance Gastropods in Pantai Bunga Beach Batu Bara Regency North Sumatra. *Metamorfosa: Journal of Biological Sciences* 10(2): 324.