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MACROZOOBENTHOS COMMUNITY STRUCTURE IN THE INTERTIDAL ZONE OF MUARA AIR HAJI VILLAGE PESISIR SELATAN REGENCY WEST SUMATERA PROVINCE

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ABSTRACT

Muara Air Haji Village is a coastal area with various anthropogenic activities that can disrupt the aquatic ecology, especially in the intertidal zone. Biological indicators such as macrozoobenthos are needed to provide a correct and sustainable picture of water quality. This research uses a survey method to determine macrozoobenthos' type, abundance, diversity, uniformity, dominance, and distribution pattern in the intertidal zone. Sampling was carried out using three stations, and each station consisted of three transects and three subzones comprised of the upper, middle, and lower intertidal zones using a quadrant plot measuring 1 x 1 m. The results of this research found three classes of macrozoobenthos with five species. Abundance values at each station ranged from 0.89–4.56 ind/m^2, while abundance in the intertidal subzone ranged from 1.11–3.56 ind/m^2. The diversity index (H') at stations I and III is 1.93 and 1.17, which means it is included in the medium diversity category, while the diversity index (H') at station II is 0.84, which means it is included in the low category, moderate distribution of individuals or non-uniform number of individuals, moderate ecological pressure and moderately polluted water stability. The uniformity index value ranges from 0.65–0.99, which means the uniformity category is balanced. At station II, macrozoobenton dominates with an index value of 0.62, while stations I and III have no dominant species with index values of 0.30 and 0.45. The distribution pattern (Id) of macrozoobenthos is clustered with a value of 3.45–4.18.

Keywords: Structure, Macrozoobenthos, Intertidal zone, Muara Air Haji Village

1. INTRODUCTION

Muara Air Haji Village is one of the coastal areas with the potential for natural resources and environmental. Services with various activities in the coastal area include fishing, tourism, development, etc. With a variety of activities carried out in the coastal region, it will contribute to the pollution of the waters in Muara Air Haji Village, so that it may cause deterioration of water quality and disrupt the ecological value in these waters, especially in the intertidal zone.

The intertidal zone is the part of the coast that will be inundated with water during high tide (turns into waters) but will dry up when the water recedes (turns into mainland). In the intertidal zone, there are significant variations in aquatic environmental factors, both physically and chemically[1]. So, for dynamic waters such as the intertidal zone, biological indicators are needed to provide accurate and sustainable estimates of water quality.

One of these biological indicators is macrozoobenthos, which are invertebrate animals that live sedentary on the bottom of the waters and have varying adaptability to the environment regarding biotic and abiotic factors. Macrozoobenthos in waters

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act as suspension feeders, detritivores, predators, or live as parasites, playing a role in the process of mineralization of sediments and the cycle of organic matter[2], as well as balancing the nutritional conditions of the environment.

Bearing in mind that coastal waters are vulnerable to changes in environmental factors, both from various anthropogenic activities and from nature itself, they impact the structure of the macrozoobenthos community in the long term. Water quality can be known by knowing the environmental factors of macrozoobenthos' life. Therefore, this research is essential to do.

2. RESEARCH METHOD

Time and Place

This research was conducted in August 2022 in the intertidal zone of Muara Air Haji village, Linggo Sari Baganti Subdistrict, Pesisir Selatan Regency, West Sumatra Province (Figure 1).

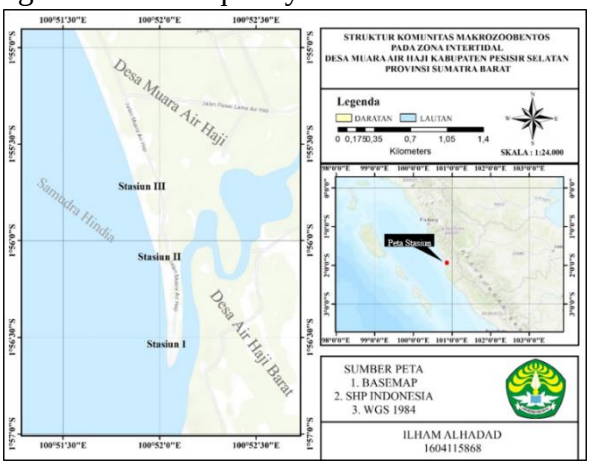

Figure 1. Map of Locations and Research Stations

Methods

This research uses a survey method. The samples were analyzed at the Marine Biology Laboratory, Faculty of Fisheries and Marine, Universitas Riau.

Procedures

Determination of Sampling Locations

Determination of research sampling station points using the purposive sampling method based on the criteria of the aquatic environment areas around the research location. The research location is divided into three stations, namely Station I is near the mouth of the river in Muara Air Haji Village, station II is located at the coastal tourist location of Muara Air Haji Village, and Station III is near the residential areas of Muara Air Haji Village.

Water Quality Measurement

Observations and measurements of water quality parameters were carried out directly at the research location during the highest tide. The parameters measurement environment includes temperature, brightness, pH, and salinity.

Collections and Analysis of Macrozoobenthos Samples

Macrozoobenthos sampling was conducted at low tide using the quadrant transect sampling method. Each station uses three transects with a distance of 30 m between transects; each transect consists of three plots with a distance of 15 m and a size of 1 m^2, which are in the upper, middle, and lower zones. Samples of the macrozoobenthos epifauna were taken directly. In contrast, the macrozoobenthos infauna was taken by dredging the sediment using a shovel as deep as ±10 cm and then putting it into a sieve with a mesh size of 1 x 1 mm to separate the macrozoobenthos from the substrate[3].

The macrozoobenthos obtained was put into a plastic bag and labeled with 10% formalin preservatives. Then, the samples

were placed into styrofoam boxes and taken to the Laboratory to identify and analyze types of macrozoobenthos species based on morphology obtained from identification books[4].

Sediment Sampling and Analysis

Sediment samples were taken in each station's upper, middle and lower zones. Sediment samples were taken using a shovel of approximately 500 g, put in plastic samples, labeled, and then stored in styrofoam boxes to be taken to the Marine Chemistry Laboratory and analyzed.

To analyze the type of sediment fraction in each subplot using two methods at once, namely the wet sieving method (gradient sieve) and the pipette method[5]. The multilevel sieve method was used to obtain the types of gravel and sand fractions (Ø-1–Ø4), while for the pipette method, a volumetric pipette was used to obtain the silt fraction types (Ø5–Ø>7).

Sediment Organic Matter Analysis

Analysis of the organic matter content of the sediments was carried out in the Marine Chemistry laboratory. Analysis of organic matter content in sediments was carried out using the Loss on Ignition method[6].

Sediment Data Processing

Determination of the type of sediment substrate was carried out using the Shepard triangle method to calculate the percentage of sediment particle size based on the proportion of gravel, sand, and silt diameter particle size content divided into a triplicate diagram into ten classes[5]. Calculation of the total organic matter content of sediments uses the Loss on Ignition formula[7:]

$$BOT = \frac{a-c}{a-b}\ x\ 100\ \%$$

Information:

a = Weight of cup and sediment sample before burning (g)
b = Cup weight (g)
c = Weight of cup and sample after burning (g)

Macrozoobenthos Data Processing

The abundance of each species at each observation site is calculated using formula[8]:

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

Information:

K = Individual species abundance (ind/m^2)
N = The total number of individuals of the i-th species obtained in A
A = Plot area of the i-th species found (m^2)

Macrozoobenthos diversity is calculated using the Shannon-Wienner formula[1]:

$$H' = -\sum_{i=1}^{S} pi\ (\log_2 pi)$$

Information:

H' = Diversity index
Pi = ni/N
Ni = The total of individuals in the i-th species
N = Total number of individuals
s = Number of species caught

Macrozoobenthos uniformity is calculated using the Evennes Index formula[9]:

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

Information:

E = Uniformity index
H' = Diversity index
H' maks = Log_2 S
S = Total species

Macrozoobenthos dominance is determined using the Dominance of Simpson formula[10]:

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

Information:

C = Dominance index
ni = Total individuals of each species
N = Total of individuals of all species
s = Number of individuals caught

The macrozoobenthos distribution pattern was calculated using the morphic dispersion index formula[8]:

$$\text{Id} = n\frac{\sum X^2 - N}{N\,(N-1)}$$

Id = Moricity dispersion index
n = Tolat of plots
N = Total number of individuals
Σx^2 = Individual square summary

3. RESULT AND DISCUSSION

General Conditions of Research Locations and Water Quality

Geographically Muara Air Haji Village is located at 01°55'15,2" South Latitude and 100°52'51,8" East Longitude with its territorial boundaries: to the north, it is bordered by Nagari Muara Kandis Punggasan; to the east, it is bordered by Nagari Air Haji, to the west by the Indian Ocean, and to the south by Nagari Air Haji Barat.

There is a river mouth south of the village, a place for fishing boat traffic, and community plantations along the river banks. The beach in Muara Air Haji Village has quite strong waves, and there is construction of wave breakers around the intertidal zone of the beach. Residents ' housing and tree vegetation are just a short distance from the beach, but along the coast towards the estuary, there is a vast stretch of open sand on the beach.

The results of measuring the water quality in the intertidal zone of Muara Air Haji Village at each station obtained surface water temperature of an average of 27.67°C, water pH of an average of 6.67, water salinity with average 30.34 ppt and while the clarity of the water with average 36.67 cm. The results of water quality measurements are shown in Table 1.

Table 1. Observations on Water Quality in the Intertidal Zone of Muara Air Haji Village

Station	pH	Temperature (^{o}C)	Salinity (‰)	Brightness (cm)
I	7	26	29	35
II	6	29	31	37
III	7	28	31	38
Average	6.67	27.67	30.34	36.67

Sediment Substrate Type

The average results of the analysis of the sediment fraction found in the intertidal zone in Muara Air Haji Village are dominated by sand and muddy sand. The muddy sand sediment fraction was only found at station I. Meanwhile, the sand sediment fraction was found at stations II and III. The highest percentage of silt sediment fraction was found in the lower zone of station I, with a value of 23.12%, and the highest percentage of sand sediment fraction was found in station III, with a value of 87.63%. In contrast, the highest gravel fraction was found in the upper zone of station I.

Currents and waves are the main force factors that determine the direction and distribution of sediments. These forces also cause different sediment characteristics, so the bottom waters comprise various sediment fraction groups[5]. The results of measuring the percentage of each weight fraction and type of sediment in each zone between stations can be seen in Table 2.

Sediment Total Organic Matter

The total organic matter content of sediments in each zone between research stations has various percentages. The highest average total sediment organic matter content was found at station I, which was near the river mouth, with a percentage of 15.54%, and the lowest was found at station II, which was near coastal tourism sites, with a rate of 6.09%, while at station III which is near the housing of residents has a percentage of 9.07%.

Table 2. Sediment Types in the Intertidal Zone in Muara Air Haji Village

Station	Zone	Gravel (%)	Sand (%)	Mud (%)	Sediment type
I	Upper	10.71	70.26	19.04	Muddy sand
	Middle	8.73	69.86	21.41	Muddy sand
	Lower	8.05	68.82	23.12	Muddy sand
II	Upper	5.91	85.45	8.64	Sand
	Middle	4.91	83.76	11.33	Sand
	Lower	5.38	87.50	7.13	Sand
III	Upper	10.59	82.94	6.43	Sand
	Middle	7.49	86.70	5.81	Sand
	Lower	8.43	87.63	3.94	Sand

The total organic matter content of the sediments in the results of this study was relatively higher. The high content of total sediment organic matter, especially at station I compared to stations II and III, is influenced by the type of muddy sand substrate that enters river estuaries and sea wave currents, which are not too strong, resulting in the deposition of organic matter on the substrate waters. The results of calculating total organic matter between research stations can be seen in Table 3.

Table 3. Sediment Total Organic Matter

Zone	Total organic ingredients inter-station sediments (%)		
	I	II	III
Upper	14.12	5.73	10.29
Middle	15.64	6.06	7.74
Lower	16.87	6.48	9.18
Average	15.54	6.09	9.07

Types of Macrozoobenthos

Based on the results of research in the intertidal zone of Muara Air Haji Village, the macrozoobenthos found at each station consisted of two phyla, three classes, four genera, and five species (Table 4). The bivalve class was the most common at each station, and the most common species was Donax cuneatus.

There are many classes of clams found because mussels can live on muddy and sandy substrates in coastal areas with sufficient organic matter content. Mussels also have a hard shell (limestone shelly), which functions as a barrier and adapts to environmental changes by closing the shell. Bivalvia are included in the suspension feeder, deposit feeder, and burrower groups, so their numbers are abundant in soft sediments such as silt compared to sandy or stony substrates.

Macrozoobenthos Abundance Between Stations

Macrozoobenthos abundance is defined as the number of individuals in the sediment per unit area. The abundance of macrozoobenthos at each station in the intertidal zone of Muara Air Haji Village was low, with an average of 2.15 ind/m^2. The highest average abundance of macrozoobenthos was at Station I, with an amount of 4.56 ind/m^2, while the lowest average abundance of macrozoobenthos was at Station II, with an amount of 0.89 ind/m^2. The average abundance of macrozoobenthos at station III was one ind/m^2.

The high abundance value at a station I compared to other stations could be because this station is close to a river mouth. Even though there is anthropogenic activity and freshwater input from rivers, the highest abundance can occur because macrozoobenthos can tolerate

environmental changes. This is also supported by the type of muddy sand substrate and a sediment organic matter content of 15.54% so that macrozoobenthos can adapt. This organic material is a food source for marine biota, so their dependence on organic material, including macrozoobenthos[7], is considerable.

Table 4. Macrobenthos Species in the Intertidal Zone in Muara Air Haji Village

Phylum	Class	Order	Family	Genus	Species
Mollusca	Bivalvia	Cardiida	Donacidae	Donax	*Donaxcuneatus* *Donax faba*
		Veneroidea	Mesodesmatidae	Atactodea	*Atactode astriata*
	Gastropoda	Neogastropoda	Fasciolariinae	Latirus	*Latirus philberti*
Anthropoda	Malacostraca	Decapoda	Ocypodidae	Ocypode	*Ocypode cordimanus*

The lowest abundance of macrozoobenthos was obtained at station II, with a value of 0.89 ind/m^2. This area is in a coastal tourism location with many anthropogenic activities, the acquisition of sand substrate types, and a sediment organic matter content of 6.09%. This station has an open beach condition with quite strong waves, and there is a plaster or wave break project that can cause sediment agitation and provide ecological pressure and disturbance to the abundance of macrozoobenthos.

Macrozoobenthos abundance at station III was slightly higher than at station II, with a one ind/m^2 value. This station area is near residential communities. Although this area is somewhat shadier than other stations with tree vegetation behind residents' housing, the low abundance can be caused by anthropogenic activities.

At this station, the organic matter of the sediment is relatively high, with a value of 9.07%, with a sand substrate type and seawater waves that are strong enough to cause the movement of sediment particles to be transported, mixed, and deposited again, thus affecting the macrozoobenthos habitat. The existence of benthos animals in waters is strongly influenced by various environmental factors such as aquatic physics-chemical factors and high human activity in these habitats[11]. The results of calculating the abundance of macrozoobenthos at each station can be seen in Figure 2.

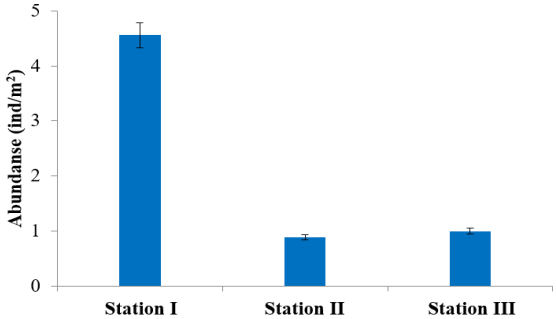

Figure 2. The Macrozoobenthos Abundance (ind/m^2) Between Stations in Muara Air Haji Village

Macrozoobenthos Abundance Between Intertidal Subzone

The abundance of macrozoobenthos between the intertidal subzone in Muara Air Haji Village was low, with an average of 2.15 ind/m^2. The highest abundance was in the sublower zone with an average of 3.56 ind/m^{2,} and the lowest abundance was in the subupper zone with an average of 1.11 ind/m^2, while in the submiddle zone it had an abundance value of 1.78 ind/m^2. This can happen because the lower zone has

more abundant food availability, such as organic matter in the bottom water substrate, than other zones.

The lower zone intertidal in coastal waters has suitable substrate and habitat and supports the protection of macrozoobenthos from various threats in these waters and other environmental factors. In addition, the conditions in the lower zone, which tend to be more humid and wetter, make it possible for macrozoobenthos to survive more compared to other zones, which tend to be drier due to sea tides so that it is suitable for the survival of macrozoobenthos.

The abundance of macrozoobenthos in the intertidal subzone in the upper zone found three macrozoobenthos and four species in the middle and lower zones. The highest abundance of macrozoobenthos was found in the lower zone of station I, which reached 25 individuals, much higher than the other zones and stations. Differences in the abundance of macrozoobenthos in each subzone between stations can be seen in Figure 3.

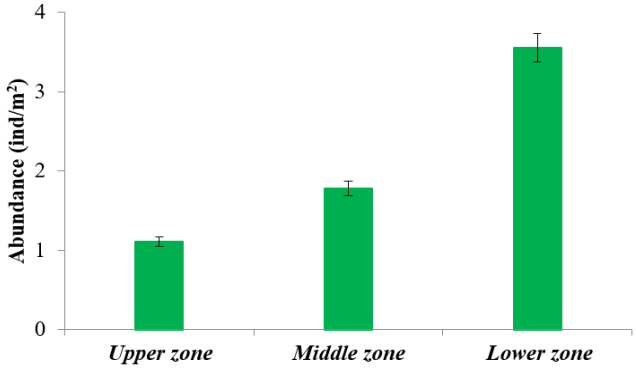

Figure 3. Macrozoobenthos Abundance Between Intertidal Subzone in Muara Air Haji Village

Diversity, Uniformity, and Dominance of Macrozoobenthos

The diversity index (H') value of macrozoobenthos at each station in the intertidal zone of Muara Air Haji village is classified as moderate with an average of 1.31, the uniformity index value (E) including height with an average of 0.84 and the dominance index value (C) including low with average 0.46.

Based on the diversity index criteria Fadly[10], at stations I and III with a value of 1.93 and 1.17, classified as moderate where the index value ranges from $1.0 \leq H' < 3.0$: Medium diversity, medium distribution of individuals or the number of individuals not uniform, moderate ecological pressure and stability of moderately polluted waters. Meanwhile, the diversity at station II, with a value of 0.84, is categorized as low, where the H' index value <1. If the distribution of individuals is uneven, the species diversity is low to moderate.

Based on the criteria for the index value of macrozoobenthos uniformity[12], at each research station, it was classified as high, with 0.65-0.99 (E > 0.5). A uniformity index value close to one indicates that the distribution of individuals or species tends to be even. These results indicate that the condition of the waters is considered balanced with a community that tends to be stable.

Based on the criteria Fadly[10], macrozoobenthos dominate at station II, with an index value of 0.65 (C>0.5). Meanwhile, stations I and III did not dominate macrozoobenthos with index values of 0.30 and 0.45 (C<0.5). The existence of dominance indicates that not all macrozoobenthos have the same adaptability and ability to survive against environmental factors, which makes the distribution and abundance of species in favor of certain species.

Data from the calculation of diversity, uniformity, and dominance values between

stations in the intertidal zone in Muara Air Haji Village can be seen in Table 5.

Table 5. Index of Diversity (H'), Uniformity (E), and Dominance (C) of Macrozoobenthos in the Intertidal Zone in Muara Air Haji Village

Station	H'	E	C
I	1.93	0.87	0.30
II	0.84	0.65	0.62
III	1.17	0.99	0.45
Average	1.31	0.84	0.46

Distribution Pattern of Macrozoobenthos

The pattern of distribution of macrozoobenthos in the intertidal zone in Muara Air Haji Village is clustered with an average value of 3.91 (Table 6). The value of the moricity index > 1 indicates a clustering distribution pattern or distribution of macrozoobenthos[8].

Table 6. Distribution Pattern of Macrozoobenthos in the Intertidal Zone of Muara Air Haji Village

Station	Id	Spread pattern
I	4.18	Groups
II	3.54	Groups
II	4.00	Groups
Average	3.91	Groups

The distribution pattern is determined by the nature of each individual, namely genetics and preference in choosing a habitat, as well as the interaction of several environmental factors.

4. CONCLUSION

Based on the results of research on the community structure of macrozoobenthos in the intertidal zone of Muara Air Haji Village, five species of macrozoobenthos were found, namely *Donax faba, Donax cuneatus, Atactodea striata, Latirus philberti* and *Ocypode cordimanus.* The abundance of macrozoobenthos at each station and intertidal subzone was low.

Diversity is classified as moderate, the distribution of individuals is mild, the number of individuals is not uniform, ecological pressure is moderate, and the stability of the waters has been moderately polluted. Macrozoobenthos uniformity is in the high and uniform category, indicating that the distribution of individuals or species tends to be even. Low macrozoobenthic dominance demonstrates that no species dominates, but there is macrozoobenthic dominance at stations at marine tourism locations. The existence of species dominance indicates that not all macrozoobenthos have the same adaptability and ability to survive environmental factors. The overall distribution pattern of macrozoobenthos in the tidal zone of Muara Air Haji village is clustered. Distribution patterns are determined by the natural characteristics of each individual, namely genetic characteristics and preferences in choosing a habitat, as well as the interaction of several environmental factors.

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