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Identification of Macrozoobenthos Diversity in the Coastal Area of Balo Balo Beach, Wotu District, East Luwu Regency

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Abstract

Macrozoobenthos play an important ecological role in coastal ecosystems and are widely used as bioindicators of environmental quality due to their sensitivity to habitat changes. This study aimed to identify the diversity of macrozoobenthos inhabiting the coastal area of Balo-Balo Beach, Wotu District, East Luwu Regency, Indonesia. Sampling was con-ducted from March to April 2023 using a quantitative descriptive approach across three observation stations representing different levels of anthropogenic activity. Macrozoo-benthos were collected manually within 5 × 5 m plots during low tide and analyzed using the Shannon–Wiener diversity index. A total of 308 individuals belonging to 7 species, 7 families, and 6 orders were identified, namely Faunus ater, Meretrix meretrix, Neverita didyma, Saccostrea cucullata, Scylla serrata, Telescopium sp., and Uca vocans. Mere-trix meretrix showed the highest abundance with 133 individuals, whereas Scylla serrata exhibited the lowest abundance with 4 individuals. The overall diversity index was H′ = 1.56, indicating a moderate level of diversity. Station III exhibited the highest diversity value (H′ = 1.61), likely due to lower human disturbance and more favorable environ-mental conditions. Water quality parameters, including temperature (23–32°C), pH (6.14–7.16), and salinity (20–23‰), were within ranges suitable for macrozoobenthos survival. The findings suggest that coastal environmental conditions and anthropogenic activities influence the structure and diversity of macrozoobenthos communities in Ba-lo-Balo Beach. Therefore, macrozoobenthos can serve as effective biological indicators for monitoring coastal ecosystem health and supporting sustainable coastal manage-ment.

Keywords: Macrozoobenthos, Biodiversity, Coastal Ecosystem, Shannon–Wiener Index, Bioin-Dicator, Balo-Balo Beach

1. Introduction

Coastal ecosystems are among the most productive and ecologically important environments because they support diverse biological communities and provide essential ecological services for human life. Coastal areas function as transition zones between terrestrial and marine ecosystems and are highly influenced by both natural processes and anthropogenic activities [1,2]. Increasing human activities such as

tourism, settlement expansion, fisheries, and coastal exploitation may significantly alter environmental quality and threaten aquatic biodiversity. Environmental degradation in coastal regions can directly affect the abundance, distribution, and diversity of aquatic organisms, particularly benthic communities that inhabit the bottom substrate of aquatic ecosystems.

Macrozoobenthos are benthic invertebrates that live on or within sediment substrates and play an essential role in nutrient cycling, organic matter decomposition, and aquatic food webs [3,4]. These organisms include gastropods, bivalves, crustaceans, and other bottom-dwelling fauna that are relatively sedentary and highly responsive to environmental changes. Due to their limited mobility, relatively long-life cycles, and sensitivity to pollution and habitat disturbance, macrozoobenthos are widely recognized as reliable biological indicators for assessing water quality and ecosystem health. Variations in macrozoobenthos community structure often reflect ecological conditions and environmental disturbances occurring in coastal waters [5-7].

The diversity of macrozoobenthos is strongly influenced by environmental parameters such as substrate type, salinity, temperature, dissolved oxygen, pH, and organic matter content. Coastal areas with stable environmental conditions generally exhibit higher macrozoobenthos diversity, whereas disturbed habitats tend to show lower species richness and community imbalance. Human-induced pressures, including waste disposal, coastal tourism, and habitat conversion, may alter sediment characteristics and reduce the suitability of habitats for benthic organisms. Consequently, monitoring macrozoobenthos diversity is important for evaluating ecological conditions and supporting sustainable coastal management strategies.

Several previous studies have reported the ecological importance of macrozoobenthos in coastal ecosystems. Research conducted in Jepara coastal waters identified various macrozoobenthos species dominated by Gastropoda and Bivalvia groups, indicating their adaptability to coastal habitats. Other studies in Bangka Tengah, Aceh, and Nunukan also demonstrated that macrozoobenthos diversity is closely associated with substrate conditions and environmental quality [8,9]. These findings confirm the relevance of macrozoobenthos as ecological indicators in tropical coastal environments.

Balo-Balo Beach, located in Wotu District, East Luwu Regency, South Sulawesi, is a coastal area that has experienced increasing human activities, particularly tourism and community-based coastal utilization. The presence of visitors, fishing activities, boat anchoring, and improper waste disposal may potentially affect the ecological condition of the coastal ecosystem and influence the sustainability of benthic organisms inhabiting the area. Despite its ecological importance, information regarding the diversity and community structure of macrozoobenthos in this coastal region remains limited. Therefore, scientific assessment is necessary to provide baseline ecological data for environmental monitoring and conservation planning [10,11].

This study aimed to identify the species composition and analyze the diversity of macrozoobenthos in the coastal area of Balo-Balo Beach, East Luwu Regency, Indonesia. The findings of this study are expected to contribute to the understanding of coastal biodiversity and provide scientific information for sustainable coastal ecosystem management and environmental conservation efforts.

2. Materials and Methods

2.1 Study Area and Period

This study was conducted in the coastal area of Balo-Balo Beach, Wotu District, East Luwu Regency, South Sulawesi, Indonesia, from March to April 2023. The study area represents a coastal ecosystem characterized by varying levels of anthropogenic activities, including tourism, fisheries, and community utilization of coastal resources.

2.2 Research Design

The study employed a quantitative descriptive approach to assess the diversity of macrozoobenthos in the coastal ecosystem. Observations and sampling were conducted at three sampling stations selected based on differences in environmental conditions and levels of human activity. Station I represented an area with high anthropogenic activity, Station II represented moderate activity, and Station III represented a relatively undisturbed area with low human activity.

2.3 Sampling Procedure

Macrozoobenthos sampling was carried out during low tide between 07:00 and 10:00 WITA to facilitate specimen collection. At each station, three sampling plots measuring 5 × 5 m were established with a distance of 10 m between plots. Each station covered an approximate area of 50 m along the coastal zone.

Samples were collected manually by direct observation on the substrate surface and by excavating sediment to a depth of approximately 10 cm using a small shovel. All macrozoobenthos individuals found within each plot were collected, separated from the sediment, and stored in sample containers for further identification. Species identification was conducted using morphological characteristics and taxonomic references from relevant scientific literature and identification guides.

2.4 Enviromental Parameters

Several environmental parameters were measured in situ at each sampling station to evaluate habitat conditions influencing macrozoobenthos communities. Water temperature was measured using a thermometer, pH was measured using a pH meter, and salinity was determined using a salinity measuring instrument. In addition, substrate characteristics at all stations were visually observed and classified as sandy mud substrate.

2.5 Data Analysis

The collected data were analyzed qualitatively and quantitatively. Qualitative analysis included species identification and taxonomic classification of macrozoobenthos. Quantitative analysis was performed to determine the diversity level using the Shannon–Wiener diversity index (H′). The diversity index was calculated using the following formula:

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

Where:

H'= Shannon–Wiener diversity index

p_i= proportion of individuals of species iii relative to the total number of individuals

n_i= number of individuals of species iii

N= total number of individuals of all species

The proportion of each species was determined using:

$p_i = \frac{n_i}{N}$

3. Results

3.1. Macrozoobentshos Species Composition and Abundance

The survey conducted in the coastal area of Balo-Balo Beach, Wotu District, East Luwu Regency, successfully identified 308 macrozoobenthos individuals distributed across three sampling stations. The collected specimens consisted of 7 species belonging to 7 families and 6 orders. The identified species included *Faunus ater*, *Meretrix meretrix*, *Neverita didyma*, *Saccostrea cucullata*, *Scylla serrata*, *Telescopium* sp., and *Uca vocans*.

The taxonomic composition demonstrated that the phylum Mollusca dominated the macrozoobenthos community, represented by gastropods and bivalves. Crustacean species were represented by *Scylla serrata* and *Uca vocans*. The dominance of molluscan species indicates that the substrate and environmental conditions in the study area were favorable for organisms adapted to sandy-mud coastal habitats.

The abundance of each species varied considerably across the three sampling stations. *Meretrix meretrix* was identified as the most dominant species with a total abundance of 133 individuals, accounting for approximately 43.18% of the total macrozoobenthos population. The second most abundant species was *Faunus ater* with 52 individuals, followed by *Telescopium* sp. with 46 individuals and *Neverita didyma* with 39 individuals. Meanwhile, *Uca vocans* contributed 27 individuals, whereas *Saccostrea cucullata* and *Scylla serrata* showed relatively low abundances with only 7 and 4 individuals, respectively.

The dominance of *Meretrix meretrix* may be associated with its high ecological adaptability to muddy and sandy coastal substrates. This species is known to tolerate fluctuations in environmental conditions such as salinity and substrate composition. In addition, the filter-feeding behavior of *Meretrix meretrix* enables it to efficiently utilize organic particles available within coastal sediments, contributing to its high abundance throughout the sampling area.

In contrast, the relatively low abundance of *Scylla serrata* may be related to habitat specificity and ecological sensitivity. This species generally prefers mangrove-associated habitats with more complex ecological structures and may not thrive in areas experiencing intensive human disturbance. Similarly, *Saccostrea cucullata* was found only in limited numbers because this species typically requires hard substrates for attachment and survival.

3.2. Distribution of Macrozoobenthos Among Sampling Stations

Differences in macrozoobenthos abundance and diversity were observed among the three sampling stations. Station I recorded a total of 66 individuals, Station II recorded 86 individuals, and Station III recorded the highest abundance with 156 individuals.

Station I was characterized by intense tourism activities and high human presence, which may have negatively influenced the macrozoobenthos community structure. Physical disturbances caused by visitors, litter accumulation, and coastal recreational activities potentially altered substrate conditions and reduced habitat suitability for several benthic organisms.

Station II represented an area with moderate anthropogenic activities, including seaweed drying and boat anchoring conducted by local communities. Although macrozoobenthos abundance at Station II was higher than at Station I, human activities still likely contributed to ecological disturbances affecting species distribution patterns.

Station III exhibited the highest macrozoobenthos abundance and diversity. This station was relatively undisturbed by human activities and maintained more natural environmental conditions. The limited anthropogenic pressure in this area likely supported ecological stability, allowing macrozoobenthos species to grow and

reproduce more effectively. The high abundance of *Meretrix meretrix* and *Faunus ater* at this station further indicates favorable habitat conditions.

3.3. Shannon-Wiener Diversity Index

The diversity of macrozoobenthos communities was evaluated using the Shannon–Wiener diversity index (H′). The calculated diversity values differed among the sampling stations. Station, I had a diversity index value of H' = 1.42, Station II had H' = 1.47, and Station III exhibited the highest diversity index with H' = 1.61.

The overall diversity index for the coastal area of Balo-Balo Beach was calculated as:

$$H' = 1.56$$

Based on the Shannon–Wiener classification criteria, the obtained value indicates a moderate level of macrozoobenthos diversity.

The moderate diversity category suggests that the coastal ecosystem of Balo-Balo Beach still maintains relatively stable ecological conditions capable of supporting multiple macrozoobenthos species. However, the diversity level also indicates the existence of environmental pressures that may limit species richness and evenness.

The higher diversity value observed at Station III reflects better ecological quality and lower environmental disturbance compared to Stations I and II. Areas with reduced anthropogenic activities generally provide more stable habitats, better sediment quality, and greater food availability for benthic organisms. Conversely, lower diversity values in Stations I and II may indicate ecological stress resulting from tourism and coastal utilization activities.

3.4. Environmental Conditions

Environmental measurements conducted during the study showed that all sampling stations possessed sandy-mud substrates, which are generally suitable habitats for macrozoobenthos organisms. Sandy-mud substrates provide favorable conditions for burrowing species, organic matter accumulation, and nutrient availability.

Water temperature measurements ranged from 23°C to 32°C across the study area. The lowest temperature was recorded at Station I, whereas the highest temperature occurred at Station III.

The recorded temperatures were still within the optimal range for macrozoobenthos survival and development. Temperature is an important ecological factor influencing metabolism, respiration, reproduction, and distribution of benthic organisms. Stable temperature conditions may enhance macrozoobenthos growth and support community stability.

The pH values measured during the study ranged from 6.14 to 7.16. Station I exhibited a slightly acidic condition with a pH of 6.14, while Stations II and III showed nearly neutral conditions.

These pH values were considered suitable for macrozoobenthos communities because most benthic organisms can tolerate pH conditions near neutral. Extreme acidic or alkaline conditions could potentially reduce biodiversity and interfere with physiological processes in aquatic organisms.

Salinity measurements ranged between 20% and 23% across all stations. These values indicate relatively stable salinity conditions that support the survival of coastal macrozoobenthos species. Salinity is a critical environmental parameter affecting osmoregulation, distribution, and reproductive success of marine and estuarine organisms.

Overall, the measured environmental parameters indicated that the coastal ecosystem of Balo-Balo Beach remains ecologically suitable for macrozoobenthos communities. Nevertheless, differences in macrozoobenthos abundance and diversity among stations suggest that anthropogenic disturbances may influence habitat quality and community structure within the coastal ecosystem.

4. Conclusions

Course scheduling must be properly organized; therefore, an optimization method is required to optimize classroom utilization. One way to optimize classroom utilization is by assigning courses to appropriate classrooms. The assignment of courses to classrooms also depends on the duration of each course, the number of students enrolled, and the number of lecturers teaching the course in order to avoid scheduling conflicts..

This study successfully identified the diversity and community structure of macrozoobenthos in the coastal area of Balo-Balo Beach, Wotu District, East Luwu Regency, Indonesia. A total of 308 individuals belonging to 7 species, 7 families, and 6 orders were recorded during the sampling period. The identified species consisted of *Faunus ater*, *Meretrix meretrix*, *Neverita didyma*, *Saccostrea cucullata*, *Scylla serrata*, *Telescopium* sp., and *Uca vocans*. Among these species, *Meretrix meretrix* was the most dominant species, while *Scylla serrata* showed the lowest abundance.

The Shannon–Wiener diversity index indicated a moderate level of macrozoobenthos diversity in the study area, with an overall diversity value of:

$$H' = 1.56$$

Station III exhibited the highest diversity value compared to the other sampling stations, likely due to lower anthropogenic disturbance and more stable environmental conditions. In contrast, stations with higher human activities, such as tourism and coastal utilization, showed lower macrozoobenthos abundance and diversity.

Environmental parameters, including temperature, pH, salinity, and sandy-mud substrates, were generally within suitable ranges for macrozoobenthos survival and growth. These findings indicate that the coastal ecosystem of Balo-Balo Beach still supports relatively stable macrozoobenthos communities, although anthropogenic activities may influence community composition and ecological balance.

Therefore, macrozoobenthos can serve as effective biological indicators for evaluating coastal environmental quality and ecosystem health. The findings of this study provide baseline ecological information that may support future coastal conservation, environmental monitoring, and sustainable coastal management programs in East Luwu Regency.

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Conflicts of Interest: The authors declare no conflicts of interest.

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