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Community Structure and Macrobenthos Diversity in the Coastal Waters of Tasik Ria, Mokupa Village, North Sulawesi

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Abstract: Benthic organisms belong to a group of aquatic ecosystems that have a role as key organisms in the food web. Macrobenthos are aquatic bottom organisms that are 1 mm in size. Macrobenthos community structure can be known based on its composition, abundance, diversity, and distribution. This study aims to determine the community structure of macrobenthos in Tasik Ria waters. The method used in this research is Survey method with *purposive sampling* technique. Sampling was conducted at 2 stations using 50 cm x 50 cm plots. Macrobenthos sampling was conducted in the water using a 8x2 inch sieve and selecting locations with different substrates, namely rocky and seagrass beds. The results showed that macrobenthos found in Tasik Ria Beach consisted of 74 species, 26 orders, 14 classes and 615 individuals. The value of Shannon-Wiener diversity index (H') in Tasik Ria Beach was 3.30 which indicated high diversity. The species richness index of Station 1 (11.81) Station 2 (14.81) is high in both stations, as well as the evenness index of Station 1 (0.71) and Station 2 (0.76) and uniformity of Station1 (0.71) and Station 2 (0.76) which shows the distribution of individuals between species is quite even. Low dominance index values indicate the absence of dominating species. The species *Cymodocea rotundata* Ascherson & Schweinfurth, 1870 has the highest importance value, indicating its ecological dominance in the study area. This study proves that the ecosystem conditions in Tasik Ria Waters support diverse and balanced macrobenthos life.

Keywords: Community structure; diversity; macrobenthos; tasik ria

Introduction

North Sulawesi is one of the regions in Indonesia that has a very high level of marine biodiversity, especially in coastal ecosystems such as beaches, seagrass beds, mangroves, and coral reefs. Its geographical position in the Coral Triangle makes this region one of the world's centers of marine biodiversity. The coastal waters of North Sulawesi, such as Tasik Ria Beach, Bunaken, Lembeh, Bitung, and Bangka Island, are home to various species of marine flora and fauna, including reef fish, mollusks, crustaceans, echinoderms, and various types of macrobenthos (DLH North Sulawesi, 2009).

Tasik Ria is part of Indonesian waters located in the village of Mokupa, Tombariri District, Minahasa Regency, North Sulawesi. This area consists of three ecosystems, namely mangrove ecosystems, seagrass beds, and coral reefs. Tasik Ria Beach is often used for activities such as local tourism and fishing. Tourism and fishing greatly support human life, but need to be managed sustainably in order to maintain water quality. One way to monitor water quality is by monitoring the structure of the community and the diversity of macrobenthos (Connoly, 2005). Community structure is a structure that studies the composition or arrangement of species and their abundance in an ecosystem. The number of species in a community is ecologically

important because species diversity increases as the community becomes more stable (Wirakusuma, 2003).

Macrobenthos are a variety of animals and plants that live on the bottom of water bodies. Benthos are organisms that inhabit the substrate, both animals and plants. The word macro refers to a minimum size of 0.1 cm. Macrobenthos usually consist of algae, marine spermatophytes, invertebrates and lower chordates such as snails, starfish, crabs, oysters, clams, tunicates and insect larvae (Rahayu, 2015). In the ecosystem, macrobenthos can serve as a "home" for other benthos, contributing oxygen to the water and decomposing organic matter. Benthic organisms can be used as indicators because of their sessile or short-distance migratory habits and their varying adaptive abilities depending on their species, so that water quality can affect their survival and diversity in the monitored area (Dauvin et al., 2016; Prahmawaty et al., 2018; Ratih et al., 2015; Ruswahyuni et al., 2013; Sahidin et al., 2014). The composition and abundance of macrobenthos depend on their tolerance to environmental changes. Each community responds to changes in habitat quality by adjusting the structure of the community (Sulphayrin et al., 2018).

Several studies have been conducted around the waters of Mokupa. However, this area is very large and divided into several local tourist sites. In terms of ecosystem, Mokupa consists of mangrove ecosystems, seagrass beds, and coral reefs. Research conducted in Mokupa has generally been limited to coral reefs, with a focus on Echinodermata and seagrass beds (Umboh et al., 2016; Tuhumena et al., 2013; Zachawerus et al., 2015). Information on the condition of macrobenthos, which is the object of monitoring water quality in the Mokupa Lake area, is still rarely found. Based on this gap, it is considered necessary to study macrobenthos ecological indices such as community structure and macrobenthos diversity in the waters of Lake Ria, Mokupa Village, North Sulawesi.

Method

Time and Place of Research

The research was conducted at Tasik Ria Beach, Mokupa, Tombariri District, Minahasa Regency, North Sulawesi. The research location was around 1º24ˈ59.1"N 124º42ˈ24.7"E (**Figure 1**). Sampling was conducted from December 2024 to January 2025 and selected locations with different substrates, namely rocky and seagrass beds. The method used was an exploratory method with a sampling technique of purposive sampling.

Tools and Materials

The tools and materials used in this study were: writing instruments, identification guidebook, camera, loop, tape measure, litmus paper, pipe, 8x2 inch Retsch sieve, portable refractometer (ATC), sample containers (plastic), thermometer, and 70% alcohol.

Research procedures

Macrobenthos and sediment sampels

Macrobenthos and sediments were collected using 50 cm x 50 cm plots. The method used was the Survey method with a sampling technique called Purposive Sampling, whereby plots were placed in areas where benthic communities were found. Areas within the plots were sampled by filtering the sand substrate using an 8x2 inch Retsch sieve. The sediment remaining on the sieve was then separated into inorganic and organic (benthic) sediments. Rocks that entered the plot were washed on the sieve, and algae or seagrass plants were identified. These plants were also washed on the sieve to separate the benthos attached to the leaves. The samples were placed in zipper plastic bags and separated for each plot.

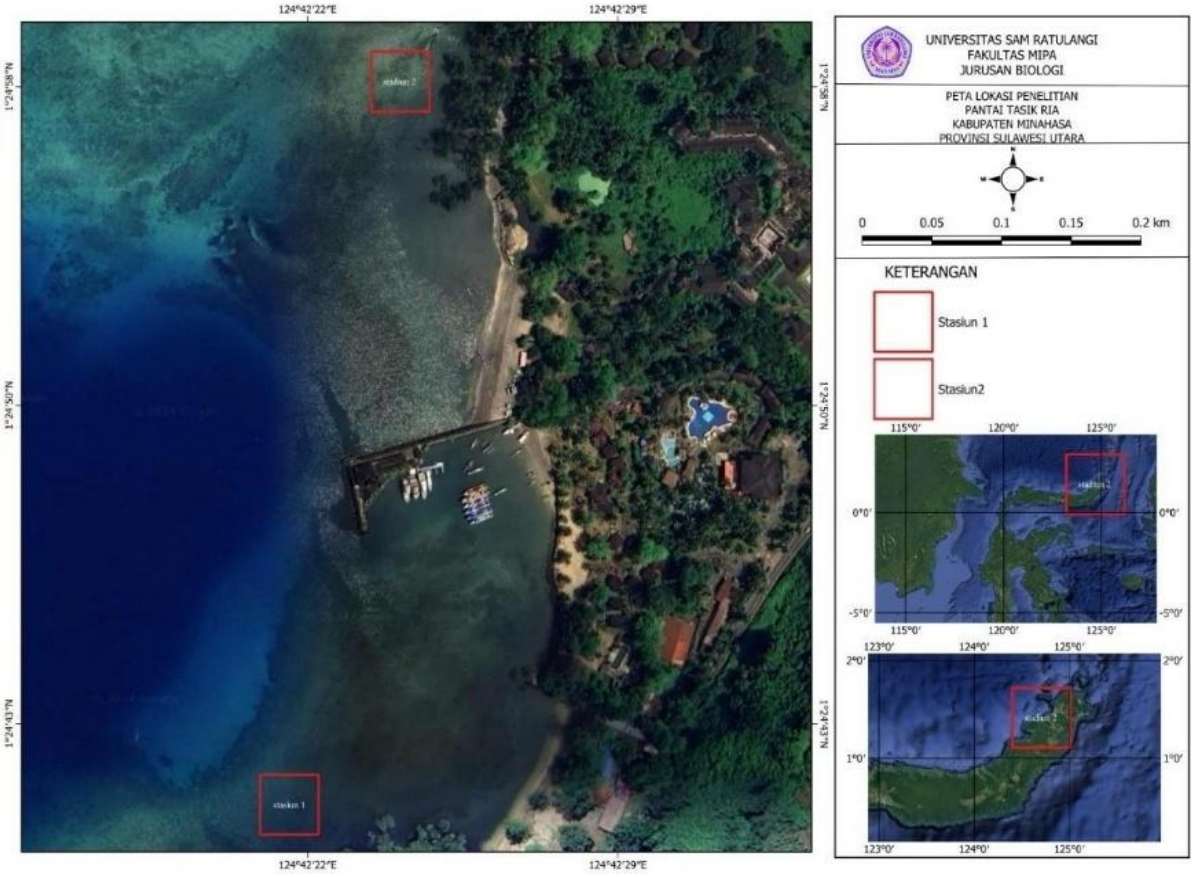

Figure 1. Research location

The sampling procedure was repeated 20 times around the study site, with 10 repetitions at Station 1 (1˚24'59.1“N 124˚42'25.0”E) and 10 repetitions at Station 2 (1˚24'40“N 124˚42'22”E). The macrobenthos samples were then preserved in 70% alcohol solution. Next, the macrobenthos were identified by observing their morphological characteristics with reference to the identification book.

Environmental Factor Measurement

The parameters analyzed were temperature, pH, and salinity. Temperature was measured using a thermometer, pH was measured using litmus paper, and water salinity was measured using a refractometer. This data describes the environmental conditions at the time of sampling.

Data analysis

This study analyzed species diversity index, evenness index, dominance index, uniformity index, and INP (Importance Value Index) based on the formulas described below.

Species Diversity Index

The species diversity index value is expressed based on the Shannon Wiener index.

$$H' = -\sum_{i=1}(pi \ln pi)$$

Description:

H' = Diversity index value

N = Total number of individuals of all species

ni = Number of individuals of species i

ln = Natural logarithm
s = Number of species in the community
Criteria:
H' < 1.00 = Low diversity
1.0 < H' < 3.00 = Moderate diversity
H' > 3.00 = High diversity

Equity Index

The concept of equity or uniformity or balance (equity) indicates the degree of equity in abundance among species. This analysis was conducted using the following formula (Krebs, 1989):

$$J = H'/ \ln S$$

Explanation:
J = Evenness index
H' = Species diversity index
S = Number of species observed
The criteria for the level of evenness according to (Odum,1993) are:
• J' > 0.75 = high evenness
• J' < 0.75 = low evenness

Dominance Index

The dominance index is used to indicate the presence or absence of macroinvertebrate organisms that dominate a macroinvertebrate community in aquatic environments. The calculation method used is the Simpson dominance index formula (Odum, 1996).

$$C = (\frac{ni}{N})2$$

Explanation:
C = Dominance index
ni = Number of individuals at genus level i
N = Total number of individuals from all genera
Criteria according to Simpson (1949):
C approaching 0 = Low dominance
C approaching 1 = High dominance

Uniformity Index

Browner & Zar (1984) state that the evenness index is calculated using the following formula:

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

Explanation:
E = Evenness index
H' = Diversity index
H max = Log2(S)
S = Number of species
Criteria for determining the Evenness Index:
E'<0.4 = Low evenness
0.4<E<0.6 = Moderate evenness
E' >0.6 = High evenness

Importance Value Index (INP)

The importance value index is a quantitative parameter that can be used to express the level of dominance (level of control) of species in a community (Agustinus and Pratomo, 2013). INP is calculated by adding the relative density and relative frequency values, namely:

$$INP = KR + FR$$

Where:

$$K = \frac{number\ of\ individuals\ of\ a\ species}{area\ size}$$

(KR) relative density of a species

$$KR = \frac{density\ of\ a\ species}{density\ of\ all\ species} \times 100\%$$

(F) Frequency of a species

$$F = \frac{number\ of\ points\ of\ a\ species}{total\ number\ of\ points}$$

(FR) Relative frequency

$$FR = \frac{frequency\ of\ a\ species}{density\ of\ all\ species} \times 100\%$$

Results and Discussions

Macrobenthos species

Based on the results of the research conducted, the macrobenthos found in the waters of Tasik Ria Beach, Mokupa Village, North Sulawesi, numbered 615 individuals consisting of 14 classes and 27 orders with a total of 74 species. The most abundant species was *Cymodocea rotundata* (138 individuals), from the phytobenthos group of the Magnoliopsida Division (Class Alismatales). The second most abundant species was *Tryphosella spitzbergensis* (90 individuals), which is a zoobenthos group from the Crustacea group. The species found can be seen in **Table 1**.

Table 1. Classification of Macrobenthos in the Coastal Waters of Tasik Ria, Mokupa Village, North Sulawesi

Ordo	Familly	Species	Total		∑
			St 1	St 2	
Neogastropoda	Cestellariidae	*Vexillum gruneri*	2	0	2
		Vexillum virgo	3	2	5
		Vexillum obeliscus	3	1	4
		Vexillum exasperatum	1	0	1
	Conidae	*Conus geographus*	1	0	1
		Conus glaucus	2	0	2
		Conus eximinus	1	0	1
		Conus anemone	1	0	1
		Conus eburneus	1	1	2
	Columbellidae	*Euplica scripta*	1	0	1
	Mitridae	*Pseudonebularia chrysalis*	1	0	1
		Imbricaria flammigera	2	1	3

Ordo	Familly	Species	Total		∑
			St 1	St 2	
		Scabricola olivaeformis	1	0	1
	Muricidae	*Arakawania granulate*	4	6	10
		Drupella cornus	2	3	5
		Drupella margariticola	4	2	6
		Morula biconica	2	2	4
	Neritidae	*Nerita balteata*	1	0	1
	Nassariidae	*Nassarius globosus*	2	1	3
	Terebridae	*Neoterebra pedroana*	1	1	2
	Pseudomelatomidae	*Crassispira*	2	0	2
	Olividae	*Oliva oliva*	2	0	2
Mesogastropoda	Cerithiidae	*Rhinoclavis aspera*	1	0	1
Archaegastropoda	Netridae	*Nerita plicata*	0	1	1
Caenogastropoda	Potamidididae	*Prinella cingulata*	2	0	2
Littorinimorpha	Eulimidae	*Melanella acicula*	2	0	2
	Triviidae	*Trivirostra oryza*	2	0	2
	Littorinidae	*Littoraria intermedia*	1	0	1
		Littoraria articulata	0	1	1
		Littoraria scabra	1	0	1
	Cypraeidae	*Cypraea annulus*	1	0	1
Stylommatophora	Achatinidae	*Paropeas achatinaceam*	1	0	1
Cycloneritida	Neritidae	*Nerita signata*	0	1	1
	Littorinidae	*Littoraria ianthostoma*	1	0	1
Decapoda	Stenopodidae	*Stenopus hispidus*	5	7	12
	Epialtidae	*Hyastenus hilgendorfi*	2	3	5
		Macrocoeloma eutheca	2	1	3
	Pilumnidae	*Pilumnus vespertilio*	3	4	7
	Penaidae	*Penaeus monodon*	4	2	6
		Metapenaeus monoceros	1	2	3
	Varunidae	*Hemigrapsus crenulatus*	4	3	7
	Alpheidae	*Alpheus spongiarum*	2	6	8
	Portunidae	*Thalamita latreille*	3	0	3
	Palaemonidae	*Ancylomenes holthuisi*	18	2	20
	Paguridae	*Pagurus bernhardus*	1	0	1
Cardiida	Cardiidae	*Vasticardium subrogosum*	1	0	1
		Ciliatocardium ciliatum	1	0	1
Diadematoida	Diadematidae	*Diadema savignyi*	14	9	23
		Echinothrix calamaris	7	5	12
Camarodonta	Temnopleuridae	*Mespilia globulus*	2	1	3
	Echinometridae	*Echinometra mathei*	3	0	3
Valvatida	Ophidiasteridae	*Linckia laevigata*	1	1	2
Ophiacanthida	Ophiarachnidae	*Ophiarachnella septemspinosa*	7	5	12
		Ophiomastix janualis	8	5	13
		Ophiarachna incrassate	5	7	12
Amphinomida	Amphinomidae	*Choleia flava*	2	1	3

Ordo	Familly	Species	Total		∑
			St 1	St 2	
Eunicaida	Eunicidae	*Marphysa sanguinea*	0	1	1
		Palola viridis	5	0	5
Phyllodocida	Syllidae	*Syils spongiphila*	4	0	4
	Polynoidae	*Lepidonotus* sp	3	0	3
Alismatales	Hydrocharitaceae	*Halophila minor*	7	0	7
	Cymodoceaeceae	*Syringodium isoetifolium*	8	5	13
		Cymodocea rotundata	120	18	138
Fucales	Sargassaceae	*Sargassum spinuligerum*	6	3	9
Dictyotales	Dictyotaceae	*Padina boergesenii*	4	1	5
		Canistrocarpus cervicornis	8	5	13
Gracilariales	Gracilariaceae	*Gracilaria salicornia*	8	5	13
Ceramiales	Rhodomelaceae	*Acanthophora spicifera*	3	3	6
Corallinales	Lithopyllaceae	*Amphiroa rigida*	6	2	8
Brypsidales	Halimedaceae	*Halimeda macroloba*	5	2	7
		Halimeda opuntia	5	2	7
Scleractinia	Faviidae	*Lobophyllia vitiensis*	4	0	4
Amphipoda	Tryphosidae	*Tryphosella spitzbergensis*	87	3	90
	Uristidae	*Ichnopus sp*	53	1	54
26	48	74	484	138	615

Number of macrobenthos species

The amount of macrobenthos varies at each station. Station 1, which has a seagrass bed substrate, has a high abundance of macrobenthos. Meanwhile, Station 2 has a low abundance because it has a substrate of sand mixed with coral fragments and has less seagrass bed substrate than Station 1. The high abundance at Station 1 is related to the presence of seagrass beds in the substrate. Seagrass beds are ideal habitats for surrounding biota as places to shelter and feed. For some types of biotas, seagrass beds are even spawning grounds (Boesch, 1973).

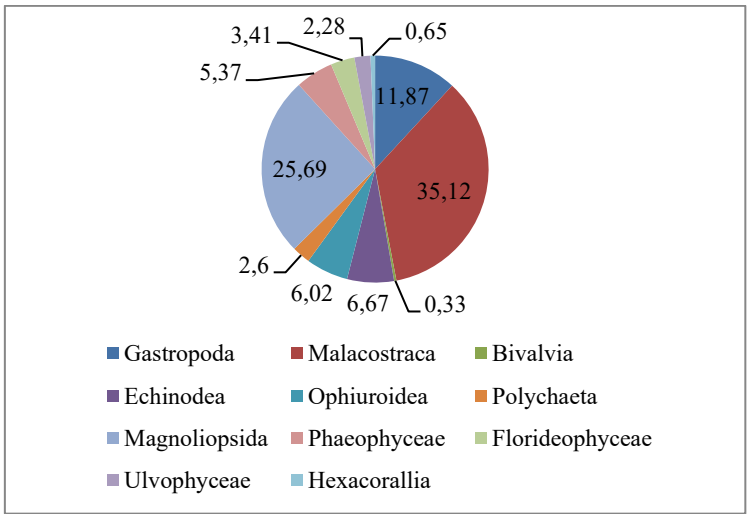

Figure 2. Diagram showing the number of individuals in each Macrobenthos Class

The macrobenthos found varied in size. Zoobenthos such as Gastropoda, Malacostraca, Magnoliopsida, and Echinoidea were more dominant in the Tasik Ria coastal area. Information on the types and number of macrobenthos individuals found on Tasik Ria Beach can be seen in **Figure 2**. This analysis illustrates the high diversity of macrobenthos in the area.

Based on the diagram, it can be seen that the Malacostraca class dominates, with a total of 216 Malacostraca individuals (35.12%). In second place is Magnoliopsida with 158 individuals (25.69%), Gastropoda with 75 individuals (11.87%), Echinoidea with 41 individuals (6.67%), Ophiuroidea with 37 individuals (6.02%), Phaeophyceae with 33 individuals (5.37%), Florideophyceae with 21 individuals (3.41%), Polychaeta with 16 individuals (2.60%), Ulvophyceae with 14 individuals (2.28%), Hexacorallia with 4 species (0.65%), and Bivalvia with 2 individuals (0.33%). Magnoliopsida or seagrass plants are the basic biota that make up the ecosystem at Station 1. However, Crustacea had the highest abundance of individuals. This is because small Amphipoda occupy Cymodacea leaves as a shelter. Generally, zoobenthos found on Magnoliopsida leaves (seagrass beds) do not directly eat the seagrass leaves, but rather eat microbes, macro and micro algae (epiphytes) that attach to the seagrass leaves. Small crustaceans such as Amphipoda have many food preferences, including organic matter, larvae, and copepods. Thus, larvae and organic matter that settle on seagrass leaves become food for small crustaceans (Wellborn et al., 2015).

The Malacostraca class has a higher value because seagrass beds are a very widespread biotype in coastal and estuarine environments that have high biological productivity thanks to the association of flora and fauna concentrated in these seagrass beds (Azkab, 2000). Malacostraca feed on other small organisms that live attached to seagrass leaves and are also a major component of food webs in seagrass beds. Crustacea play an important role in the relationship between primary producers and higher trophic levels (Tomascik et al., 2013). The class Bivalvia has a low value due to unsuitable substrate, limited water flow, and competition or other environmental pressures.

Macrobenthos diversity index

The macroinvertebrate diversity index (H') at Tasik Ria Beach is 3.30. This value is classified as high. This indicates that the ecosystem at Tasik Ria Beach supports the life of macroinvertebrate species. The most dominant order is Neogastropoda with 22 species, followed by Decapoda with 9 species, Littorinimorpha with 6 species, Ophiacanthida with 3 species, Alismatales with 3 species, Cycloneritida with 2 species, Cardiida with 2 species, Diadematoida with 2 species, and Camarodonta with 2 species. Dictyotales with 2 species, Eunicaida and Phyllodocida with 2 species each, Brypsidales with 2 species, and Mesogastropoda, Archeogastropoda, Caenogastropoda, Stylommatophora, Fucales, Stomatopoda, Gracilariales, Ceramiales, Corallinales, and Scleractinia with 1 species each (**Figure 3**).

Species diversity is influenced by the number of species and the distribution of individuals of each species, because even if a community has many species, if the distribution of individuals is uneven, its species diversity will be low. Diversity expresses the variation of species in an ecosystem. When an ecosystem has a high diversity index, it tends to be balanced (Kim et al., 2023).

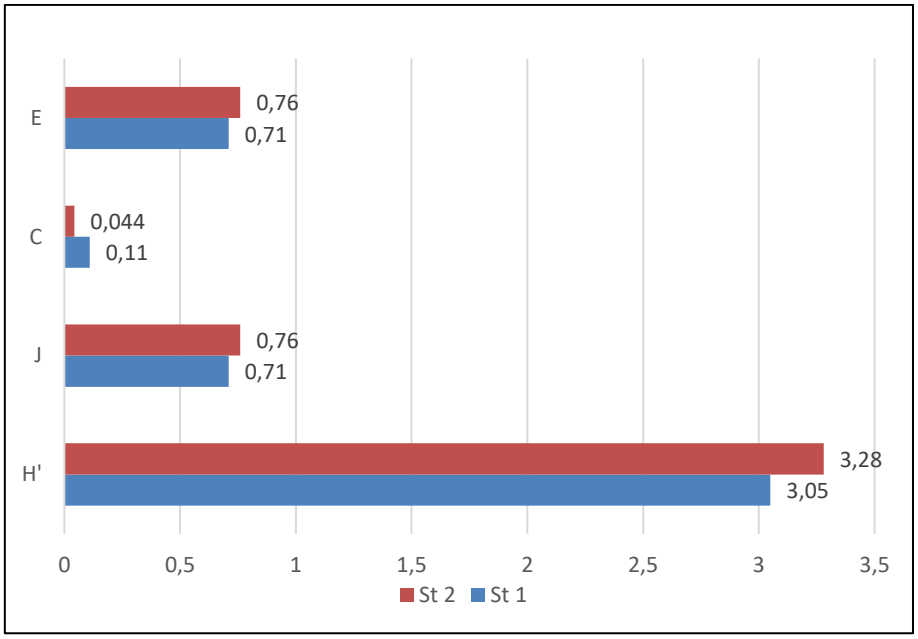

Figure 3. Ecological Index Diagram (H' = Diversity Index, J = Evenness Index, C = Dominance Index, E = Uniformity Index)

Several previous studies have discussed the community structure and diversity of macrobenthos on various beaches in Indonesia. one of which is the study by Wulandari et al. (2020) in the waters of Jakarta Bay, which found 23 species with a diversity index value of 1.88, where the level of diversity in this area is moderate because it is a residential and industrial area, and an evenness index value of 0.76, where there are no dominant species so that the distribution of species is even. Madyowati and Kusyairi's (2020) study in Banyuurip Village, Ujungpangkah District, Gresik Regency, found 15 species, with a station value of 2.57 at station 1, 2.45 at station 2, and 1.66 at station 3. The Diversity Index value at stations 1-2 was > 3.0, which is categorized as “moderate”. A moderate diversity levels indicate a fairly balanced ecosystem with ecological pressures, resulting in a fairly even distribution of macrobenthos species, while Station 3 has a diversity index of < 2.0, which is categorized as “low.” Low diversity levels indicate that the distribution of individuals of each species is uneven. This is due to the smaller number of species and the presence of a few individuals in greater numbers, resulting in ecosystem instability. Station 3, which is a river mouth adjacent to the ocean, has extreme conditions, so the macrobenthic biota that live there are those that are truly able to adapt to these conditions, resulting in low macrobenthic diversity. The Dominance Index value of 0.2 means that no species dominates at any sampling station. Low dominance levels in a macrobenthic community in a water body indicate that the aquatic ecosystem has uniform diversity.

The results of this study show that the community structure and macrobenthic diversity at Tasik Ria Beach have a diversity index (H') of 3.30, which is categorized as “high.” This value places Tasik Ria Beach in first place compared to various other locations in Indonesia that have been studied previously. The high Community Structure and Macrobenthos Diversity in this area is closely related to the diversity of habitat characteristics, which include variations in substrate types and environmental conditions that support species abundance and distribution.

Equity index

The species evenness index values at Station 1 and Station 2 can be categorized as high with an index value of J' > 0.75. This value indicates that no species dominates the community, and each species has a relatively balanced number of individuals (Krebs, 1989; Boesch, 1973). This condition reflects that the aquatic environment at Tasik Ria Beach is stable and supports a balanced variety of macrobenthos life. High evenness is also related to the distribution of seagrass beds, which are the "host" for most of the macrobenthos found.

Dominance index

From the results of the Dominance Index (C) obtained at Station 1 was 0.11, while at Station 2 it was 0.044. This value is considered low or indicates the absence of a dominant species. The level of dominance is interrelated with the uniformity index value. If the uniformity index (E) is high, the dominance index (C) tends to be low, and vice versa. A dominance index value close to 0 is usually followed by a relatively high uniformity value, while a dominance index close to 1 indicates dominance in a water body characterized by a low diversity index value (Munandar et al., 2016).

Based on **Table 1**, it can be seen that no species dominated at any observation station. This indicates that the community is stable, with no ecological pressure causing environmental changes. Mou et al. (2023) state that dominance indicates that the area has low species richness with uneven distribution, meaning that within the observed community, there are species that dominate other species.

Uniformity index

The uniformity of macrobenthos in the waters of Tasik Ria Beach is shown in Figure 4.76. The uniformity level (E) at each station is categorized as high, with a uniformity index of 0.71 at Station 1 and 0.76 at Station 2. Macrobenthos in the waters of Tasik Ria Beach is evenly distributed, referring to Krebs (1989) where if 0.6 < E, then the level of uniformity is high.A stable community indicates that the ecosystem has high diversity, with no dominant species and an even distribution of individuals, meaning that the number of individuals of each species is the same and there is no tendency for a particular species to dominate (Odum, 1971).

Importance value index

Based on **Table 2**, the macrobenthos species with the highest INP value is Cymodocea rotundata, indicating that this species has a wide distribution, high frequency of occurrence at various sampling points, and a dominant number of individuals. These conditions show that the species is highly adaptive to the environmental conditions at the study site and is able to make optimal use of available resources.

Table 2. Important Value Index of Macrobenthos in the Coastal Waters of Tasik Ria, Mokupa Village, North Sulawesi

Species	Total	K	KR	F	FR	INP
Vexillum gruneri	2	1	0.33	1	0.94	1.27
Vexillum virgo	5	2.5	0.81	2	1.89	2.70
Vexillum obeliscus	4	2	0.65	2	1.89	2.54
Vexillum exasperatum	1	0.5	0.16	1	0.94	1.11
Conus geographus	1	0.5	0.16	1	0.94	1.11
Conus glaucus	2	1	0.33	1	0.94	1.27
Conus eximinus	1	0.5	0.16	1	0.94	1.11
Conus anemone	1	0.5	0.16	1	0.94	1.11
Conus eburneus	2	1	0.33	2	1.89	2.21

Species	Total	K	KR	F	FR	INP
Euplica scripta	1	0.5	0.16	1	0.94	1.11
Mitra chrysalis	1	0.5	0.16	1	0.94	1.11
Imbricaria flammigera	3	1.5	0.49	2	1.89	2.37
Imbricaria olivaeformis	1	0.5	0.16	1	0.94	1.11
Morula granulata	10	5	1.63	2	1.89	3.51
Drupella cornus	5	2.5	0.81	2	1.89	2.70
Morula margariticola	6	3	0.98	2	1.89	2.86
Habromorula biconica	4	2	0.65	2	1.89	2.54
Nerita balteata	1	0.5	0.16	1	0.94	1.11
Nassarius globosus	3	1.5	0.49	2	1.89	2.37
Neoterebra pedroana	2	1	0.33	2	1.89	2.21
Crassispira Swainson	2	1	0.33	1	0.94	1.27
Oliva olive	2	1	0.33	1	0.94	1.27
Rinoclavis aspera	1	0.5	0.16	1	0.94	1.11
Nerita plicata	1	0.5	0.16	1	0.94	1.11
Cerithidea cingulata	2	1	0.33	1	0.94	1.27
Melanella acicula	2	1	0.33	1	0.94	1.27
Trivirostra oryza	2	1	0.33	1	0.94	1.27
Littoraria intermedia	1	0.5	0.16	1	0.94	1.11
Littoraria articulata	1	0.5	0.16	1	0.94	1.11
Littorina scabra	1	0.5	0.16	1	0.94	1.11
Cypraea annulus	1	0.5	0.16	1	0.94	1.11
Paropeas achatinaceam	1	0.5	0.16	1	0.94	1.11
Nerita signata	1	0.5	0.16	1	0.94	1.11
Littoraria ianthostoma	1	0.5	0.16	1	0.94	1.11
Stenopus hispidus	12	6	1.95	1	0.94	2.89
Hyastenus hilgendorfi	5	2.5	0.81	2	1.89	2.70
Macrocoeloma eutheca	3	1.5	0.49	2	1.89	2.37
Pilumnus vespertilio	7	3.5	1.14	2	1.89	3.03
Penaeus monodon	6	3	0.98	2	1.89	2.86
Metapenaeus monoceros	3	1.5	0.49	2	1.89	2.37
Hemigrapsus crenulatus	7	3.5	1.14	2	1.89	3.0
Alpheus spongiarum	8	4	1.30	2	1.89	3.19
Thalamita latreille	3	1.5	0.49	1	0.94	1.43
Ancylomenes holthuisi	20	10	3.25	1	0.94	4.20
Squilla mantis	1	0.5	0.16	1	0.94	1.11
Trachycardium subrogosum	1	0.5	0.16	1	0.94	1.11
Ciliatocardium ciliatum	1	0.5	0.16	1	0.94	1.11
Diadema savignyi	23	11.5	3.74	2	1.89	5.63
Echinothrix calamaris	12	6	1.95	2	1.89	3.84
Mespilia globulus	3	1.5	0.49	1	0.94	1.43
Echinometra mathei	3	1.5	0.49	2	1.89	2.37
Linckia laevigata	2	1	0.33	2	1.89	2.21
Ophiarachnella septemspinosa	12	6	1.95	2	1.89	3.84
Ophiomastix janualis	13	6.5	2.11	2	1.89	4.00
Ophiarachna incrassate	12	6	1.95	2	1.89	3.84
Choleia flava	3	1.5	0.49	2	1.89	2.37
Marphysa sanguinea	1	0.5	0.16	1	0.94	1.11
Palola viridis	5	2.5	0.81	1	0.94	1.76
Syils spongiphila	4	2	0.65	1	0.94	1.59
Lepidonotus sp	3	1.5	0.49	1	0.94	1.43
Halophila minor	7	3.5	1.14	2	1.89	3.03
Syringodium isoetifolium	13	6.5	2.11	2	1.89	4.00
Cymodocea rotundata	138	69	22.44	2	1.89	24.33
Sargassum spinuligerum	9	4.5	1.46	2	1.89	3.35
Padina boergesenii	5	2.5	0.81	1	0.94	1.76
Dictyota cervicornis	13	6.5	2.11	2	1.89	4.00

Species	Total	K	KR	F	FR	INP
Gracilaria salicornia	13	6.5	2.11	2	1.89	4.00
Acanthophora spicifera	6	3	0.98	2	1.89	2.86
Amphiroa rigida	8	4	1.30	2	1.89	3.19
Halimeda macroloba	7	3.5	1.14	2	1.89	3.03
Halimeda opuntia	7	3.5	1.14	2	1.89	3.03
Scolymia vitiensis	4	2	0.65	1	0.94	1.59
Tryphosella spitzbergensis	90	45	14.63	1	0.94	15.58
Ichnopus sp	54	27	8.78	1	0.94	9.72
Total	615	307.5	100	106	100	200

Species with high INP are generally also ecological indicators, either as species tolerant to pollution or as markers of healthy environmental conditions, depending on the type. For example, the dominance of opportunistic or pollution-tolerant species can be an indication of environmental pressure. Conversely, the dominance of species that are sensitive to pollution indicates that water conditions are still relatively good (Baderan et al., 2021).

Environmental parameters

According to Suin (2002), environmental factors greatly influence the distribution and abundance of an organism's population. If the abundance of a species in an ecosystem is very high, it indicates that the environmental factors in that ecosystem support the life of that species (Kim et al., 2023). In this study, the environmental parameters measured were pH, temperature, and salinity. Based on the results of environmental parameter measurements at Tasik Ria Beach, Mokupa Village, North Sulawesi, the data can be seen in **Table 4**.

Table 4. Environmental parameters of Tasik Ria Beach

Parameter	St 1	St 2
pH	7	7
Temperature	34	35
Salinity	30	30

The pH values obtained from the research locations were 7 at Station 1 and 7 at Station 2. These values indicate neutral conditions, which is the ideal range for most aquatic organisms, including macrobenthos. These values are in accordance with the quality standards according to Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning marine water quality standards for marine biota with a pH value of 7.0-8.5 ppm. A neutral pH indicates that there are no significant changes in the water buffer system, thereby supporting the survival of marine biota (Yulianto et al., 2023).

The temperature obtained from the research results was 34ºC at Station 1 and 35ºC at Station 2. The temperatures obtained at both stations are still within the normal range for macrobenthos development. According to Isman (2016), the temperature range that can be tolerated by macrobenthos is between ±25-36ºC.

The salinity obtained at both research locations ranged from 30 ppt. This value is in accordance with the quality standards according to Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning marine water quality standards for marine biota with a salinity of 0-35 ppt. Salinity stability also reflects the absence of disturbances from freshwater inflow or significant brackish water intrusion.

Conclusion

Macrobenthos in the waters of Tasik Ria, Mokupa Village, North Sulawesi, consists of 14 classes, 26 orders, and 74 species. The Shannon-Wiener diversity index (H') at Tasik Ria Beach is 3.30, indicating a high level of diversity. The evenness index (0.77) and uniformity index (0.77) are also relatively high, indicating that the distribution of individuals among species is fairly even and not dominated by any particular species. This is reinforced by the low dominance index value (0.09). The species *Cymodocea rotundata* was recorded as having the highest importance value of 24.33, indicating its dominant ecological role.

References

Agustinus, Y dan Pratomo A. (2013). Struktur Komunitas Makrozoobentos Sebagai Indikator Kualitas Perairan di Pulau Lengkang Kecamatan Belakang Padang Kota Batam Provinsi Kepulauan Riau. Jurnal Ilmu Kelautan, FIKP, Universitas Maritim Raja Ali Haji (UMRAH).

Baderan, D., Rahinm, S., Angio, M. & Salim, A. (2021). Keanekaragaman, Kemerataan, dan Kekayaan Spesies Tumbuhhan dari Geosite Potensial Benteng Otanaha Sebagai Rintisan Pengembangan Geopark Provinsi Gorontalo. Al-Kauniyah: Jurnal Biologi 14(2), 264-274. http://dx.doi.org/10.15408/kauniyah.v14i2.16746

Boesch, D.F. (1973). Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. Marine Biology 21, 226–244. https://doi.org/10.1007/BF00355253

Brower, J, E. & Zar, J, R. (1984). - Field and Laboratory Methods for general Ecology. Dubuque, Iowa: 226 p.Wm. C. Brown Publishers.

Connoly, S. R., Hughes, T. P., Bellwood D. R., and Karlson, R. H (2005) *"Community Structure of Corals and Reef Fishes at Multiple Scales"* Science, 305(5618), 1925-1927.

Dauvin, J. C., Andrade, H., de-la-OssaCarretero, J. A., Del-Pilar-Ruso, Y., & Riera, R. (2016). Polychaete/amphipod ratios: An approach to validating simple benthic indicators. Ecological Indicators, 63, 89-99. doi:https ://doi.org/10.1016/j.ecolind .2015.11.055

Isman, M. (2016). Hubungan Makrozoobentos dengan Bahan Organik Total (BOT) pada Ekosistem Mangrove di Kelurahan Ampalas Kec. Mamuju Kab. Mamuju Sulawesi Barat. (Skripsi). Universitas Hasanuddin Makasar. 61 hlm

Kim, S. L., Kang, S. M., Lee, H. G., Han, G. H., & Yu, O. H. (2023). Species Diversity and Community Structure of Macrobenthos in the Ulleung Basin, East Sea, Republic of Korea. Journal of Marine Science and Engineering, 11(1), 92. https://doi.org/10.3390/jmse11010092

Krebs, C. J. (1989). Ecological methodology. New York: Hoper and Row Publisher.

Madyowati Sri & Kusyairi Achmad (2020). Keanekaragaman Komunitas Makrobentos pada Ekosistem Mangrove di Desa Bayuurip Kecamatan Ujung Pangkah Kabupaten Gresik. Journal of Fisheries and Marine Research Vol 4 No 1 (2020)116-124

Mou, J., Liu, K., Huang, Y., Lin, J., He, X., Zhang, S., Li, D., Zu, Y., Chen, Z., Fu, S., Lin, H., & Liu, W. (2023). Species Diversity and Community Structure of Macrobenthos in the Cosmonaut Sea, East Antarctica. Diversity, 15(12), 1197. https://doi.org/10.3390/d15121197

Munandar, A., Ali, M., Karina, S. (2016). Struktur Komunitas Makrozoobenthos di Estuari Kuala Rigaih Kecamatan Setia Bakti Kabupaten Aceh Jaya." Jurnal Ilmiah Mahasiswa Kelautan Perikanan Unsyiah, vol. 1, no. 3.

Odum E. P., 1971. Fundamental of Ecology. Published by W.B Saunders Company. Philadelphia and London

Prahmawaty, R.F., Putro, S.P dan Hariyati, R. (2018). Struktur Komunitas Makrobentos Pada Kawasan Budidaya dan Non Budidaya Di Pulau Tembelas, Kabupaten Karimun Kepuluan Riau. Bioma. Vol. 20, No. 1, Hal. 66-74.

Rahayu Siti. (2015). "Kelimpahan Dan Keanekaragaman Makrozoobentos Di Beberapa anak sungai Batang Lubuh". Jurnal MIPA. Vol. 2. No. 1.

Ratih, I., Prihanta, W., Susetyarini, R, E. (2015). Inventarisasi Keanekargaman Makozoobentos di Daerah Aliran Sungai Brantas Kecamatan Ngoro Mojokerto sebagai Sumber Belajar Biologi SMA Kelas X. Jurnal Pendidikan Biologi Indonesia, Vol 1, No 2, Hal 158-169.

Ruswahyuni. (2010). Populasi dan Keanekaragaman Hewan Makrobentos pada Perairan Tertutup dan Terbuka di Teluk Awur, Jepara. Jurnal ilmia perikanan dan kelautan, 2 (1): 11-20.

Tuhumena, Jeremias R., Janny D. Kusen, and Carolus P. Paruntu. (2013). "Struktur Komunitas Karang Dan Biota Asosiasi Pada Kawasan Terumbu Karang Di Perairan Desa Minanga Kecamatan Malalayang II Dan Desa Mokupa Kecamatan Tombariri." Jurnal Pesisir Dan Laut Tropis 1 (3): 6.

Sahidin, A., Setyobudiandi, I., Wardianto, Y (2014). Struktur Komunitas Makrozoobentos di Perairan Pesisir Tangerang, Banten.

Sulphayrin, Ola, L.O.L., Arami, H. (2018). Komposisi dan Jenis Makrozoobenthos (Infauna) Berdasarkan Ketebalan Substrat Pada Ekosistem Lamun Di Perairan Nambo Sulawesi Tenggara. Jurnal Manajemen Sumber Daya Perairan, 3(4): 343-352.

Suin, N.M. (2002). Metoda Ekologi. Penerbit Universitas Andalas. Padang.

Umboh, S. C. S., Rembet, U. N. W. J., Loho, A. V. (2016). Komunitas Bintang Laut Di Perairan Pantai Desa Mokupa Kecamatan Tombariri Kabupaten Minahasa Provinsi Sulawesi Utara. Jurnal Ilmiah Platax.Vol. 4(1). ISSN: 2302-3589.

Wirakusuma, S. (2003). Dasar-Dasar Ekologi Menopang Pengetahuan Ilmu-Ilmu Lingkungan. Jakarta: UI Press.

Wellborn, G. A., Witt, J. D. S., & Cothran, R. D. (2015). Chapter 31—Class Malacostraca, Superorders Peracarida and Syncarida. In J. H. Thorp & D. C. Rogers (Eds.), Thorp and Covich's Freshwater Invertebrates (Fourth Edition) (pp. 781–796). Academic Press. https://doi.org/10.1016/B978-0-12-385026-3.00031-0

Wulandari, D., Widyastuti, E., Wirawati, I. & Subandi, R. (2021). Struktur Komunitas dan Keanekaragaman Makrobentos di Perairan Teluk Jakarta. Al-Kauniyah: Jurnal Biologi 14(1), 115-126. http://dx.doi.org/10.15408/kauniyah.v14i1.16277

Yulianto, H., Maharani, H., Delis, P. & Finisia, N. (2023). Struktur Komunitas Makrozoobentos pada Ekosistem Mangrove di Daerah Penyangga Taman Nasional Way Kambas. *"Jurnal Sumberdaya Perairan*, vol. 17 no. 1.

Zachawerus, F., Kambey, A., & Mantiri, R. (2015). Structure Community of Seagrass (Lamun) In The Village Beach Of Mokupa Tombariri Subdistrict, Minahasa District North Sulawesi.. Jurnal Ilmiah PLATAX, 3(1), 16-21. doi:https://doi.org/10.35800/jip.3.1.2015.18954