Jurnal Natur Indonesia
22(2), October 2024: 129-135

p-ISSN 1410-9379
e-ISSN 2503-0345

Macrozoobenthos as a Bioindicator for Water Quality on the Coast of Padang City, West Sumatra

Makrozoobentos Sebagai Bioindikator Kualitas Perairan di Pantai Kota Padang Provinsi Sumatera Barat

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ABSTRACT

The research was carried out in January 2024 at the coastal waters of Padang City, West Sumatera Province. This research aims to determine the structure of the macrozoobenthos community as a bioindicator of water quality on the beaches of Padang City. Purposive sampling was used to get the sample, and then data was analyzed using FBI methods. (Family Biotic Index). The research results using FBI calculations show that Station 1 is in a good category with a score of 4.73, Station 2 is in the good category with a score of 4.71, and Station 3 is in the relatively poor category with a score of 6. Thus, the water quality based on macrozoobenthos as bioindicators of the coastal waters of Padang City, with an FBI value, was found to have an average of 5.14, which falls into the moderate category.

Keywords: Macrozoobenthos, Bioindicators, Quality, Aquatic

ABSTRAK

Penelitian ini dilakukan pada bulan Januari 2024 di perairan pesisir Kota Padang, Provinsi Sumatera Barat. Tujuan penelitian ini adalah untuk menentukan struktur komunitas makrozoobentos sebagai bioindikator kualitas air di pantai-pantai Kota Padang. Untuk mendapatkan sampel, digunakan metode *purposive sampling*, dan kemudian data dianalisis dengan metode FBI (*Family Biotic Index*). Hasil penelitian menggunakan perhitungan FBI menunjukkan bahwa Stasiun 1 berada dalam kategori baik dengan skor 4,73, Stasiun 2 berada dalam kategori baik dengan skor 4,71, dan Stasiun 3 berada dalam kategori agak buruk dengan skor 6. Sehingga didapat kualitas perairan berdasarkan makrozoobentos sebagai bioindikator kualitas perairan pantai Kota Padang dengan FBI di dapat nilai rata – rata 5,14 dengan kategori cukup.

Kata Kunci: Makrozoobentos, Bioindikator, Kualitas, Perairan

Received: 15 September 2024
Accepted: 30 October 2024

INTRODUCTION

Padang City, the capital of West Sumatra Province, is a popular tourist destination for local and international tourists. The beaches of Padang City serve as the hub for various activities, including fishing, ship docking, and tourism, which directly impact the habitat and environment of macrozoobenthos. These human activities can lead to coastal water pollution and disrupt the ecology around Padang City's beaches. Coastal waters play an essential role in the lives of local communities, being used for activities such as ship docking, fishing, and tourist attractions. Therefore, awareness of coastal environmental quality is crucial. Poor water quality will negatively affect macrozoobenthos, indicators of aquatic ecological health (Hamuna et al., 2019).

Previous studies have shown that the structure of macrozoobenthos communities can be used as bioindicators of water quality. Environmental factors such as temperature, pH, dissolved oxygen, salinity, substrate type, and organic matter content influence macrozoobenthos' abundance, diversity, and distribution (Gurning et al., 2019). Although there is extensive research on macrozoobenthos as bioindicators of water quality, studies on this subject in the coastal areas of Padang City are still limited. Therefore, this research aims to investigate the structure of macrozoobenthos communities as bioindicators of water quality on the beaches of Padang City.

MATERIALS AND METHOD

Time and place of research

The research was conducted in January 2024 in Padang City Beach, West Sumatra Province (Figure 1).

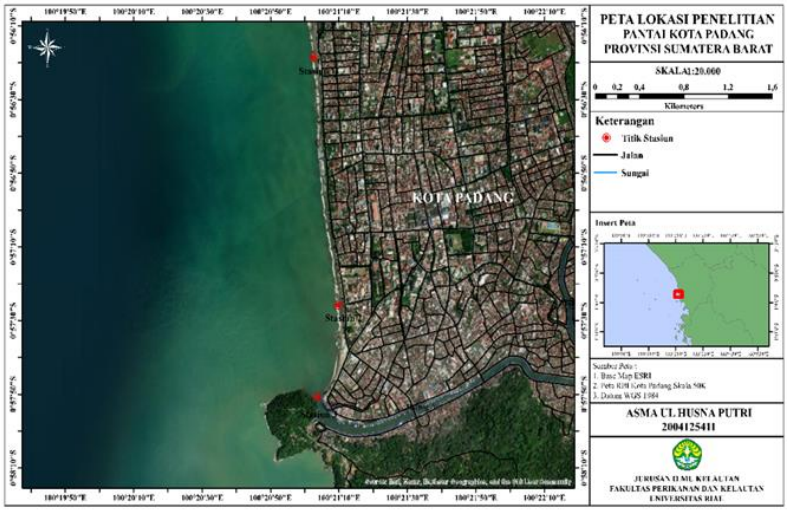

Figure 1. Research location

Determining the location of the sampling

The research method used was the survey method. The research procedure included determining sampling points, measuring water quality directly in the field, collecting macrozoobenthos samples using the quadrant transect method, and analyzing sediment samples with the wet sieving and pipette methods.

Data analysis

Sample analysis was conducted in the laboratory, including identification and grouping of macrozoobenthos, calculating abundance, diversity, uniformity, and dominance, analyzing the total organic content of the sediment and determining the sediment type. Data processing was carried out using statistical formulas to calculate abundance, diversity, uniformity, dominance, and FBI, as well as interpreting water quality based on the FBI value. The abundance of macrozoobenthos was calculated based on the number of individuals per unit area (ind/m^2) using the Shannon-Wiener formula, which is:

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

Description:

K : Species abundance (ind/m^2)
ni : Total number of macrozoobenthos individuals taken (ind)
A : Total area of sampling area (m^2)

Diversity species macrozoobenthos calculated with the Shannon-Wienner Diversity Index, formulated as follows:

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

Description:

H' : Diversity index
Pi : ni/N
ni : Number of species i
N : Total number of all species

According to Maula (2018), the diversity criteria are as follows: H< 1 low diversity; 1 ≤ H' ≤ medium diversity; and H' > 3 High diversity. Uniformity can be analyzed using the formula according to Krebs in Meisaroh et al. (2018), as follows:

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

Description:

E : Evenness uniformity index
S : Number of species
H' : Diversity index

The criteria for uniformity are as follows: E < 0.4: low; 0.4 ≤ E ≤ 0.6: medium; E > 0 .6: high. The dominance index can be analyzed using the formula according to Odum in Meisaroh et al. (2018), as follows:

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

Description:

C : Dominance Index
ni : Number of individuals of each species
N : Total number of individuals

The criteria for the dominance index are as follows: 0 ≤ C < 0, 3: low dominance; 0.3 ≤ C < 0,6: medium dominance; and 0, 6 ≤ C ≤ 1: high dominance. Water quality using the Family Biotic Index method with the following equation (Rachman et al., 2016):

$$FBI = \frac{ni\ X\ T}{N}$$

Description:

FBI : Family Biotic Index
ni : number of individuals in the i-th family group
T : tolerance level of the i-th family group
N : the number of individuals who make up the macrozoobenthos community.

The interpretation of water quality based on the FBI is presented in Table 1.

Table 1. FBI interpretation for assessing water quality (Hilsenhoff in Rachman et al., 2016)

Family Biotic Index	Water Quality Status	Pollution Level
0,00 – 3,75	Very good	Not polluted by organic matter
3,76 – 4,25	Excellent	Slightly polluted with organic matter
4,26 – 5,00	Good	Polluted with some organic matter
5,01 – 5,75	Simply	Somewhat polluted with organic matter
5,76 – 6,50	Some Bad	Polluted with much organic matter
6,51 – 7,25	Bad	Polluted very a lot of organic matter
7,26 – 10,00	Very Bad	Heavily polluted with organic matter

Organic matter levels are calculated using the formula (Gurning et al., 2019):

$$BOT = \frac{(Wt\text{-}C)\text{-}(Wa\text{-}C)}{Wt\text{-}C} \times 100\%$$

Description:

Wt : Total weight (cup + sample) before burning,
Wa : Total weight (cup + sample) after burning
C : Weight of empty cup

Determination of sediment type

Determination of sediment type was done using Shepard's triangle method. Calculations were made on the particle size content of gravel, sand and silt. Surface sediments were classified according to Shepard's diagram. The classification system is based on median diameter (Md). Shepard diagrams are an example of a triple diagram (a tool for three-unit graphs) of a 100% component system. The components are the percentages of gravel silt that make up the sediment. Each sediment sample is plotted as a point within or along the diagram's sides, depending on its grain size-specific composition. The Shepard triangle is the classification of sediment samples, dividing a triplicate diagram into ten classes.

RESULT AND DISCUSSION

Water quality

The results of water quality measurements at Padang City Beach, West Sumatra Province, can be seen in Table 2.

Table 2. Water quality parameters in Padang City Beach, West Sumatra Province

No.	Parameters	Station			Average
		I	II	III	
1	Temperature (ºC)	31	32	32	31,67
2	Salinity (ppt)	26	27	22	25,00
3	pH	7	8	7	7,33
4	Dissolved oxygen (mg/L)	6,3	6,7	5,5	6,16

The results of water quality measurements at Padang City Beach, West Sumatra, are shown in Table 2. The water temperature ranged from 31-32°C. Salinity during. The pH value at the study site ranged from 7.0 to 8.0, and the dissolved oxygen concentration ranged from 5.5 to 6.7 mg/L. Water quality measurements at Padang City Beach, West Sumatra, showed a temperature of 31-32 ° C, which is influenced by the absorption of sunlight and is suitable for macrozoobenthos life, according to PP RI No. 22 of 2021. Salinity ranges from 22-27 o/oo, still supporting macrozoobenthos life. The pH value of 7.0-8.0 shows stable conditions and follows PP RI No. 22 of 2021. The dissolved oxygen concentration is 5.5-6.7 mg/L, also following the standards of PP RI No. 22's 2021, supporting the life of macrozoobenthos.

Organic matter content

The results of the sediment organic matter content calculation at each station in Padang City Beach, West Sumatra Province, can be seen in Table 3.

Table 3. Sediment total organic matter content

Station	Transect	Average (%)
I	1	11,01
	2	5,30
	3	8,90
Average		8,40
II	1	12,13
	2	2,06
	3	1,75
Average		5,37
III	1	0,99
	2	5,49
	3	5,22
Average		3,90

Based on the analysis results (Table 3), the organic matter content in the sediments at the research site is classified as low to high fertility. Organic matter content measurement results in Padang City Beach, West Sumatra Province, ranged from 3.90 to 8.40%. Based on the analysis, the organic matter content in the sediment at Padang City Beach ranged from 3.90 to 8.40%, indicating a fertility level that varied from low to high. According to Razid et al. (2021), the content of organic matter in the sediment positively impacts the abundance of macrozoobenthos because the benthic habitat is on the bottom substrate of the water.

Sediment fraction

The results of the fraction weight percentage and sediment type analysis in Padang City Beach, West

Sumatra Province, are presented in Table 4.

Table 4. Percentage of sediment fraction

Station	Transect	Gravel (%)	Sand (%)	Sludge (%)	Sediment Type
I	1	11,91	78,63	9,46	Sand
	2	11,77	78,03	10,20	Sand
	3	11,64	77,13	11,23	Sand
Average		11,77	77,93	10,30	Sand
II	1	5,07	87,11	7,82	Sand
	2	5,02	86,13	8,85	Sand
	3	4,96	85,51	9,53	Sand
Average		5,02	86,25	8,73	Sand
III	1	35,93	48,71	15,36	Gravelly Sand
	2	35,49	48,14	16,37	Gravelly Sand
	3	34,99	47,56	17,45	Gravelly Sand
Average		35,47	48,14	16,39	Gravelly Sand

The fraction of sediment grains at each station in Padang City Beach, West Sumatra Province, has a condition of gravelly sand and muddy sand, a substrate that contains various types of macrozoobenthos. Sediment types at Padang City Beach are dominated by gravel and silty sand. The average gravel fraction at station I was 11.77%, sand 77.93%, and mud 10.30%. At station II, gravel was 5.02%, sand was 86.25%, and mud was 8.73%. At station III, gravel was 35.47%, sand 48.14%, and mud 16.39%. The dominant sediment texture is sand, followed by mud and gravel, with variations between stations due to differences in sedimentation processes. These conditions affect macrozoobenthos' life, with gravelly sand and muddy sediments supporting a variety of macrozoobenthos species. High concentrations of organic matter affect the abundance and dominance of certain species.

Types of macrozoobenthos

Several types of macrozoobenthos and their classification are found at the study site presented in Table 5.

Table 5. Types of macrozoobenthos in Padang City Beach

Station	Family	Species
I	Matutidae	*Ashtoret lunaris*
	Babyloniidae	*Babylonia spirata*
	Ampullariidae	*Pila ampullaceal*
	Neritidae	*Nerita fulgurans*
	Varunidae	*Hemigrapsus takanoi*
	Hippidae	*Emerita* sp.
	Ampullariidae	*Pila occidentalis*
II	Turritellidae	*Turritella communis*
	Portunidae	*Portunus pelagicus*
	Neritidae	*Vittina turrita*
III	Matutidae	*Matuta victor*
	Muricidae	*Indothais malayensis*

In Table 5, it can be seen that there are nine families and 12 species of Macrozoobenthos found in Padang City Beach, West Sumatra Province. 9 families are *Matutidae, Babyloniidae, Ampullariidae, Neritidae, Varunidae, Hippidae, Turritellidae, Portunidae* and *Muricidae.* Based on observations, nine families and 12 macrozoobenthos species were found in the waters of Padang City Beach, West Sumatra. The families include Matutidae, Babyloniidae, Ampullariidae, Neritidae, Varunidae, Hippidae, Turritellidae, Portunidae, and Muricidae. According to Ernawati et al. (2019), Muricidae live in shallow waters and prey on worms with acid secretions, while Neritidae are predators of bivalves and gastropods in the sea, beach, or mud. Species found include Ashtoret lunaris, Babylonia spirata, and Matuta victor, with Matuta victor being the most widespread. Rizka et al. (2016) noted that Matuta victor is often mobile, leading to its wide distribution.

Macrozoobenthos abundance

Based on the calculation of the abundance of macrozobenthos at each station in Padang City Beach, West Sumatra Province can be seen in Table 6.

Table 6. Macrozoobenthos abundance at each station in Padang City Beach, West Sumatra Province

Station	Transect	Abundance (ind/m^2)	Average
I	1	6,3	
	2	4	4,77
	3	4	
II	1	2,7	
	2	1,3	2,55
	3	3,7	
III	1	2,7	
	2	2	2,33
	3	2,3	

Table 6 shows that the results of calculating the abundance value of macrozoobenthos in each station have an average range of 2.33 - 4.77 ind/m^2. Where the value of density and abundance at station I is 4.77 ind / m2, station II is 2.55 ind/m^2, and station III is 2.33 ind/m^2. Based on the calculation results, the abundance of macrozoobenthos at each station ranged from 2.33-4.77 ind/m^2. Station I had the highest value (4.77 ind/m^2), station II (2.55 ind/m^2), and station III (2.33 ind/m^2). The highest abundance is found in areas with high community activity related to physical and chemical factors of water, such as DO and pH. The low abundance at station II is thought to be due to low pH and DO due to industrial waste, which can reduce dissolved oxygen levels and harm aquatic biota. Miloslavich et al. (2013) stated that fishing activities also affect macrozoobenthos abundance. Other physical and chemical factors such as light penetration, water temperature, pH, DO, and BOD also affect the abundance of macrozoobenthos (Fadilla et al., 2022).

Diversity index, uniformity index and dominance index

Based on the calculation of the diversity index, uniformity index, and dominance index of macrozoobenthos can be seen in Table 7.

Table 7. Diversity index, uniformity index, dominance index and distribution pattern

Station	H'	E	C
I	1,64	0,87	0,18
II	0,70	0,64	0,36
III	0,67	0,97	0,52

Table 7 shows that the species diversity index at station I is 1.64, meaning $1 \leq H' \leq 3$, which has a moderate level of species diversity; at station II is 0.70, meaning $H < 1$, which has a low level of species diversity and at station III is 0.67 meaning $H < 1$ which has a low level of species diversity. The species uniformity index at station I is 0.87, meaning $E > 0.6$, which has high organism uniformity. At station II, it is 0.64 $E > 0.6$, which has high organism uniformity; at station III, it is 0.97 $E > 0.6$, which has high organism uniformity. The species dominance index at station I is 0.18, meaning $0 \leq C < 0.3$, which has low dominance; at station II, it is 0.36, meaning $0.3 \leq C < 0.6$, which has moderate dominance. Station III is 0.52, meaning $0.3 \leq C < 0.6$, which has moderate dominance (Meisaroh et al., 2018). The different levels of diversity, uniformity, and dominance indices are caused by each individual's physical factors of water, nutrient availability, and adaptability (Hamuna et al., 2019).

Family Biotic Index (FBI)

Based on the results of calculating the biotic family of macrozoobenthos index and tolerance value can be seen in Table 8.

Table 8. Biotic index families and values tolerance families and species

Station	Family	Species	Tolerance Value	FBI
I	Matitudae	*Ashtoret Lunaris*	6	4,73
	Babyloniidae	*Babylonia spirata*	4	
	Ampullariidae	*Pila ampullaceal*	4	
	Neritidae	*Nerita Fulgurans*	4	
	Varunidae	*Hemigrapsus takanoi*	6	
	Hippidae	*Emerita* sp.	5	
	Ampullariidae	*Pila occidentalis*	4	
II	Turritellidae	*Turritella communis*	4	4,71
	Portunidae	*Portunus pelagicus*	6	
	Nertidae	*Vittina turrita*	4	
III	Matutidae	*Matuta victor*	6	6,00
	Muricidae	*Indothais malayensis*	6	

The FBI value of macrozoobenthos at three observation stations ranged from 4.71 to 6.00. The highest FBI value of macrozoobenthos is found at station 3 with a value of 6.00, which means that the water quality is in a rather lousy category with a pollution level polluted by much organic matter, followed by station 1 with a value of 4.73, which means that the water quality is in a good category with a pollution level polluted by some organic matter. In contrast, the lowest FBI value is found at station 2. with a value of 4.71, which means that the water quality is in a good category with some organic matter pollution. Thus, the water quality based on macrozoobenthos as bioindicators of the coastal waters of Padang City, with an FBI value, was found to have an average of 5.14, which falls into the moderate category. The high FBI value at station III was due to the dominance of the Matitudae and Varunidae families, which highly tolerate environmental changes. The low FBI value at station II was due to facultative species, such as bivalves and gastropods, indicating some organic matter pollution.

CONCLUSION

Based on the results of this study, water quality based on macrozoobenthos as a bioindicator of water quality of Padang City Beach with FBI calculations at an average value of 5.14 with a sufficient category.

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