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RESEARCH ARTICLE

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Analysis of diversity of macrobenthos in mangrove ecosystems as a bioindicator of pollution of the Kalianget coastal area

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Abstract

Macrobenthos is a biological resource of water that lives on the bottom of the waters with characteristics that have a high level of sensitivity to changes in environmental quality as a bioindicator of pollution and environmental quality. The purpose of the study was to determine macrobenthos diversity as an indicator of pollution in the Kalianget coastal mangrove forest. Descriptive research with random sampling method with squared transects. Data collection through observation of macrobenthos populations. Research results a) the greatest diversity of macrobenthos of the class Crustaceans obtained 9 species, class Gastropods 5 species, class Bivalves found 3 species and from class Polychaeta found 1 species. b) The Macrobenthos Diversity Index on the Kalianget coast is 1.084539 with the category of moderate macrobenthos diversity, has moderate community stability and polluted waters but is still within the threshold that living things can tolerate.

Keywords: Diversity; Index diversity; Macrobenthos; Mangrove ecosystems

Introduction

Kalianget Coast is one of the coasts in Sumenep regency which still has an abundance of mangroves as the main place and habitat of macrobenthos in the water area[1]. Land areas in Sumenep Regency still have mangrove forest, one of which is Kalianget District with a total area of 129 hectares[1,2]. The dominating mangrove species are *Rhizophora mucronata* and *Avicenia alba*[3]. These two species have compatibility with habitats on the coast of Kalianget due to the compatibility of soil conditions to plant growth with the characteristics of muddy soils[2]. Biographical conditions on the coastline Kalianget Subdistrict also support the breeding of macrobenthos so that they can adapt well[4].

Macrobenthos are aquatic biological resources that live at the bottom4. These organisms are easy to find and identify in coastal and coastal areas. In others, this animal has a high level of sensitivity to

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changes in environmental quality or water quality. So in the amount, composition and distribution can be a reference in knowing the quality of the environment[5]. The role of macrobenthos as bioindicators is in assessing and knowing the condition of a water[6]. Changes in water conditions and habitats will affect the number, abundance and distribution of this organisms[6–8]. A community consists of a collection of various populations living in a particular region at the same time, interacting with each other and influencing each other. The surrounding environment is very important for the organism, so this also needs to be studied the type, composition of the organism, the distribution of organisms, as well as their function and relationship to the environment[7].

Most of the macrobenthos living in mangrove areas live on muddy and also hard soils[7,8]. macrobenthos in mangrove areas lives on the substrate by soaking in mud pits, on the surface of the substrate or by attaching to mangrove roots. At low tide, macrobenthos forage from the rest of the substrate and foliage litter found in the mud[6]. Macrobenthos commonly found in mangrove areas are gastropods, crustaceans, bivalves, and polychaeta. The life of macrobenthos depends on the presence of nutrients in the form of detritus, this relates to its role as a decomposer[4,8].

The main role of mangrove forests in the ecosystem is through the process of leaves falling into the waters[9]. Leaves that fall a lot have nutrient content that is beneficial for plants and marine animals, but the process of leaf utilization cannot occur immediately[10,11]. This is because it takes time for the litter to undergo weathering or decay with macrobenthos as a facilitator who can speed up the process of decay[9,10].

Pollution that occurs in waters, especially in coastal and coastal areas, is an important problem that must be considered by various parties[12]. Among the various sources of pollutants that enter and accumulate in coastal or coastal areas, among others, they come from the accumulation of waste from residential areas, productive and non-productive activities of residents that accumulate and produce waste that goes to the coast[10]. Pollution materials that enter the waters mainly consist of various kinds of waste, both organic and inorganic waste, soil sediments, pesticide residues and others[13].

The rate of population growth and rapid development activities have caused the coastal environment in several areas have decreased or damaged, especially marked by a decrease in mangrove land in coastal areas in Kalianget District[1]. There are indications of quality decline on the Kalianget Coast as explained in the previous section, then macrobenthos diversity research to find out water quality indicators on the coast of Sumenep Regency needs to be carried out because it is important to be used as a basis for study in developing regional areas and as a reference for other researchers to be used as a reference source in the learning process.

Materials and methods

Study area

Research on mangrove forests was conducted on the Kalianget Coast, Sumenep Regency, located in 7°02'37.9"SL 113°55'10.5"EL. The research was carried out in the afternoon with the most optimal estimated receding time of seawater[14]. Macrobenthos samples were identified in the laboratory of the State University of Malang using a guide from the Indonesian Snail and Shellfish identification book[15].

Research Procedure

The method used in this study is transecting random sampling, which is a random sampling technique that does not consider population stratification to obtain a homogeneous population[14]. There are 3 research stations with 10 sample plots at each station[5,16]. The tools and materials used in the research are GPS, Grab sampler, cool box, bucket, Sieve net, tweezers, digital cameras, stationery, sample bags, label paper, aquades, alcohol 70%, identification book of Macrobenthos.

Macrobenthos sampling was using a grab sampler by creating a square plot with an area of 1 × 1 meters at each sampling spot/point. Sampling is carried out evenly to a predetermined surface. The sampling location is in the intertidal zone. Each location is repeated 4-5 times on average, so each location has 10 sampling points for observation[14].

Data Analysis

This study uses data analysis techniques with a Diversity Index (H') that describes the state of the macrobenthos population mathematically to make it easier to analyze the diversity of Macrobenthos species on the Kalianget coast. The macrobenthos diversity index was calculated by the Index Evennes formula[5]:

$$H' = -\Sigma\ ni/N \times In\ ni/N$$

H' as the Species Diversity Index; ni is the individual total of each species; N represents the total number of individuals. Diversity (H') has a large value if individuals come from different genera or species, while a small value is obtained if all individuals are from one species or genus5. The interpretation of the results of the diversity index in species can be seen in **Table 1**.

Table 1. Diversity index categories (H')

No.	Diversity (H')	Category
1.	H' < 2,0	Low
2.	2,0 < H' < 3,0	Moderate
3.	H' ≥ 3,0	High

Results

Distribution, Type Composition and Abundance of Macrobnthos

The structure of the macrobenthos community can be known by studying several aspects related to the Macrobenthos community including the process of proper identification and understanding of the diversity of species that exist in a community[4]. The structure of the macrobenthos community consists of numbers at type and density. The composition of the macrobenthos analyzed is species diversity which is closely related to the quality of water[4,6]. The composition of macrobenthos species can be seen in the **Table 2**.

Discussion

Diversity of Macrobenthos Species

Based on **Table 1**, 18 species of macrobenthos species can be identified which are found in all stations. The macrobenthos species consisted of 5 species from the Gastropod class (Fillum Mollusca), 3 species from the Bivalvia class (Fillum Mollusca), 9 species from the Crustacea class (Fillum Arthropoda) and 1 species from the Polychaeta class (Fillum Annelida). This indicates that the macrobenthic community is an animal that lives on the bottom and also sediments in waters, the life cycle can be carried out by digging holes, creeping or sessile or attaching them to the substrate, this is in accordance with the sampling location (Kalianget coast) which has water characteristics. Sandy, muddy and full of litter[4,17]. This is in accordance with reference sources that the dominant group of organisms that compose macrofauna in coastal and bottom waters usually consists of 4 groups: Class Polychaeta, Class Crustacea, Class Bivalvia and Class Gastropods[18].

Macrobenthos species with the highest number of species diversity Class Crustacea in the order Decapoda such as shrimp group with the following species: *Acetes indicus*, *Cambarellus* sp., *Alpheus carlae*,

A. angulosus, *A. bouvieri* and *Macrobrachium rosenbergii*. In addition, in the Class Crustacea in the order Decapoda in the crab group, 3 species were also found, namely: *Uca* spp., *Scylla serrata* and *Metopograpsus oceanicus*. Apart from the Crustacea class, there was also Gastropods class with 5 species, namely: *Bolinus brandaris*, *Cerithidea* sp., *Cerithium* sp., *Littorina* sp. and *Turbo* sp. Then in Class Bivalvia which is a group of macrobenthic animals that have a way of life by crawling, digging the soil and attaching directly to the substrate, 3 species are obtained, namely: *Papillicardium papillosum*, *Lucinoma borealis* and *Crassostrea* sp.

Table 2. Distribution, composition and number of macrobenthos

No	Species	∑ Species		
		I	**II**	**III**
	Crustacea/shrimp			
1.	*Acetes indicus*	3	-	-
2.	*Cambarellus sp.*	-	2	-
3.	*Alpheus carlae*	1	-	3
4.	*Alpheus angulosus*	-	-	1
5.	*Alpheus bouvieri*	-	-	1
6.	*Macrobrachium rosenbergii*	5	2	-
7.	*Uca spp.*	1	1	-
8.	*Schylla serrata*	-	2	-
9.	*Metopograpsus oceanicus*	-	1	1
	Gastropod/snail			
1.	*Bolinus brandaris*	-	-	1
2.	*Cerithidea sp.*	12	3	-
3.	*Cerithium sp*	2	2	5
4.	*Littorina sp*	3	1	1
5.	*Turbo sp*	1	2	-
	Bivalvia/shellfish			
1.	*Papillicardium papillosum*	1	1	-
2.	*Lucinoma borealis*	1	4	-
3.	*Crassostrea sp.*	2	2	1
	Polychaeta/ sea worm			
1.	*Sthenelais boa*	1	-	-
	Summary	**33**	**23**	**14**
	Total Species		**70**	

Note: Processed by Researchers 2020/2021

The fewest Macrobenthos are The Polychaeta Class, species *Sthenelais boa*. The reasons for the species in this class were found in small numbers according to other studies, found that the Class Polychaeta with the species *Glycera* sp. and *Arenicola marina* are the most difficult families/classes to find this is due to the characteristics and habits of this species which likes to hide themselves by digging soil or sand at the bottom of the waters[19]. Some references also explain that the species *A. marina* is animal with the character of digging soil or burrowing, which is the lowest number of macrobenthos in waters15. While species from the genus *Arenicola* are a group of deposit-eating Polychaeta that obtain food by digging soil or substrates, eating and absorbing organic matter by digging channels in soil sediments with a U shape and able to survive for several kilometers in the depths of the sediment, so

this explains that species in the class Polychaeta are a little difficult to find because they are hidden in the ground[19,20].

Based on the discussion of diversity in macrobenthos, 18 species can be identified at 3 stations. The six types/species of macrobenthos are as follows: 5 species in the gastropod class and 3 species in the bivalves' class from the Phylum Mollusca; 9 species in the Class Crustacea of the Phylum Arthropoda and 1 species in the class Polychaeta of the Phylum Annelida. Based on his results, the results obtained are the number of macrobenthos species found on the Kalianget coast in the medium category.

Distribution and Abundance of Macrobenthos

Based on the distribution **Table 2**, the most abundant number of macrobenthic species is found in Station I. The abundance of macrobenthic distribution at Station I composed by 4 classes with 12 species and 33 total number of individuals, this indicates that the ecological condition at station 1 is very good so that it can support the growth of macrobenthos well. Supporting factors in these conditions include soil structure which highly abundance of nutrients, causing the organic matter supplies optimally enrich the macrobenthos growth and development[9,21].

Meanwhile, Station II found 3 classes and 12 species with a total of 23 individuals. At station II, although the number of species is not as much as in station I, the distribution of species is still the same as in station I, but the number of species found is not too much. This indicates that Station II has good ecological conditions but in terms of soil structure and nutrient abundance is still below Station I, so it does not support the abundance of species.

Station III is a station with the least number of species found in 3 classes of 8 species with a total number of 14 individuals. The factor that causes the number of macrobenthos species decrease because the organic matter in the substrate present at station III is at minimal quantity. The condition of station III is close to residential areas so that it presented a higher level of pollution characterized by turbid water conditions compared to other stations causing the bottom substrate content of the waters to become less stable and less good so that it is not optimal in supporting the growth and distribution of macrobenthos[9–11,21].

The distribution of macrobenthos is dominated by the crustacean class and the gastropod class. Some of the reasons that make the dominance of these two classes high are the adaptability to the environment, both in good substrate conditions to minimal substrate conditions and high pollution[2]. The Crustacea class has high adaptability to habitat that have a muddy soil structure supported by mangrove trees that can maximize defense from predators[2,9]. The gastropod class has a watertight shell with good protection against the environment, making it more survive than other classes[3,22]. An additional structure in gastropods is the operculum which can easily open and close tightly in the cracks in the shell so that the water circulation process can be overcome properly and can become an additional protective structure for this class[15]. The Bivalves class also has a fairly high distribution because this class is group of organisms that can adapt well to silt sediments to coarse sand and morphological characteristics also support adaptation to this environment[19].

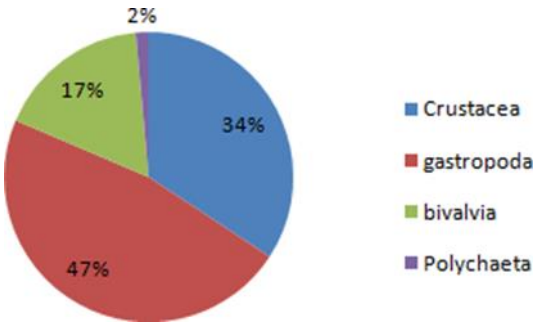

Figure 1. The total composition of Macrobenthos individuals at the entire station

Based on the **Figure 1**, the results were obtained: from 17 types/species of macrobenthos spread across three observation stations. The macrobenthos found consists of 4 main classes, those are the Crustacean class with 9 species and a number of individuals as many as 24 individuals/cm^2, the gastropod class of 5 species with a total number of 33 individuals/cm^2, the bivalves of 3 species with a total number 12 Individu/cm^2, and Class Polychaeta as many as 1 species with the lowest number with 1 Individu/cm^2. Gastropod composed the highest intensity and quantity of the macrobenthos community, it proven that gastropod as indicator of the relatively low pollution area in presence of abundance and number of species of gastropods. This result explains that gastropods are one of the aquatic animals that can be used as bioindicators if there is pollution in water; this is in accordance with the ecological and anatomical functions in this class which has very slow movement mobility with habitats, litter-eaters/detritus and lives at the bottom of the waters[19]. Another the important roles of the Gastropod class is that it can carry out the decomposition process of organic waste in the form of leaf litter produced by dominant vegetation on the coast, namely mangrove trees and these organisms also have sensories that are very sensitive to all kinds of changes in the aquatic environment[5,9,18].

Diversity Index Results (H')

In general, to understand Macrobenthos diversity can use the measurement formula of the Evenness Diversity Index[5], the function of this formula describe the state of macrobenthic populations mathematically to make it easier to analyze the diversity of species on the Kalianget coast. Measurement of this Index Value is carried out thoroughly at Station I to Station III. The results are presented at **Table 3**.

Table 3. Domination Index

Species	Total	ni/N	Ln ni/N	H′
Crustacea	24	0.342857	-1.07044	-0.36701
Gastropoda	33	0.471429	-0.75199	-0.35451
Bivalvia	12	0.171429	-1.76359	-0.30233
Polychaeta	1	0.014286	-4.2485	-0.06069
∑	70			**1.084539**

Source: Processed by Researchers 2020/2021

The diversity index value of macrobenthos in Kalianget was 1.084539. So with this value, the macrobenthos diversity index category on the Kalianget coast is classified as moderate. This category is obtained if the number of individual distributions in each species/genera has good community stability and there is pollution in the waters but still within the threshold that can be tolerated by living organisms[5,16].

Conclusions

The most dominate macrobenthos were from the Crustacea class (Fillum Arthropoda) obtained 9 species with a total of 24 species found, then the Gastropod class (Fillum Mollusca) found 5 species with a total of 33 individuals, the Bivalvia class (Fillum Mollusca) 3 found species with a total of 14 individuals, and the Polychaeta class (Fillum Annelida) found 1 species with a total of 1 individual. The Macrobenthos Diversity Index on the Kalianget coast is 1.08 classified as moderate. It means the macrobenthos in Kalianget have moderate community stability and polluted waters but still within the threshold that can be tolerated by living organism.

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Conflicts of Interest

There are not potential conflicts of interest.

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