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THE DIVERSITY OF MACROZOOBENTHOS ON THE COASTAL AREAS OF BATU BARA REGENCY

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ABSTRACT

Research of the diversity macrozoobenthos in Batu Bara Regency is crucial to identify the current condition of coastal ecosystems. This information can provide an overview of water quality, resource sustainability status, and serve as a basis for better planning and management of coastal areas. This research is also expected to serve as a reference for developing strategies to mitigate the negative impacts of human activities on coastal ecosystems, ensuring the balance of ecosystems and the preservation of biodiversity. This research will be analyze diversity and abundance (ind/ha) of macrozoobenthos, ecological index data and physical environmental factors and substrate characteristics. The diversity of macrozoobenthos at Sujono Beach, Sejarah Beach, and Kresek Beach consists of three phyla, six classes, and 28 species. The abundance of macrozoobenthos at Sujono Beach is 2459 ind/m3, at Sejarah Beach is 1525 ind/m3, and at Kresek Beach is 1218 ind/m3. The species richness index, diversity index, and evenness index of macrozoobenthos at all three beaches fall into the moderate category, while in the dominance index, none of the beaches have dominating species. The substrate characteristics at Sujono Beach have a sandy clay texture, while at Sejarah Beach and Kresek Beach, they have a dusty clay texture.

Introduction

Macrozoobenthos are a group of organisms that inhabit the bottom of aquatic environments, including marine, estuarine, and freshwater ecosystems, with body sizes exceeding 1 mm. These organisms play a crucial role in aquatic ecosystems, serving both as bioindicators of water quality and as key contributors to energy flow and organic matter cycling within benthic ecosystems. Their presence and population density are influenced by various environmental factors, such as substrate characteristics, water quality, tidal patterns, and human activities in coastal areas.

The Batu Bara Regency has many beaches, including Sejarah Beach, Sujono Beach, and Kresek Beach. Apart from being tourist destinations for both local and international tourists, these three beaches play an important role as stopover points for migrating shorebirds from the northern and southern regions. One reason why many shorebirds stop at these beaches is the abundance of their food sources in the form of macrozoobenthos. Macrozoobenthos are macroorganisms that live on the seabed or in shallow waters such as worms, mollusks, clams, crabs, and various other invertebrate species. The distribution of macrozoobenthos is influenced by various factors, including water temperature, food availability, dissolved oxygen, substrate type, salinity, sea waves, and other environmental factors.

Research about diversity of macrozoobenthos in fish and shrimp ponds identified 12 species belonging to three phyla and six classes. The abundance of macrozoobenthos in the two types of ponds (fish and shrimp) ranges from 892 ind/m³ to 1400 ind/m³. (Pradana *et al*, 2024).

The importance of macrozoobenthos for the survival of various species of shorebirds poses a challenge in determining the abundance and diversity of macrozoobenthos species in the three aforementioned beach areas. Additionally, the physical environmental factors and characteristics of the substrate texture in these three areas are important for analysis as supporting data in identifying important habitats for shorebirds.

This research will be focus on analysis data on the number of species (diversity) and abundance (ind/ha) of macrozoobenthos, ecological index data and physical environmental factors and substrate characteristics at the research site.

MATERIAL AND METHODS
Material

The tools used are Surber nets, a cool box, Global Positioning System (GPS), a digital camera, 10 kg plastic bags, 5 ml syringes, alcohol bottles, laminated graph paper, permanent markers, tweezers, a work board, and writing tools. The materials used are 70% alcohol, Lugol's solution, label paper, and rolled tissues.

The Determination of Sampling site Locations

The sampling locations were determined using purposive sampling based on the distribution of the largest/most abundant bird populations and divided into three locations: (i) mid ebb tide, approximately three hours before low tide with the current parallel to the coast; (ii) late ebb tide, approximately 90 minutes before low tide with the current starting to recede; (iii) low ebb tide, the final receding current. Sampling was conducted at three points in each location, repeated three times

Sampling Techniques

Research team: two persons for sample collection, two persons for sorting and preparing samples, one person for documentation.
1. The bottom substrate is scraped to a depth of ± 10cm (according to the size of the Surber net: 30x30x30cm) using a modified Surber net, with three repetitions.
2. The captured macrozoobenthos are sorted using tweezers and documented on laminated paper.
3. The documented samples are then placed into sample bottles based on their taxa (different Phyla/Classes).
4. Each sample is preserved in 70% alcohol and stained with Rose Lugol.
5. Subsequently, they are placed in a cool box filled with ice for identification in the laboratory.
6. In the laboratory, the obtained samples are then identified and specifically documented to obtain taxonomic species or genus levels.

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7. Identified samples are then preserved as specimens using formalin for further identification references.

3. Data Analyze

The data analysis conducted includes population abundance, species richness index (R), Shannon-Wiener Diversity Index (H'), Species Evenness Index, and Dominance Index.

a. Population abundance of macrozoobenthos
Population abundance describes the number of individuals occupying a certain area, calculated using the formula:

K = The number of individuals of a species.
        Total area of Surber ner

b. Indeks of Species Richness
Species richness index can describe the species richness at a research location. This index is calculated based on the formula:

$$R = \frac{S-1}{\ln N}$$

R: Indeks of species richness
S: Total species
N: The total number of individuals of all species.

R < 3,0 Low species richness
3,0 – 5 Moderate species richness
R >5 High species richness

c. Indeks of Diversity Shannon – Wiener (H')
The Shannon-Wiener Diversity Index analysis can depict the diversity level of a species within the overall species present, thereby revealing dominant species in the study.

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

H'   = indeks diversitas Shannon – Wiener

Pi   = the proporsion of spesies
ln   = logaritma Nature
pi   = $\sum ni / N$ (The calculation of the total number of individuals of all species)

$0 < H' < 1$ = Low diversity
$1 < H' < 3$ = Moderate diversity
$H' > 3$ = High diversity

d. Indeks of Eveness
The Evenness Index can describe the evenness of a species within the overall observation area, calculated using the formula:

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

E   : Indeks of eveness
H'   : Indeks of diversity
S   : Total of species

$0 \leq E \leq 0,4$: Low eveness
$0,4 \leq E \leq 0,6$: Moderate eveness
$E \geq 0,6$: High eveness

e. Indeks of Dominance
The Dominance Index describes the dominance of a species over all species in the observation location, calculated using the formula:

$$D = \sum \left(\frac{ni}{N}\right)^2$$

D   = Indeks of Dominance
ni   = The total number of individuals of a species
N   = The total number of individuals of all species.

Description value D:
D<0,5 No species dominate
D>0,8 Species dominance exist

Result and Discussion

Diversity and Abundance of Macrozoobenthos Species at the Research Site

The diversity of macrozoobenthos species on the three beaches consists of three Phyla, six Classes, and 27 species of macrozoobenthos. The number of species and individuals at the three locations is shown in Table 1.

Table 1. Diversity and Abundance of Macrozoobenthos at Sujono Beach, Sejarah Beach, and Kresek Beach in Batu Bara Regency

Phylum	Class	Specis	Number of Species		
			Sujono Beach	Sejarah Beach	Kresek Beach
Annelida	*Polychaeta*	*Glycera* sp.	9	15	17
	Polychaeta	*Nephtys* sp.	35	63	47
	Polychaeta	*Nereis* sp.	153	129	88
Arthropoda	*Crustacea*	*Pinnotheres* sp.	7	5	5
	Malacostraca	*Asellidae* sp. (larvae)	17	-	-
	Malacostraca	*Litopeneaeus* sp. (larvae)	23	-	-
	Malacostraca	*Macrophthalmus* sp.	11	8	13
	Malacostraca	*Paguridae* sp	7	5	5
	Thecostraca	*Chthamalus* sp	3	7	7
Molusca	*Bivalvia*	*Anadara granosa*	55	37	33
	Bivalvia	*Anadara gubernaculum*	3	6	9
	Bivalvia	*Callista lilacina*	19	37	154
	Bivalvia	*Donax trunculus*	2	9	4
	Bivalvia	*Mactra grandis*	56	31	27
	Bivalvia	*Mytilus platensis*	207	39	47
	Bivalvia	*Orbicularia orbiculata*	5	3	1
	Bivalvia	*Unio* sp.	-	1	-
	Gastropoda	*Cerithideopsilla* sp.	18	7	5
	Gastropoda	*Clypeomorus* sp.	2	3	1
	Gastropoda	*Littoraria* sp.	1	1	-
	Gastropoda	*Nassarius elegantissimus*	10	3	2
	Gastropoda	*Nassarius margaritifer*	7	-	-
	Gastropoda	*Nassarius reeveanus*	8	-	-
	Gastropoda	*Natica tigrina*	1	2	2
	Gastropoda	*Orania xuthedra*	1	-	-
	Gastropoda	*Peringia ulvae*	1	-	-
	Gastropoda	*Pomaceae* sp	1	-	-
	Gastropoda	*Turritella terebra*	2	1	1
Total			**664**	**412**	**329**
Abundance (ind/m^3)			**2459**	**1525**	**1218**

Based on Table 1, it can be observed that the number of species in the phylum Annelida and class Polychaeta consists of three species: *Glycera* sp., *Nepthys* sp., and *Nereis* sp. The class Polychaeta has the ability to maximize substrate habitats such as mud and sand to obtain nutrients and survive. Nereis sp. is a type of Polychaeta that can adapt well to extreme conditions and environments. The number of species in the phylum Arthropoda consists of the class Crustacea, namely *Pinnotheres* sp., and the class Malacostraca, namely Asellidae sp.

and Litopeneaeus sp. in larval form, *Macrophthalmus* sp., and *Paguridae* sp., as well as the class Theostraca, namely Chthamalus sp. The number of species in the phylum Mollusca consists of two classes: Bivalvia and Gastropoda. Mytillus platensis is the most abundant species among the eight other classes of Bivalvia, while Cerithideopsilla sp. has the highest number of individuals and is always present at each observation location.

The highest individual abundance is found at Sujono Beach with 2459 ind/m3, Sejarah Beach with 1525 ind/m3, and Kresek Beach with 1218 ind/m3. The high number of individuals classified at Sujono Beach can be attributed to the organic substrate content derived from mangrove vegetation around the beach and organic waste from rivers that flow into these three beaches. The high number of macrozoobenthos individuals at the three beaches is also influenced by environmental factors and a balanced and well-maintained relationship among predators, competitors, and parasites. Additionally, abiotic factors such as temperature, humidity, light intensity, and pH also contribute to the high number of individuals at these three beaches.

The macrozoobenthos in the mangrove forest of Lubuk Kertang Village, North Sumatra, consisted of eight species, which were classified into three classes: Gastropods, Bivalvia, and Malacostraca (Basyuni et al., 2018). The macrozoobenthic diversity in the Sei Barombang mangrove ecosystem revealed gastropods and bivalves as the dominant species. Barbatia *Amygdalumtosum* and *Glauconome virens* were the most frequently encountered species across all stations (Dimenta et al., 2020). The abundance of macrozoobenthos in the intertidal zone of Sambungo Village, Pesisir Selatan, West Sumatera ranged from 3.33 to 5.11 ind/m² (Anggara et al., 2021).

Indeks of Ecology
Indeks of Species richness

The highest species richness index of macrozoobenthos is found at Sujono Beach with a value of 4.155, followed by Sejarah Beach with 3.322 and Kresek Beach with 3.106. Based on the values of the species richness index, Sujono Beach, Sejarah Beach, and Kresek Beach have macrozoobenthos richness in the moderate category. All three beaches have species richness index values in the moderate category. This indicates that each beach provides suitable habitats for the survival of various macrozoobenthos species.
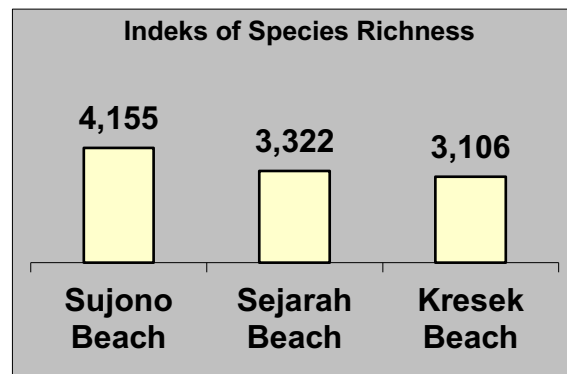

Figure 1. Indeks of Species Richness Makrozoobenthos in Sujono Beach, Sejarah Beach and Kresek Beach

The comparison index species richness of macrozoobenthos between the coastal areas and fish and shrimp ponds shows a significant difference about 3,1 to 4,1 and 0,6 to 1,5. Based on research conducted in the pond area of Ulee Matang village, species richness in fish ponds was higher than in shrimp ponds, with an index value of 1,5 compared to 0,6 (Pradana *et al*, 2024)

Indeks of Diversity

The highest Shannon-Wiener diversity index of macrozoobenthos is found at Kresek Beach with a value of 2.306, followed by Sejarah Beach with 2.266 and Sujono Beach with 2.197. Based on the diversity index values, Sujono Beach, Sejarah Beach, and Kresek Beach have macrozoobenthos richness in the moderate category. The diversity index is

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one of the best parameters for comparing each community to determine the level of stability at the observation site. It serves as the basis for studying various factors such as habitat suitability, occurring threats, biotic and abiotic environmental factors affecting a species in maintaining its existence. High diversity can indicate stability in communities and even in stable ecosystems. In this study, all three beaches have moderate diversity index values, indicating potential patterns of distribution and even distribution of each species in different areas.
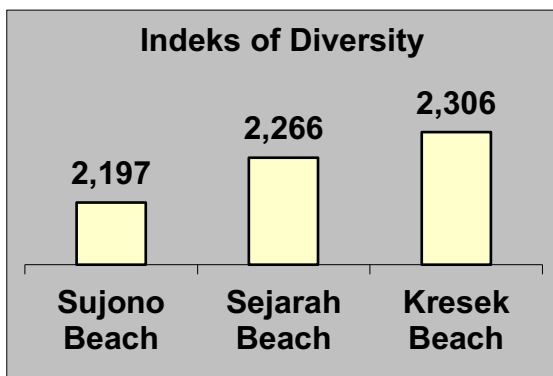

Figure 2. Indeks of Species Richness Makrozoobenthos in Sujono Beach, Sejarah Beach and Kresek Beach

The macrozoobenthos in the coastal waters of Marsegu Island, Maluku, exhibited a diversity index ranging from 2.07 to 3.56, which falls into the moderate to high diversity category (Yunita et al., 2018). Another study conducted in the Ogan River near Baturaja City reported diversity index values ranging from 1.117 to 2.22, also classified as moderate (Nurainah et al., 2022).

Indeks of Eveness

The highest evenness index of macrozoobenthos is found at Sejarah Beach with a value of 0.744, followed by Kresek Beach with 0.742 and Sujono Beach with 0.659. Based on the evenness index values, Sujono Beach, Sejarah Beach, and Kresek Beach have macrozoobenthos richness in the moderate category. Sejarah Beach and

Kresek Beach have evenness index values that are not significantly different due to similarities in habitat and substrate texture, both consisting of dusty clay. The closer the evenness index value is to one, the more evenly distributed the species are.
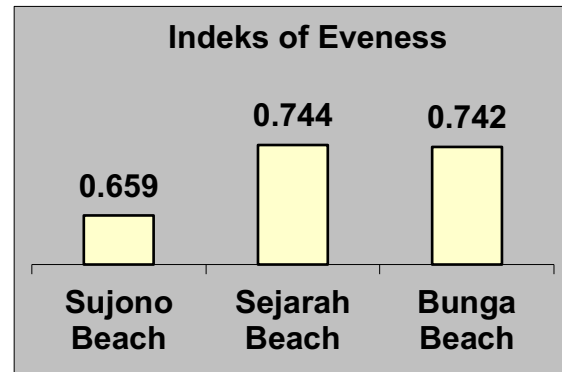

Figure 3. Indeks of Eveness Makrozoobenthos in Sujono Beach, Sejarah Beach and Kresek Beach

The diversity and evenness indices in the waters of Gorontalo were classified as medium, with no dominant species observed in the marine area. The biotic communities at the lower reach station resembled estuarine biota more than marine biota (Kadim et al., 2022).

Indeks of Dominance

The highest Simpson dominance index of macrozoobenthos is found at Sujono Beach with a value of 0.172, followed by Sejarah Beach with 0.156 and Kresek Beach with 0.138. Based on the dominance index values, no species dominates Sujono Beach, Sejarah Beach, or Kresek Beach.
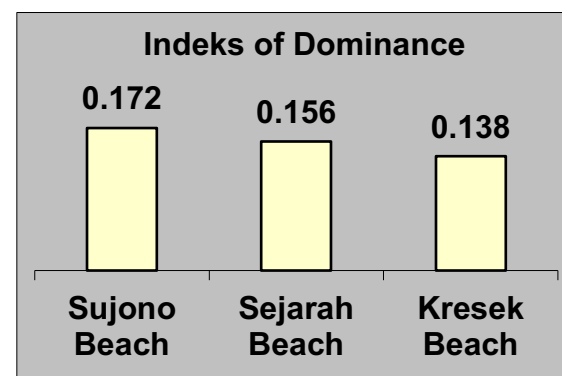
Figure 4. Indeks of Dominance Makrozoobenthos in Sujono Beach, Sejarah Beach and Kresek Beach

The dominance of macrozoobenthic species on the coastal shores is lower compared to that in the ponds, due to higher species diversity. The comparison of dominance index values ranges from 0.13 to 0.17 for the coast, compared to 0.22 to 0.41 for the ponds (Pradana *et al*, 2024). The macrozoobenthic community structure in the estuary of the Donan River, Cilacap, Central Java, revealed that the macrozoobenthos density, diversity index, evenness index, and dominance index were categorized as moderately ecologically polluted (Hakiki et al., 2017).

Environmental Physical Factors and Characteristics of Substrate Texture at the Research Site

The results of the physical factors and substrate characteristics at Sujono Beach, Sejarah Beach, and Kresek Beach in Batu Bara Regency are shown in Table 2. Based on Table 2, it is observed that the temperature at all three beaches is relatively similar, ranging from 29 to 30°C. However, the pH value shows a significant difference, with a neutral pH of 6.8 at Sujono Beach and acidic conditions (pH 4.5) at Sejarah Beach and Kresek Beach. The acidity or alkalinity level of a substrate is expressed by the pH value.

The pH value indicates the ratio of hydrogen ions (H+) to hydroxide ions (OH-) in the substrate. The pH value of the substrate can be used to describe the availability of nutrients in the soil. It also determines the ease or difficulty of nutrient absorption by plants; neutral pH greatly facilitates nutrient absorption. Additionally, the pH value can indicate the presence of toxic elements. Acidic soil texture with high aluminum content can be toxic to plants and can bind phosphorus, which is essential for plant growth. In this study, all three beaches have pH values ranging from 6.5 to 6.8, which fall into the neutral category, potentially indicating high nutrient availability and easy absorption for shorebirds, as well as safety from toxicity for flora and fauna in this area.

Table 2. Environmental Physical Factors and Substrate Texture at the Research Site

No	Research site	Environmental Physical Factors		Substrate Texture				
		Temperature	pH	Sand (%)	Dust (%)	Clay (%)	C-Organic (%)	Texture (USDA)
1	Sujono	29	6,8	64	28	8	4,71	sandy clay texture
2	Sejarah	30	6,5	30	62	8	4,19	dusty clay texture
3	Kresek	30	6,5	30	62	8	3,97	dusty clay texture

The substrate characteristics at Sujono Beach are sandy clay texture, dominated by sand (64%), with 28% dust and 8% clay content. Meanwhile, the substrate composition at Sejarah Beach and Kresek Beach is dusty clay texture, dominated by dust (62%), with 30% sand and 8% clay content. Substrate texture is one of the factors that determines the physical and chemical properties of the substrate, such as water penetration rate, water retention, aeration, and fertility levels. Substrate texture plays a role in determining the volume of stored water.

Clay texture has a higher water retention capacity compared to sand texture due to its adsorptive thickness, resulting in finer texture and greater water retention ability. In this study, all beaches have the same clay content, indicating equal water retention capacity at Sujono Beach, Sejarah Beach, and Kresek Beach.

The composition of other substrates, such as organic carbon (C-organic), at all three beaches ranges from 3.97% to 4.71%. Sujono Beach has the highest organic carbon content at 4.71%, Sejarah Beach has a content of 4.19%, and Kresek Beach has a content of 3.97%. Organic carbon plays a role in improving nutrient availability and enhancing the ability of the substrate to retain water. Additionally, organic matter can help bind clay content in the substrate, thus increasing nutrient availability.

Conclusion

The conclusions from this study are:

1. The diversity of macrozoobenthos at Sujono Beach, Sejarah Beach, and Kresek Beach consists of three phyla, six classes, and 28 species.
2. The abundance of macrozoobenthos at Sujono Beach is 2459 ind/m3, at Sejarah Beach is 1525 ind/m3, and at Kresek Beach is 1218 ind/m3.
3. The species richness index, diversity index, and evenness index of macrozoobenthos at all three beaches fall into the moderate category, while in the dominance index, none of the beaches have dominating species.
4. The substrate characteristics at Sujono Beach have a sandy clay texture, while at Sejarah Beach and Kresek Beach, they have a dusty clay texture.

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