Comparison of Macrozoobenthos Community Structure in Reclaimed and Natural Beaches in Padang City, West Sumatra

Perbandingan Struktur Komunitas Makrozoobenthos di Pantai Reklamasi dan Pantai Alami di Kota Padang, Sumatera Barat

Helda[1*], Afrizal Tanjung[1], Thamrin[1]

[1]Department of Marine Science, Faculty of Fisheries and Marine,
Universitas Riau, Pekanbaru 28293 Indonesia
*email: helda0663@student.unri.ac.id

Abstract

Padang City is one of the cities with a long coastline. The Padang City government has made many reforms to manage the beach area as a tourist attraction. This research aimed to determine the comparison of macrozoobenthos community structure, including species composition, species abundance, relative abundance, diversity index, similarity index, dominance index, and distribution patterns in the reclaimed and natural beaches of Padang City, West Sumatra Province. The method used was purposive sampling with sample collection using the transect method. The results of this study indicate that the water quality in Padang City, West Sumatra, is sufficiently good to support macrozoobenthos life. The highest species abundance of macrozoobenthos was found at the Reclamation Beach Station. The macrozoobenthos species found belong to 2 classes: Gastropoda and Crustacea. The Gastropoda class consists of 4 species: *Babylonia spirata, Pila ampullacea, Pila occidentalis*, and *Nerita fulgurans*, while from the Crustacea class, three species were found: *Ashtoret lunaris, Hemigrapsus takanoi*, and *Emerita* sp. Meanwhile, the lowest abundance was found at the Natural Beach Station, where the species belonging to the Crustacea class, specifically *H.takanoi*, was found. The species diversity of macrozoobenthos at the Natural Beach Station is considered low but moderate at the Reclamation Beach Station. Similarity at the Natural Beach Station is low, while at the Reclamation Beach Station, it is high. Additionally, there is a dominant species at the Natural Beach Station, whereas no dominant species were found at the Reclamation Beach Station. The distribution pattern of macrozoobenthos in the coastal waters of Padang City is categorized as clustered distribution.

Keywords: Beach Reclamation, Natural Beach, Macrozoobenthos

Abstrak

Kota Padang merupakan salah satu kota yang memiliki garis pantai yang panjang. Pemerintah Kota Padang telah banyak melakukan perombakan dalam pengelolaan kawasan pantai sebagai objek wisata. Penelitian ini bertujuan untuk mengetahui perbandingan struktur komunitas makrozoobentos meliputi komposisi jenis, kelimpahan jenis, kelimpahan relatif, indeks keanekaragaman, indeks kemiripan, indeks dominansi, dan pola sebaran di pantai reklamasi dan pantai alami Kota Padang, Provinsi Sumatera Barat. Metode yang digunakan adalah purposive sampling dengan pengumpulan sampel menggunakan metode transek. Hasil penelitian ini menunjukkan bahwa kualitas air di Kota Padang, Sumatera Barat, cukup baik untuk mendukung kehidupan makrozoobentos. Kelimpahan jenis makrozoobentos tertinggi terdapat di Stasiun Pantai Reklamasi. Spesies makrozoobentos yang ditemukan termasuk dalam 2 kelas

yaitu Gastropoda dan Crustacea. Kelas Gastropoda terdiri dari 4 spesies: *Babylonia spirata, Pila ampullacea, Pila occidentalis*, dan *Nerita fulgurans*, sedangkan dari kelas Crustacea ditemukan tiga spesies: *Ashtoret lunaris, Hemigrapsus takanoi*, dan *Emerita* sp. Sedangkan kelimpahan terendah terdapat di Stasiun Natural Beach yang merupakan tempat ditemukannya spesies yang termasuk dalam kelas Crustacea, khususnya *H.takanoi*. Keanekaragaman jenis makrozoobentos di Stasiun Pantai Alam tergolong rendah, sedangkan di Stasiun Pantai Reklamasi tergolong sedang. Kemiripan di Stasiun Pantai Alam tergolong rendah, sedangkan di Stasiun Pantai Reklamasi tinggi. Selain itu, terdapat satu spesies dominan di Stasiun Pantai Alam, sedangkan di Stasiun Pantai Reklamasi tidak ditemukan spesies dominan. Pola sebaran makrozoobentos di perairan pesisir Kota Padang dikategorikan sebaran mengelompok.

Kata kunci: Pantai Reklamasi, Pantai Alami, Macrozoobenthos

1. Introduction

West Sumatra is one of Indonesia's provinces facing the Indian Ocean. According to Ruspianda (2019), it is said that Padang City is located on the west coast of Sumatra Island, with a total area of 694.96 km² or equivalent to 1.65% of the area of the province. 694.96 km² or equivalent to 1.65% of the total area of West Sumatra Province. West Sumatra Province. Padang City is one of the cities with a long coastline. According to Istijono (2013), the type of beach in Padang City is a sandy beach that forms a straight line with a length of approximately 60 km. Approximately 60 km long. Padang City has approximately 120 ha of mangrove forest, modified little by human intervention and slightly modified by human intervention.

Tourist visitors flock to the beaches every year in Padang City; because of this, the Padang City government has made many reforms to manage the beach area as a tourist attraction. Attraction of out-of-town and international tourists. Reclamation, in principle, presents new land in regions previously river or sea waters; Reclaimed land is referred to as reclaimed land or landfill. One is conducting coastal reclamation, which affects sedimentation, tidal patterns, and biota life around the reclamation area (Ramadhan et al., 2022).

Macrozoobenthos is an organism that lives in coastal areas from intertidal to abyssal zones. Organisms that live in coastal regions from intertidal to abyssal zones. Macrozoobenthos has a relatively sedentary nature or low movement, so it gets much influence from its environment. so that they get much influence from their environment. Community structure is a concept or study that studies a community's composition or abundance of species. Species composition and abundance in a community are fascinating to study. According to Tanjung (2023), community structure consists of various parameters, including species abundance, relative abundance, species diversity, species similarity, dominance, and distribution patterns.

Thus, this research needs to be done to compare macrozoobenthos species and macrozoobenthos community structure in areas that have been reclaimed and those that have not. Areas that have been carried out coastal reclamation, including coastal areas that have not been affected by coastal reclamation on the coast of Padang City, West Sumatra, have still very little done.

2. Material and Method

2.1. Time and Place

This research was conducted from December 2023 to February 2024. Sampling was carried out in the coastal area of Padang City, West Sumatra Province. Then, macrozoobenthos samples were identified at the Marine Biology Laboratory, and sediment type analysis was conducted at the Chemical Oceanography Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau

2.2. Methods

The method used in this research is the survey method, namely direct observation of the study area, sampling and measurement of sampling, and measuring aquatic environmental quality parameters in the field.

2.3. Procedures

Sampling stations were determined based on the Purposive Sampling technique. The sampling was divided into two stations: the Natural Beach Station on the beach that is not affected by reclamation and is not affected by industrial or residential activities on Pasir Putih Beach, Koto Tangah District, Padang City, and the Reclamation

Beach Station in the reclamation beach area that is directly influenced by the people who live around the beach and the beach visitors at Padang Indah Beach, Padang City (Figure 1).
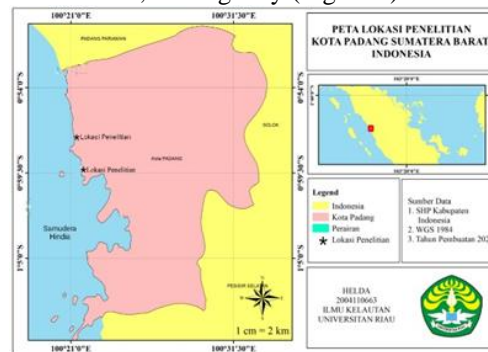

Figure 1. Research location

Data was collected during the lowest tide. The sampling technique was carried out using the transect method, given three quadrants (plots). The plots' macrozoobenthos and sediment were sampled by digging the substrate to a depth of ±20 cm. Then, the sample was sieved using a sieve to separate it from the substrate. Water quality measurements are temperature using a thermometer, salinity using a hand refractometer, pH using a pH meter, and brightness using a Secchi disk.

2.4. Data Analysis
2.4.1. Species Abundance
The abundance of macrozoobenthos species was calculated using the formula proposed by Tanjung (2023) as follows:

$$Di : ni/A$$

Description:
- Di = abundance of the i-th individual species (ind/m^2)
- ni = Number of individuals of the i-th species obtained
- A = Plot area of the i-th species found (m^2)

2.4.2. Relative Abundance
Relative abundance is calculated using the formula proposed by Tanjung (2023)

$$R = ni/Nx\ 100\%$$

Description:
- R = Relative Abundance
- Ni = Number of Individuals of Each Species
- N = Number of Individuals

2.4.3. Species Diversity Index (H')
The species diversity index was calculated using the index proposed by Tanjung (2023):

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

Description:
- H' = diversity index
- Pi = ni / N ni = number of individuals of each i-th species
- N = total number of individuals
- ln = Logaritme nature

Categories of diversity index according to Shannon-Wiener (Lubis & Sidabutar, 2017) are defined as: H' < 1: low species diversity; 1 < H'<3 : medium species diversity, and H' > 3: high species diversity

2.4.4. Similarity Index (E)
The similarity index is calculated with the formula by Tanjung (2023):

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

Description:
- E = similarity index
- H' = Shannon Wiener diversity index Wiener
- Hmaks = ln S

S   = number of species

The categories of similarity index according to Shannon-Wiener are defined as follows: $0 \leq E < 0,4$: Low similarity; $0,4 \leq E < 0,6$: Medium similarity; and $0, 6 \leq E < 1$: High similarity.

2.4.5. Dominance Index (C)

The dominance index is calculated based on the dominance index formula from Tanjung (2023):

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

Description:
C   = dominance index
ni   = number of i-th individual
N   = total number of individuals

With the Shannon-Wienner dominance index category, C approaches (0 to 0.5) = no dominating species, and C close to (0.5 to 1) = there is a dominating species.

2.4.6. Distribution Pattern (Id)

Macrozoobenthos distribution pattern is calculated using the formula Morisita index (Wahyuni et al., 2017) as follows:

$$Id = N \ \frac{\sum X^2 - \sum X}{(\sum X)^2 - \sum X}$$

Description:
Id = Morisita Spread Index
N   = Number of sampling plots
Σx = Number of individuals per plot
$\Sigma x2$ = Sum of squares of individual plots

The results of this distribution are grouped into three criteria (Tanjung, 2023): Id < 1 = The distribution pattern is evenly distributed; Id = 1 (the Distribution pattern is random); and Id > 1 (the distribution pattern is clustered).

2.4.7. Sediment Fraction and Type Analysis

The laboratory analysis of the sediment fraction follows the procedure referred to by Rifardi (2008). The grain size analysis for the sand and gravel fraction used wet sieving, and the mud fraction used the pipette method. The results of calculations on particle size content in the form of gravel, sand, and silt in surface sediments are classified according to the Sheppard diagram to determine the sediment type.

2.4.8. Sediment Total Organic Matter Content

BOT content was analyzed using the Loss On Ignition (LOI) method (Prasetia et al., 2019). Organic matter content was calculated using the formula (Pett, 1993):

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

Description:
a   = total weight (cup + sample) after drying at 105 ^{0}C,
b   = weight of cup
c   = weight of cup + sample after burning at 550 ^{0}C

3. Result and Discussion

3.1. General Condition of Waters

Padang City is located in the West Sumatra Province. Natural Beach Station is a natural beach not exposed to reclamation and located at coordinates 0°52.2.85 "LU 100°19, 9.1 "BT. Mangrove planting conservation beach that is still classified as natural and not exposed to human intervention modifications. Station Reclamation Beach is a reclamation area at Purus Padang in West Padang District, West Sumatra, located at coordinate point 0°19.35.5" LU 100°21.0.18" BT. This beach is a of Padang City that experienced human intervention in the form of beach filling or reclamation to support or reclamation to support tourism.

3.2. Water Quality Parameters

Measured water quality measurements include temperature, salinity, brightness, and pH. The results of water quality measurements are shown in Table 1.

Table 1. Water quality parameters of Padang City Beach

No.	Water Quality	Natural Beach	Reklamation Beach	Mean
1	Temperature (ºC)	30	31	30,5
2	Salinity (ppt)	28	27	27,5
3	Brightness (%)	90	80	85
4	pH	7	7	7

The highest temperature is found at Natural Beach Station, 31℃, and the lowest at Natural Beach Station, 30℃. The highest salinity found at the Natural Beach Station is 28 ppt, and the weakest at the Reclaimed Beach Station is 27 ppt. The highest brightness is found at the Natural Beach Station, which is 90%, and the lowest at the Reclaimed Beach Station, which is 80%. The degree of acidity (pH) at both stations is 7.

3.3. Sediment Fraction
The results of the sediment fraction calculation on Padang City Beach can be seen in Table 2.

Table 2. Percentage of Sediment Fractions and Types between Research Stations

Station	Transect	Sampling Point	% Fractions			Sediment Type
			Gravel	Sand	Mud	
Natural Beach	I	Upper	9,76	87,37	2,87	Sandy
	II	Middle	1,80	97,42	0,78	Sandy
	III	Lower	16,40	80,16	3,44	Sandy
Reklamation Beach	I	Upper	8,69	89,99	1,32	Sandy
	II	Middle	16,07	72,66	11,27	Gravely sand
	III	Lower	10,98	73,24	15,79	Muddy sand

Research stations that analyzed sediment samples in Padang City's waters found that the sediment type consists of sand, gravelly, and muddy sand. Both research stations have sediment types that dominate sandy.

3.4. Sediment Total Organic Matter Content
The results of the analysis of the total organic matter content of sediment found in the waters of Padang City can be seen in Table 3:

Table 3. Organic matter content between research stations

Station	Transect	Sampling point	% BOT	Mean	Reynold criteria
Natural Beach	I	Upper	2,17	3,52%	Medium
	II	Middle	6,77		
	III	Lower	8,66		
Reclamation Beach	I	Upper	11,91	6,04%	Medium
	II	Middle	8,08		
	III	Lower	10,22		

Based on the analysis of the total organic matter content of sediments at the Natural Beach Station, it has an average value of 3.52%. At the same time, at the Reclamation Beach Station, it is 6.04%. This value is classified into moderate criteria (Reynold, 1971).

3.5. Types of Macrozoobenthos
Macrozoobenthos found in the waters of Padang City Beach can be seen in Table 4 and Figure 2.

Table 4. Types of macrozoobenthos found between research stations

Classes	Sampling Point	
	Natural Beach	Reklamation Beach
Crustacea	*Hemigrapsus Takanoi*	*Emerita* sp
		Ashtoret lunaris
		Hemigrapsus takanoi
Gastropoda		*Pila ampullaceal*
		Pila occidentalis
		Babylonia spirata
		Nerita fulgurans

Based on the observations of macrozoobenthos species in the waters of Padang city, macrozoobenthos comes from 2 classes, namely Gastropoda and Crustacea. The Gastropoda class consists of 4 species, namely *B.spirata, P.ampullaceal, P.occidentalis*, and *N. fulgurans*. From the Crustacea class, three species were presented, namely *A.lunaris, H.takanoi*, and *Emerita* sp. At the Natural Beach Station, a natural beach station with a sandy substrate and mangrove forest vegetation, the most common species, *H.takanoi* species from the Crustacea class, were

found the most. This is in line with Haruna's (2022), which revealed that the mangrove forest substrate strongly supports crab macrozoobenthos's life, especially for mating and molting around the water. While at the Reclamation Beach Station, which is in the reclamation area, the species with the highest abundance is *Emerita* sp from the Crustacean class. The Crustacean class is commonly found at Reclamation Beach Station due to its good tolerance to high sea surface temperatures. At the Reclamation Beach Station, the temperature value was 31 °C. According to Septiani et al. (2019), the range of temperatures that Crustacean class macrozoobenthos can tolerate by Crustacean class macrozoobenthos are 12°C-35°C.
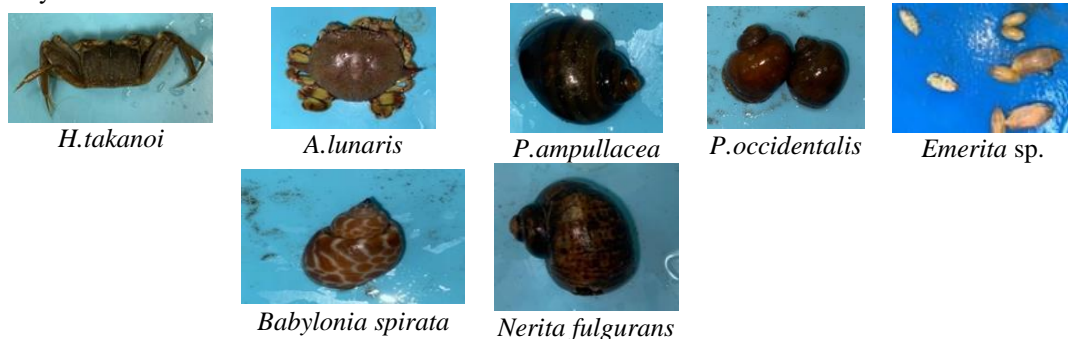

H.takanoi   *A.lunaris*   *P.ampullacea*   *P.occidentalis*   *Emerita* sp.

Babylonia spirata   *Nerita fulgurans*

Figure 2. Macrozoobenthos found at the research station

3.6. Abundance of Macrozoobenthos Species

The abundance of macrozoobenthos species between research stations can be seen in Figure 3.
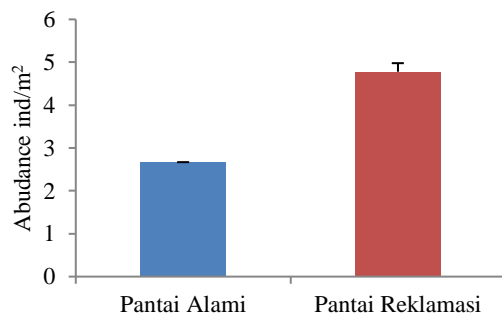

Figure 3. Macrozoobenthos abundance between research stations
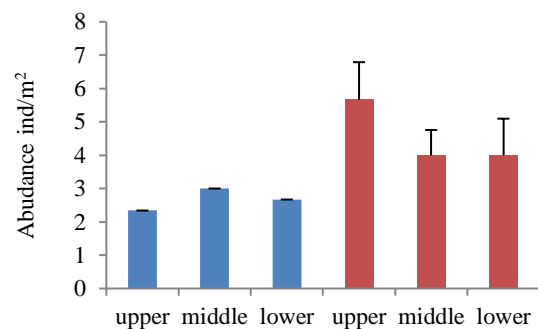

Figure 4. Macrozoobenthos Abundance In the Research Subzone

The abundance of macrozoobenthos species between Natural Beach Station and Reclamation Beach Station obtained 2.67 and 4.78 ind/m^2 results. The Natural Beach Station has a low species abundance value. Only one species was found at the station, which resulted in a low abundance of macrozoobenthos species. The highest abundance was found at the Reclamation Beach Station. This station is a reclaimed beach and is also a beach with a tourist destination, so this station has the highest organic matter content of 6.04%. This is in line with the research of Gultom et al. (2018), which stated that organic matter that settles on the bottom of the water is a source of food for benthic organisms, so the amount and rate of its increase in sediment has a significant influence on the population of benthic organisms.

Based on the calculation of the abundance of macrozoobenthos species between sub-zones at both stations, results of 5.67-2.34 ind/m^2. At Natural Beach Station, the highest abundance of macrozoobenthos is found in the middle subzone, 3.00 ind/m^2, and the lowest in the upper subzone (Figure 4). This is thought to be caused by competition in search of food so that the survival of macrozoobenthos in this subzone is disrupted. At the Station Reclamation Beach Station, the zone with the highest abundance of macrozoobenthos is the upper subzone, which is 5.67 ind/m^2. The highest abundance in this zone is thought to be because the substrate in this zone is still suitable for the survival of macrozoobenthos and has sufficient food availability. The lowest abundance is in the middle and lower subzone, 4.00 ind/m^2. This zone is at the lowest ebb and is affected by ocean waves, thus making macrozoobenthos experience the threat of waves and disrupt their survival process. In line with the opinion of Saleky et al. (2019), the continuous splashing of waves makes marine organisms tend to live in higher areas than in areas where the waves are higher. Marine organisms tend to live in higher places than areas exposed to high waves.

3.7. Relative Abundance

Based on the calculation of relative abundance at the Natural Beach Station, the highest results were obtained for *H.takanoi* species from the Crustacea class with a value of 100%. This happened because only one species was found at this station. According to Nur & Kuntjoro (2020), an ecosystem's relative abundance shows the

proportion of each species of all individuals. At the Reclamation Beach Station, the highest relative abundance was *Emerita* sp, which comes from the Crustacea class. According to Nugraha et al. (2018), *Emerita* sp. can tolerate in the temperature range of 28-33°C, which is thought to be one of the factors for the high relative abundance at the Reclamation Beach station.

Table 5. Relative abundance of macrobenthos between research stations

Species	Natural Beach	Reklamation Beach
H.takanoi	100 %	13,95%
B.spirata		9,30%
P.ampullacea		9,30%
N. fulgurans		16.27%
Emerita sp.		20,93%
P. occidentalis		16,27%
A. lunaris		13,95%

3.8. Species Diversity Index (H'), Similarity Index (E), and Dominance Index (C) of Macrozoobenthos

Based on the data analysis obtained, the calculation of diversity, similarity, and dominance between the coastal stations of Padang can be seen in Table 6.

Table 6. Species diversity index (H'), similarity index (E), and dominance index (C)

Station	(H')	(E)	(C)
Natural Beach	0	0	1
Reklamation Beach	1,90	0,98	1,20

Based on the results of calculating the macrozoobenthos diversity index at Natural Beach Station, a natural beach, the result is 0 with low criteria. Only one macrozoobenthos species, Hemigrapsus takanoi, was found at Natural Beach Station. According to Baderan et al. (2021), the index value will be low if the community has a small number of species and each species has a large number of individuals. In the Reclamation Beach Station, a reclaimed beach, the result is 1.90 with moderate criteria. Measurements of organic matter at this station are relatively high, and it is a food source for biota. Diversity, classified as mild in an area, can be caused by the influence of community activities such as industry, households, and tourism (Baiun et al., 2021).

The similarity index at the Natural Beach Station has a value of 0, which is classified as low, while at the Reclamation Beach Station, which has a value of 0.98, it is classified as high. Ilham et al. (2020) explained that if the index similarity index is close to one, then the organisms in the community show similarity; otherwise, if the similarity index is close to zero, the microorganisms in the community are not uniform. This is in line with the results of the study at the Natural Beach Station, which found only one type of species, *H.takanoi*, which is thought to be caused by the type of substrate and the geographical condition of the Natural Beach Station, which is directly facing the ocean so that not many macrozoobenthos organisms can survive by the waves. In contrast, similarity at the Reclamation Beach Station station is classified as moderate, which means that the station has a reasonably uniform macrozoobenthos, namely from the class Gastropoda and Crustacea.

The dominance index at the Natural Beach Station obtained a result of 1, meaning that there is a dominating species at the Natural Beach Station. In line with the results of macrozoobenthos identification, only one species was found in this station, *H.takanoi*. While at the Reclamation Beach Station, we obtained a result of 0.15, which indicates that there is no dominating species. This is due to the dispersed pattern of dominance due to the high food availability at the Reclamation Beach Station, so there is no competition. The dominance index describes the pattern of dominance of a species over other species in an ecosystem community. The higher the dominance index value of a species illustrates, the more the dominance pattern is centered on only certain species or the more suitable the community is for certain species. Conversely, the lower dominance index value will illustrate the pattern of mastery of species in the community relatively spread in each species (Ferawati et al., 2021).

3.9. Distribution Pattern

Calculation of macrozoobenthos distribution patterns between stations can be seen in Table 7.

Table 7. Distribution pattern of macrozoobenthos between research stations

Station	Id	distribution patterns
Natural Beach	9,00	Clustered
Reklamation Beach	1,20	Clustered

The distribution pattern (Id) of macrozoobenthos in the waters of Padang City obtained results at the Natural Beach Station at 9.00 while at the Reclamation Beach Station at 1.20. then it can be concluded that the distribution of macrozoobenthos in the waters of Padang City is clustered. Based on the study results, it is suspected that this clustering habit is caused by the presence of food and the instinct of macrozoobenthos shelter from high waves.

According to Putra et al. (2021), distribution occurs in groups because it is influenced by habitats that provide sufficient food sources. Hence, there is no competition and abundance despite the same food source. According to Hidayati (2010), distribution patterns are caused by the instinct of a species to find a suitable living environment for that species. Species in the environment can live and grow if the environment is favorable. This opinion aligns with the results of macrozoobenthos identification and analysis of substrate type in both stations, where many biotas from the Crustacean class were found, favoring sandy substrate types.

4. Conclusions

Based on the research carried out in the waters of Padang City West Sumatra, the water quality results are still quite good for the survival of macrozoobenthos. The abundance of macrozoobenthos species significantly differs between Natural Beach Station and Reclamation Beach Station. The highest abundance is found at the Reclamation Beach Station, which comes from 2 classes, namely Gastropoda and Crustaceans. The Gastropoda class consists of 4 species: Babylonia *spirata, Pila ampullaceal, Pila occidentalis,* and *Nerita fulgurans*. The Crustacea class presented three species: *Ashtoret lunaris, Hemigrapsus takanoi*, and *Emerita* sp. The abundance of species The lowest abundance of macrozoobenthos species at Natural Beach Station only comes from the class of Crustacea, namely*Hemigrapsus takanoi* species. Low diversity and similarity values are obtained at the Natural Beach Station, while at the Reclamation Beach Station, a moderate diversity value is obtained and high similarity. At the Natural Beach Station, some species are dominating species, while at the Reclamation Beach Station, there are no dominating species. Macrozoobenthos distribution patterns at both stations' observations are grouped.

5. References

Baderan, D.W.K., Hamidun M.S., & Utina, R. (2021). Keanekaragaman Mollusca (Bivalvia dan Polyplacophora) di Wilayah Pesisir Biluhu Provinsi Gorontalo. *Bioeksperimen*, 7(1).

Bai'un, N.H., Riyantini, I., Mulyani, Y., & Zallesa, S. (2021). Keanekaragaman Makrozoobentos sebagai Indikator Kondisi Perairan di Ekosistem Mangrove Pulau Pari, Kepulauan Seribu. *Journal of Fisheries and Marine Research* 5(2): 227-238.

Ferawati, F., Bakhtiar, B., Rahmawati, A., Iqbal, M., & Azmin, N. (2021). Inventarisasi Keanekaragaman Makrozoobentos di Pesisir Pantai Rontu. *Oryza Jurnal Pendidikan Biologi*, 10 (1).

Gultom, C.R., Muskananfola, M.R., & Purnomo, P.W. (2018). Hubungan Kelimpahan Makrozoobentos dengan Bahan Organik dan Tekstur Sedimen Dikawasan Mangrove Desa Bedono Kecamatan Sayung Kabupaten Demak. *Journal of Maqueres*, 7(2):172-179.

Haruna, M.F., Karim, W.A., Rajulani, R., & Lige, F.N. (2022). Struktur Komunitas Kepiting Bakau di Kawasan Konservasi Mangrove Desa Polo Kecamatan Bunta Kabupaten Banggai. *Jurnal Pendidikan Biologi*, 9(2): 150-159.

Hidayati, T. (2010). *Studi Potensi dan Penyebaran Tengkawang (Shorea sp.) di IUPHHK-HA PT. Intracawood Manufacturing Propinsi Kalimantan Timur.* Institut Pertanian Bogor. Bogor.

Ilham, T., Hasan, Z., Andriani, Y., Herawati, H., & Sulawesty, F. (2020). Hubungan antara Struktur Komunitas Plankton dan Tingkat Pencemaran di Situ Gunung Putri, Kabupaten Bogor. *Limnotek Perairan Darat Tropis di Indonesia*, 27(2): 79–92

Istijono, B. (2013). Tinjauan Lingkungan dan Penanggulangan Abrasi Pantai Padang - Sumatera Barat. *Jurnal Rekayasa Sipil* (JRS-Unand), 9(2): 42.

Lubis, L., & Sidabutar, V. (2017). Indeks Keanekaragaman Jenis Serangga pada Fase Vegetatif dan Generatif Tanaman Kedelai (*Glacine maxmerill*) di Lapangan. *Jurnal Agroteknologi*, 5(2):474-43.

Nugraha, O.T., Suryanti, S., & Rodyanti, S. (2018). Karakteristik Habitat dan Kelimpahan Undur-Undur laut (Hippoidea) di pantai Puworejo. *Journal of Fisheries and Marine Science*, 2(2): 56-67.

Nur, B.A.S.K. (2020). Keanekaragaman dan Kelimpahan Kepiting Biola (Crustacea: Ocypodidae) di Pantai Selatan Kabupaten Bangkalan, Madura Diversity. *LenteraBio*, 9(3): 176-184

Pett, R.J.A. (1993). *Collection of Laboratory Methods for Selected Water and Sediment Quality Parameters*. Report no 13. International Development Program at Australian Universities and Colleges. PT. Hasfarm Dian Konsultan. 20p.

Prasetia, M.N., Suprihayono, S., & Frida, P. (2019). Hubungan Kandungan Bahan Organik dengan Kelimpahan dan Keanekaragaman Gastropoda pada Kawasan Wisata Mangrove Desa Bedono Demak. *Journal of Maquares*, 8(2): 87-92.

Putra, W.P.E.S., Santoso, D., & Syukur, A. (2021). Keanekaragaman dan Pola Sebaran Moluska (Gastropoda dan Bivalvia) yang Berasosiasi Pada Ekosistem Mangrove di Pesisir Selatan Lombok Timur. *Jurnal Sains Teknologi & Lingkungan*, 223-242

Ramadhan, R., Tanjung, A., & Elizal, E. (2020). The Impact of Coastal Reclamation on the Existence of Macrozoobenthos in the Nagari Mandeh Water Area, Pesisir Selatan District, West Sumatra. *Asian Journal of Aquatic Sciences*, 6(1):76-83

Reynold, S.C. (1971). *A Manual of Introductory Soil Science and Simple Soil Analysis Methods*. South Pacific. Nouena New Caledonia.

Rifardi, R. (2008). *Tekstur Sedimen, Sampling dan Analisis*. UNRI Press. Pekanbaru.

Ruspianda, R. (2019). Program Pengembangan Kawasan Pariwisata Pantai Purus Kota Padang. *JPS,* 1(1).

Saleky, D., Leatemia, S.P.O., & Yuanike, Y. (2019). Distribusi Temporal Gastropoda pada Zona Intertidal Berbatu di Pesisir Utara Manokwari Papua Barat. *Jurnal Sumberdaya Akuatik Indopasifik*, 3(3).

Septiani, M., Sunarto, S., & Mulyani, Y. (2019). Pengaruh Kondisi Mangrove terhadap Kelimpahan Kepiting Biola (*Uca* sp) di Karangsong Kabupaten Indramayu. *Jurnal Perikanan dan Kelautan*, 10(1).

Tanjung, A. (2023). *Pengantar Rekayasa Lingkungan*. Taman Karya. Pekanbaru.

Wahyuni, A.S., Prasetya, L.B., & Zuhud, E.A.M. (2017). Population and Distribution Plant Pattern Paliasa (*Kleinhovia hospita* L.) in Bontobahari District. *Media Konservasi* 22(1): 11–18