Jurnal Ilmu Pertanian Indonesia (JIPI), Januari 2025
(Indonesian Journal of Agricultural Sciences)
ISSN 0853-4217 EISSN 2443-3462

Vol. 30 (1): 1–10
http://journal.ipb.ac.id/index.php/JIPI
DOI: 10.18343/jipi.30.1.1

Macrozoobenthos as a Bioindicator of Pollution in the Malaka Strait Waters, Indonesia

Djunaidi, Perdana Putra Kelana, Tyas Dita Pramesthy, Muhammad Nur Arkham*, Rangga Bayu Kusuma Haris

(Received September 2023/Accepted December 2024)

ABSTRACT

Macrozoobentos are known as organisms that are sensitive to environmental changes, so they are widely used as biological indicators of a water. This study aims to determine the types of macrozoobenthos, the level of diversity, uniformity, and dominance of macrozoobenthos, including *the family biotic index* (FBI) to detect water quality in Dumai City. The method used was a survey with stations determined through the purposive sampling. Macrozoobenthos samples were collected using *a line transect* with a square transect and a core sampler. A total of 381 macrozoobentos individuals found in the waters of Dumai City consisted of 6 species from the Gastropods class (*Nerita articulata, Chicoreus capucinus, Littorina scabra, Ellobium aurisjudae, Cerithidae quoyii*, *and Pugilina cochlidium*)*;* Bivalvia class: 1 family and 1 species (*Polymesoda bengalensis*). The highest macrozoobenthos density was found at Station 3 (125 ind/m^2) and the lowest at station 1 (21 ind/m^2). The Shannon-Wienner diversity index ranged between 1.17 and 1.52. The diversity index at all stations was relatively low, the macrozoobenthos uniformity index was high (0.654697–to 0.783512), and the dominance index was relatively low (0.234078–to 0.43574). The Shannon-Wienner Index and the dominance index are also relatively low. Further testing using the FBI showed differences in water quality: Station 1 was adequate, Station 2 was poor, while Station 3 was somewhat poor. Monitoring macrozoobenthos diversity can be helpful in detecting changes or disturbances in ecosystems.

Keywords: bioindicator, diversity, Family Biotik Index, macrozoobenthos

INTRODUCTION

Mangroves are one of the unique ecosystems and have high ecological and economic importance. Mangrove ecosystems are important as coastal protectors from wind, currents, and waves from the sea, habitats (dwellings), feeding grounds, nursery grounds, and spawning grounds for aquatic life (Bengen 2004; Printrakoon & Temkin 2008; Kadek*et al.* 2020). The mangrove ecosystem is one of the dominant ecosystems on the coast of Dumai City, and it is estimated to reach 2,152.2 ha (Hasyim *et al.* 2022; Khairijon *et al.* 2013). One of the biggest challenges for the mangrove ecosystem in Dumai City is the pressure due to the rapid industrial development in the coastal area (Mulyadi & Amin 2016), land conversion, the existence of garbage, and the state of polluted water due to shipping and industrial activities, which causes pressure on the growth and development of the mangrove ecosystem in Dumai City (Mulyadi 2017).

The suppression of mangrove ecosystems significantly affects the ecosystem's constituent components. Mangrove ecosystems consist of biotic and abiotic components. These abiotic and biotic components are interconnected. Biotic components include the flora and fauna that inhabit the area, one is the macrozoobenthos community that lives on the bottom of the water or in the substrate (Safitri *et al.*2021). Thus, its life is influenced by the condition of the substrate and the quality of the water in the region. Macrozoobenthos are a group of biotas that live sedentary lives and are deposit feeders (accumulators) and filter feeders (filters) that can accumulate pollutants in their bodies.

Mollusks are one of the macrozoobenthos groups that play an important role in ecological functions in mangrove ecosystems. Mollusks consisting of Gastropods and Bivalves are one of the phyla of macrozoobenthos that can be used as bioindicators in aquatic ecosystems (Macintosh *et al.* Mollusks can adapt to various habitats, accumulate heavy metals without experiencing death, and act as environmental indicators (Cappenberg *et al.* 2006). These phyla have several benefits for humans,

Dumai Marine and Fisheries Polytechnic, Marine and Fisheries Research and Human Resources Agency, Dumai City 28824, Indonesia
* Corresponding Author:
Email: arkham.mnur@politeknikkpdumai.ac.id

including as a source of protein, animal feed, industrial materials, fertilizers, and medicines (Dibyowati 2009). Macrozoobenthos are aquatic organisms that settle on the bottom of the water, move relatively slowly, and can live for a relatively long time to respond to water quality conditions, and are often used as bioindicators (Zulkifli & Setiawan 2017).

Research on macrozoobenthos as an indicator in the waters of Dumai City still needs to be adequate. Proper information about macrozoobenthos as an indicator of water can support water management due to various activities in the Strait of Malacca, especially Dumai City. Therefore, this study aims to describe the water quality of Dumai City by using macrozoobenthos as a bioindicator by calculating the macrozoobenthos ecological index, FBI (family biotic index) index, and aquatic physico-chemical parameters.

METHODS

Time and Place

This research was carried out for 4 months in June-September 2022. The study was divided into 3 observation stations located in the administrative area of Dumai City, Riau Province. The selection of stations was based on the representation of the coastal sub-district administrative area in Dumai City, the existence of mangroves, and anthropogenic activities around the mangrove area. Station 1 was in the fishing residential area of Penempul Village, Sungai Sembilan District;

Table 1 Research stations

Station	Administrative location	Coordinate
Station 1	Desa Penempul, Kecamatan Sungai Sembilan	01°57’59” N; 101°19’26” E
Station 2	Kelurahan Pangkalan Sesai, Kecamatan Dumai Selatan	01°41’16” N; 101°25’57” E
Station 3	Kelurahan Guntung, Kecamatan Medang Kampai	01°38’15” N; 101°33’54” E

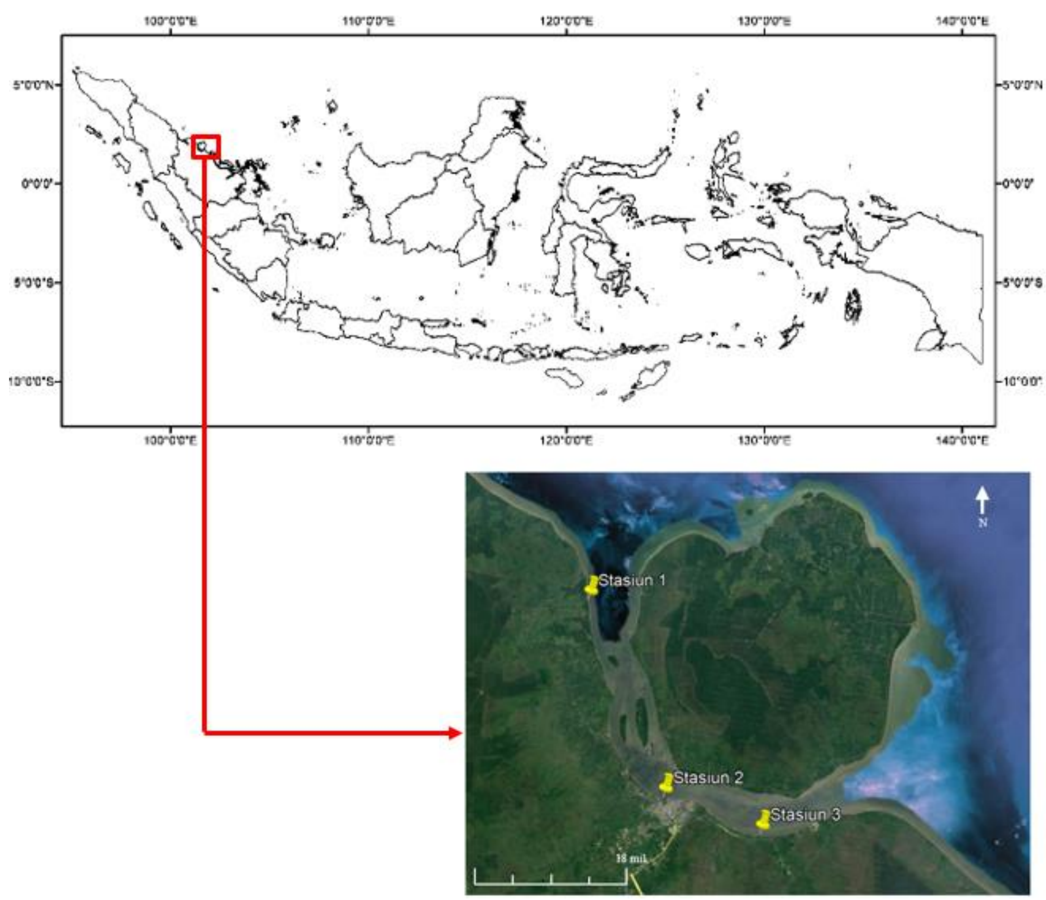

Figure 1 Location of observation stations of Dumai City, Riau Province.

Station 2 in the Bandar Bakau tourist area, Pangkalan Sesai Village, South Dumai District; and Station 3 in the mangrove planting area of Guntung Village, Medang Kampai District. Details ostationsesearch station are listed in Table 1 and Figure 1.

Equipment

The equipment used was Garmin's Global Positioning System (GPS) type 64S to record the coordinates of the research location. Roll meters and raffia ropes served to make macrozoobenthos transects. The shovel served to take sediment samples, and a digital pH tester and a litmus paper were used to measure the pH level of seawater. The refractometer was used to measure the salinity of seawater, and the digital DO meter measured the dissolved oxygen concentration. A digital thermometer to measure the seawater temperature and a 1 mm mesh size sieve to filter macrozoobenthos. A plastic bag was used to wrap the sample, with a permanent marker to mark the sample. Wipes and distilled water were used to clean the equipment. Canon's digital camera was intended to take pictures of samples and a macrozoobenthos identification keybook.

Data Collecting

Macrozoobenthos samples at each station were collected on a 10 m × 10 m mangrove vegetation observation transect in which 5 subplots were made, namely the upper right, upper left, lower right, lower left, and middle, with each subplot measuring 1 m × 1 m (Pringle 1984). Macrozoobenthos samples were taken at receding using a shovel by taking a substrate as wide as a sampling point (transect squared) 1 m x 1 m by combing. The substrate was sifted with a mesh size of 1 mm (Insafitri 2010). The filtered macrozoobenthos were cleaned with water and placed in a plastic bag that had been labeled. Macrozoobenthos samples were also taken on mangrove trunks and roots. The preserved samples were identified at the Dumai Marine and Fisheries Polytechnic Laboratory using the *Western Central Pacific Identification* book (Carpenter & Niem 1998).

The parameters of the aquatic environment as supporting data collected included water temperature, which was directly measured at each station using a thermometer (Nybakken 1988), salinity was measured with a salinometer (Effendi 2003, Ridho *et al.* 2012), DO was determined through titration (Darojah 2005) and water pH (Universal Indicator pH) (Barus 2004, Odum 1998 *in* Herawati 2008). These aquatic environmental parameters were measured in conjunction with macrozoobenthos sampling.

Sediment or substrate samples were taken *in situ* (Supriadi *et al*. 2015) using a shovel and then put into a plastic bag to be observed at the Dumai Marine and Fisheries Polytechnic laboratory.

Data Analysis

The analysis included the identification and density of macrozoobenthos, diversity index (*H*'), uniformity index (*E*), dominance index (*C*), and FBI. The data were presented in tables and graphs. The macrozoobenthos were analyzed using Equations 1–5.

- **Macrozoobenthos Density**

The obtained macrozoobenthos were then calculated in terms of the number of individuals per unit area and converted in ind/m^2 units using the following formula (Efriningsih *et al.* 2016):

$$D = \frac{Z}{A}\ x\ 10.000$$

where:
D = Number of individuals of per area (ind/ha)
Z = Number of individuals in the sampling point
A = Area of sampling points (m) (x 10,000 conversion from m^2 to ha)

- **Macrozoobenthos Diversity (H')**

Macrozoobentos species diversity was calculated by the Shannon-Wienner Diversity Index (Efringingsih *et al.* 2016):

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

where:
H' = Diversity index
pi = Ratio of the number of individuals of each type to *i*
n = Total number of species found
Diversity Index Categories: Shannon and Wienner (Safitri *et al.* 2021)
H < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

- **Macrozoobenthos Uniformity (E)**

The uniformity of a species in a community can be determined using the Simpson Uniformity Index (Efriningsih *et al.* 2016):

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

where:
E = Evenness uniformity index
S = Number of species
H' = Diversity index
Uniformity Index Category: Simpson (Safitri *et al.* 2021)

E < 0,4 : Low
0,4 < E < 0,6 : Medium
E > 0,6 : High

- **Macrozoobenthos Dominancy (C)**

The dominance of a species in a community was determined from the results of the analysis using the Simpson Dominance Index (Efriningsih *et al.* 2016):

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

where:
C = Simpson Dominance Index
ni = Number of individuals of each type
N = The sum of all individuals of each species
Dominant Index Categories: Simpson (Safitri *et al.* 2021)
0,00 < C < 0,50 : Low
0,50 < C < 0,75 : Medium
0,75 < C < 1,00 : High

- **Family biotic index (FBI)**

The FBI was used to detect organic contamination at both tolerant and intolerant family levels. The formula used to calculate this index was as follows:

$$FBI = \frac{(ni \; x \; ti)}{N}$$

where:
FBI = Benthic macrozoobenthos index value
ni = Number of individuals of the *i*th family group
Ti = The tolerance level of the *i*th family group
N = The total number of individuals who make up the macrozoobentos community

Interpretasi kualitas perairan berdasarkan FBI disajikan pada Table 2.

RESULTS AND DISCUSSION

Water Quality

Measuring water quality parameters is an important factor in determining the water condition in terms of physics and chemistry, affecting the life and growth of macrozoobenthos. The quality of the water at the research site can be seen in Table 3. The temperature range at the research site was 29.1–30.8°C with an average water temperature of 29.73°C. Water temperature conditions like this can generally still be tolerated by macrozoobenthos. The temperature range is still at a normal level, based on the quality standard of the Decree of the Minister of Environment No. 51 of 2004 for marine life, which is 28–32°C. This means that the water temperature of the three Dumai City research stations still supports the organisms' lives, and the range also shows no significant temperature spike. Biological-physiological activities within aquatic ecosystems are greatly influenced by temperature. According to Effendi (2003), rising temperatures will increase the metabolic rate of organisms. Wahyuningrum *et al.* (2016) states that the tolerance limit of benthos animals to temperature depends on the species; generally, temperatures above 35°C can suppress the growth of macrozoobenthos animal populations.

Salinity at the study site ranged from 25–28 ppt, with an average salinity of 26.33 ppt. The salinity conditions at each station showed a relatively lower value, while the

Table 2 Interpretation of the family biotic index (FBI) to assess water quality

Family biotic index	Water quality status	Pollution level
0.00–3.75	Excellent	Not polluted with organic matter
3.76–4.25	Very good	Slightly polluted organic matter
4.26–5.00	Good	Polluted with some organic matter
5.01–5.75	Fair	Polluted with a bit of organic matter
5.76–6.50	Somewhat bad	Polluted with a lot of organic matter
6.51–7.25	Bad	Polluted with much organic matter
7.26–10.00	Very bad	Heavy pollution of organic matter

Source: Dwitawati *et al*. (2015).

Table 3 Water quality at the research stations

Parameter	Physic-chemical parameters of the water			Average	Water quality standards
	Station				
	1	2	3		
Temperature (°C)	29.10	30.80	29.30	29.73 ± 0.93	28–32
Salinity °/00	28.00	25.00	26.00	26.33 ± 1.53	29–34
DO (mg/L)	4.16	5.49	5.10	4.92 ± 0.68	>5
pH	7.10	6.40	7.20	6.90 ± 0.44	7–8.5
Substrate texture	Clay	Clay	Sandy clay		

Remarks: Quality standards of the Decree of the Minister of Environment No. 51 of 2004 Appendix 3: Marine Biota.

salinity level for the optimal growth of marine life was 29–34 ppt (Decree of the Minister of Environment No. 51 of 2004). Spatially, salinity gradients can occur vertically and horizontally, while temporal gradients depend on seawater's seasons and tidal cycles (Higgins & Thiel 1988, Giere 1993). According to Wetzel (1975), salinity will increase as the depth increases. Low salinity is thought to be caused by high rainfall, while high salinity is due to high evaporation and little supply of fresh water in these waters. According to Zulfiandi *et al*. (2012), the 21–33.3 ppt salinity range is classified as feasible for marine life, including macrozoobenthos.

Based on the measurement results, dissolved oxygen was 4.16–5.49 mg/l, with an average of 4.92 mg/L. The DO value is still in normal conditions to support macrozoobent life. Dowing (1984) *in* Sudarja (1987) states that the DO level required by macrozoobenthos is 1.00–3.00 mg/L. The higher the DO level of an ecosystem, the better the macrozoobenthos that inhabit it (Hilmi & Munawar 2020). Generally, the DO value at the research site is still above the standard threshold value of seawater quality for marine life based on the Decree of the Minister of Environment No. 51 of 2004, which is that the DO must be more than 5 mg/L. Dissolved oxygen levels fluctuate daily and seasonally depending on the mixing and turbulence of water mass, photosynthesis activities, respiration, and waste that enters water bodies (Effendi 2003). The concentration of DO is closely related to the concentration of Total Suspended Solid (TSS), biological oxygen demand (BOD), and Chemical Oxygen Demand (COD). The higher the concentration of TSS, the more turbid the waters are, and it will interfere with the photosynthesis process. As a result, the DO content in the water column is also reduced. According to Ridwan *et al*. (2016), macrozoobenthos can survive if the DO content is 5 mg/L. Organisms in water, such as fish (Yanto *et al*. 2020) and macrozoobenthos (Apriadi *et al*. 2020) need oxygen for combustion and activity. In addition, oxygen plays a role in the decomposition of organic matter.

The pH at the study site was 6.4–7.2, with an average of 6.9. These results showed that the water conditions at the research site were still relatively good because they were still in the normal range for marine and estuary waters. Meanwhile, the pH value range at each research point was good enough for macrozoobenthos life, according to Effendi's (2003) statement that most aquatic biotics are sensitive to pH changes and favor pH values of 7.0–8.5. Based on the standard threshold value of seawater quality for marine life based on the Decree of the Minister of Environment No. 51 of 2004, the pH content of the water is 7–8.5. Very alkaline or very acidic water conditions will endanger the survival of organisms because they will interfere with the metabolic and respiration processes (Hamuna *et al*. 2018). The acid-base level of water affects the quality of the water because it impacts the adaptation of the organisms living in it (Barus *et al.* 2023).

In a water area, no sediment consists of only one type of substrate but consists of a combination of three fractions: sand, mud, and clay (Munandar *et al*. 2014). Table 2 explains that differences in substrate texture determine the classification of sediments; Stations 1 and 2 belonged to the clay category. The type of substrate at this station affects the abundance of macrozoobenthos. The type of substrate influences the abundance of macrozoobenthos in a body of water. A few types of macrozoobenthos are found in clay substrates (Zulkifli & Setiawan 2011). The type of substrate dominated by mud and fine sand, according to Nybakken (1992) *in* Ulfah *et al.* (2012), is not suitable for the growth of aquatic organisms because of the anaerobic decomposition process that occurs in the substrate, which can cause odors and are toxic and cause water pollution.

The substrate category at Station 3 was sandy clay. The composition of sediments like this determines the composition of the macrozoobenthos type. Macrozoobenthos that dig substrates such as mussels and crabs tend to be abundant in silt calcification or sandy silt, which contains high organic matter. Most Gastropods prefer the classification of dusty mud and fine sand to live on because the fine substrate contains more nutrients compared to the coarse and muddy substrate (Supriadi *et al*. 2015).

Macrozoobenthos Ecological Index

Macrozoobenthos found at each station in the waters of Dumai City consist of 2 classes, 7 families, and 7 species. Macrozoobenthos have a level of tolerance to changes in water quality. The tolerance level of macrozoobenthos is intolerant and facultative. The macrozoobenthos found at each station are presented in Table 3.

Based on the results of identification, it was found that the macrozoobenthos of Mollusk (gastropods and bivalves) found in the mangrove ecosystem of Dumai City consisted of a class of Gastropods with 6 families and 6 species *(Nerita articulata, Chicoreus capucinus, Littorina scabra, Ellobium aurisjudae, Cerithidae quoyii, and Pugilina cochlidium)* while from the Bivalvia class only 1 family and 1 species (*Polymesoda bengalensis*) obtained from the 3 stations. The Gastropod found at each station is more dominant than the Bivalvia. This is because macrozoobenthos from the gastropod class can survive changes in water quality conditions, especially water salinity. According to Wahab *et al.* (2019), a class of gastropods whose lives are slithering and creeping among mangrove stands. The high population of gastropods in a body of water is influenced by mangrove habitat, substrate, and environmental parameters.

Macrozoobenthos Density

The highest macrozoobenthos density was found at Station 3 at 125 ind/m^2 and the lowest at Station 1 was 21 ind/m^2. This can be seen from the type and density of macrozoobenthos organisms that vary at each station in Table 4. According to Ulfah *et al*. (2012), aquatic environmental conditions, such as aquatic physico-chemical parameters, affect the density, composition, and degree of macrozoobenthos diversity.

The most abundant species found at Station 3 is *Ellobium aurisjudae.* The high density of macrozoobenthos here is suspected because the location is an estuary area, and the community has vannamei shrimp cultivation activities, which have a higher input of organic matter than other locations. Ardi (2002) states that organic matter is one of the food sources for macrozoobentos of the gastropod type. Choirudin *et al.* (2014) also report that macrozoobenthos are closely related to the availability of organic matter in the substrate because organic matter is one of the sources of nutrients for biota, which is generally found in the basic substrate. Organic matter has a significant effect, both directly and indirectly, on the density of macrozoobentos. Macrozoobentos density is low at Station 1, with *Nerita articulate* of the gastropod class predominance. According to Faiqoh *et al.* (2016), gastropods have a strong immune system and a hard shell, making them more likely to survive than other macrozoobenthos. In addition, this low density is suspected to be due to the large number of population activities around the research site, such as industrial estates, shipyards, and ecotourism areas (Table 5).

Table 4 Macrozoobentos community structure at the research site

Station	Class	Family	Species	Tolerance level
1	Gastropod	Neritidae	*Nerita articulata*	Intolerant and Optional
		Muricidae	*Chicoreus capucinus*	
		Littorinidae	*Littorina scabra*	
		Ellobidae	*Ellobium aurisjudae*	
		Potamididae	*Cerithidae quoyii*	
2	Gastropod	Neritidae	*Nerita articulata*	Intolerant and Optional
		Muricidae	*Chicoreus capucinus*	
		Littorinidae	*Littorina scabra*	
		Ellobidae	*Ellobium aurisjudae*	
		Potamididae	*Cerithidae quoyii*	
	Bivalvia	Corbiculidae	*Polymesoda bengalensis*	
3	Gastropod	Neritidae	*Nerita articulata*	Intolerant and Optional
		Muricidae	*Chicoreus capucinus*	
		Littorinidae	*Littorina scabra*	
		Ellobidae	*Ellobium aurisjudae*	
		Potamididae	*Cerithidae quoyii*	
		Melongenidae	*Pugilina cochlidium*	
	Bivalvia	Corbiculidae	*Polymesoda bengalensis*	

Table 5 Macrozoobenthos density at the research site

Class	Family	Species	Density (ind/m^2)		
			St. 1	St. 2	St. 3
Gastropod	Neritidae	*Nerita articulata*	12	41	69
	Muricidae	*Chicoreus capucinus*	4	9	59
	Littorinidae	*Littorina scabra*	2	5	65
	Ellobidae	*Ellobium aurisjudae*	1	2	88
	Potamididae	*Cerithidae quoyii*	2	7	12
	Melongenidae	*Pugilina cochlidium*	0	0	1
Bivalvia	Corbiculidae	*Polymesoda bengalensis*	0	1	1
Total			21	65	295

Ecological Index (H', E, and C) of Macrozoobenthos

The diversity index values obtained from the three research stations were 1.17–1.52 (Table 6), which was relatively low. The highest score from the calculation results shows that Station 3 has a higher diversity index than the other stations. Desinawati *et al.* (2018) explaines that the low level of diversity shows that the distribution of individuals of each type tends to be uneven, and the condition of community stability tends to be low. This is due to the decreasing number of species and individuals, which results in an imbalance in the ecosystem that may be caused by ecological pressure or disturbances from the surrounding environment.

The uniformity index values obtained from all observation stations were 0.654697–0.783512. The uniformity index at this research location is relatively high. The uniformity value at Station 3 is the highest compared to other stations. According to Odum (1993), the high uniformity of macrozoobenthos shows that the number of individuals of each genus can be said to be the same or not much different. This is the opinion of Nurnaningsih (2000), who believes that if the genus is obtained, however, if the number of individuals in each genus is relatively large. If the distribution of each genus is unbalanced, then the value of uniformity will be high. The value of diversity will be low.

The dominance index values obtained from the three stations ranged from 0.234078 to 0.43574. The dominance index at this research location was relatively low. The dominance value at Station 2 was the highest compared to the other stations. According to Rosdatina *et al.* (2019), the value of uniformity is inversely proportional to the value of dominance. The dominance index value is low if the uniformity value is high. Odum (1993) states that a high dominance index value indicates a high concentration of dominance (some individuals are dominant); on the contrary, a low dominance index value indicates a low concentration (no one is dominant).

Station 3 had a higher diversity and uniformity index value than the other stations, and Station 2's dominance index value was higher. According to Nybakken (1988), the diversity of a high-value community shows that the area has a comfortable, balanced, or stable ecosystem and plays a significant role in maintaining a balance against disturbances that damage the ecosystem. Odum (1993) adds that diversity has the highest value if all individuals come from different species.

Family Biotic Index (FBI)

The FBI macrozoobenthos scores at the 3 research stations were 5.04–7.10, the highest at Station 2 with 7.10, and Station 3 with 6.48. This means that the water quality was in the poor category with a very high level of pollution with much organic matter, while the lowest FBI value was at Station 1 with a value of 5.04, meaning that the water quality in the category was sufficient with a relatively high level of organic matter. According to Susilowati (2017), a higher FBI score indicates worse water quality, and conversely, if the FBI score is lower, the water quality is better. The FBI provides additional insight into environmental conditions by measuring the diversity and abundance of biota species in aquatic ecosystems. Thus, this FBI assessment is an additional bioindicator measurement tool in evaluating quality and using the results of the assessment of water quality's physico-chemical parameters.

The high FBI score at Stations 2 and 3 is due to the abundance of gastropod classes with a high tolerance level to changes in environmental conditions. According to Rangan (2010), the class of gastropods has a high tolerance to changes in environmental conditions due to physical factors outside the mangrove ecosystem so that these organisms can survive and develop. The low score of the FBI at station 1 is due to the discovery of facultative types such as bivalve and gastropod classes. Facultative macrozoobenthos have more individuals and lower mobility than other macrozoobentos, indicating that the waters of Station 1 are polluted with some organic matter. According to Dwitawati *et al*. (2015), macrozoobenthos from the gastropod class have good tolerance to water conditions with light to heavy pollution.

CONCLUSION

Based on the results of the study, it can be concluded that the macrozoobenthos found and identified in the

Table 6 Macrozoobenthos ecological index at the study site

Parameter	Research location		
	Station 1	Station 2	Station 3
Diversity (H')	1.23	1.17	1.52
	Low	Low	Low
Uniformity (E)	0.763305	0.654697	0.783512
	High	High	High
Dominance (C)	0.38322	0.43574	0.234078
	Low	Low	Low

waters of Dumai City consist of the phylum Mollusks (Gastropods and Bivalvia), the class of Gastropods with 6 families and 6 species *(Nerita articulata, Chicoreus capucinus, Littorina scabra, Ellobium aurisjudae, Cerithidae quoyiiI,* and *Pugilina cochlidium)* while from the Bivalvia class 1 family and 1 species (*Polymesoda bengalensis*) with the highest density at Station 3 (125 ind/m^2) and the lowest at Station 1 (21 ind/m^2).

The diversity index of stations 1, 2, and 3 is in the low category. The uniformity index at the three stations was in the high category, and the dominance index was in the low category. Water quality based on macrozoobenthos as a bioindicator of Dumai City waters with FBI calculations at Station 1 in the fair category with a value of 5.04, Stations 2 and 3 are classified in the poor category with values of 7.10 and 6.48, respectively.

REFERENCES

Apriadi T, Muzammil W, Melani WR, Safitri A. 2020. Struktur komunitas makrozoobenthos di aliran sungai di Senggarang, Pulau Bintan, Kepulauan Riau. *Jurnal Ilmu-Ilmu Perairan, Pesisir, dan Perikanan.* 9(1): 119–130. https://doi.org/10.13170/depik.9.1.14641

Safitri A, Melani WR, Muzammil W. 2021. Komunitas makrozoobentos dan kaitannya dengan kualitas air aliran sungai Senggarang, Kota Tanjungpinang. Macrozoobenthic community and its relationship with Senggarang river flow water quality, Tanjungpinang City. *Acta Aquatica: Aquatic Sciences Journal*. 8(2): 103–108. https://doi.org/10.29103/aa.v8i2.4782

Ardi. 2002. Pemanfaatan makrozoobentos sebagai indikator kualitas perairan pesisir. [Tesis]. Bogor (ID): Institut Pertanian Bogor.

Barus TA. 2004. *Pengantar Limnologi Studi Leksono tentang Ekosistem Air dan Daratan*. Medan (ID): Universitas Sumatera Utara Press. 153–169 pg.

Barus TA, Wahyuningsih H, Simanjuntak BN, Ginting RH, Batubara AS, Hartanto A. 2023. Genetic differentiation among Batak fish populations (*Neolissochilus sumatranus*, *Tor douronensis*, and *Tor soro*) in North Sumatra, Indonesia revealed by RAPD markers. *Biodiversitas*. 24(3): 1327–1332. https://doi.org/10.13057/biodiv/d240301

Bengen DG. 2004. *Pedoman teknis: Pengenalan dan pengelolaan ekosistem mangrove*. Bogor (ID): PKSPL-IPB. 61 pg.

Cappenberg HAW, Aziz A. Aswandy I. 2006. Komunitas moluska di perairan Teluk Gilimanuk, Bali Barat. *Oseanologi dan Limnologi di Indonesia.* 40: 53–64.

Carpenter KE, Niem VH. 1998. *FAO Species Identification Guidie for Fishery Purposes. The Living Marine Resources of the Wastern Central Pacific*. Volume 2. Cephalopods, Crustaceans, Holothurians, and Sharks. Food and Agriculture Organization of the United Nations. Rome. 114–132.

Choirudin IR, Supardjo MN, Muskananfola MR. 2014. Studi hubungan konsentrasi bahan organik sedimen dengan kelimpahan makrozoobentos di muara Sungai Wedung Kabupaten Demak. *Diponegoro Jurnal of Maquares*. 3(3): 168–176. https://doi.org/10.14710/marj.v3i1.4429

Darojah Y. 2005 Keanekaragaman jenis makrozoobenthos di ekosistem perairan Rawapening Kabupaten Semarang. Semarang (ID): Universitas Negeri Semarang. 62–71 pg.

Desinawati, Adi W, Utami E. 2018. Struktur komunitas makrozoobentos di Sungai Pakil Kabupaten Bangka. *Akuatik Jurnal Sumberdaya Perairan*. 1(3): 54–63. https://doi.org/10.33019/akuatik.v12i2.701

Dibyowati L. 2009. Keanekaragaman Moluska (Bivalvia dan Gastropoda) di Sepanjang Pantai Carita, Pandeglang, Banten. [Skripsi]. Bogor (ID): Program Studi Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam Institut Pertanian Bogor.

Dwitawati DA, Sulistyarsi A, Widiyanto J. 2015. Biomonitoring kualitas air Sungai Gandong dengan bioindikator makroinvertebrata sebagai bahan petunjuk praktikum pada pokok bahasan Pencemaran Lingkungan SMP Kelas VII. *Jurnal Florea*. 2(1): 41–46. https://doi.org/10.25273/florea.v2i1.405

Effendi H. 2003. *Telaah Kualitas Air Bagi Pengelolaan Sumberdaya dan Lingkungan Perairan*. Yogyakarta (ID): Penerbit Kanisius.

Efriningsih R, Pustita L, Ramses. 2016. Evaluasi kualitas lingkungan perairan pesisir di sekitar TPA Telaga Punggur Kota Batam berdasarkan struktur komunitas makrozoobentos. *Jurnal Simbiosa*. 5(1): 1–15. https://doi.org/10.33373/sim-bio.v5i1.800

Faiqoh E, Hayati H, Yudiastuti K. 2016. Studi komunitas makrozoobenthos di kawasan hutan mangrove Pulau Penyu, Tanjung Benoa, Bali. *Journal of Marine and Aquatic Sciences*. 2(1): 24–28. https://doi.org/10.24843/jmas.2016.v2.i01.23-28

Giere O. 1993. *Meiobenthology. The Microscopic Fauna in Aquatic Sediment*. London (UK): Springer-Verlag. https://doi.org/10.1007/978-3-662-02912-1

Hasyim AF, Mulyadi A, Efriyeldi E. 2022. Mangrove vegetation community structure in Sungai Sembilan Sub-District, Dumai City. *Journal of Coastal and Ocean Sciences*. 3(1): 75–84. https://doi.org/10.31258/jocos.3.1.75-84

Hamuna B, Tanjung RHR, Suwito, Maury HK, Alianto. 2018. Kajian kualitas air laut dan indeks pencemaran berdasarkan parameter fisika-kimia di perairan Distrik Depapre, Jayapura. *Jurnal Ilmu Lingkungan.* 16(1): 35–43. https://doi.org/10.14710/jil.16.1.35-43

Herawati VE. 2008. Analisis Kesesuaian Perairan Segara Anakan Kabupaten Cilacap Sebagai Lahan Budidaya Kerang Totok (Polymesoda Erosa) Ditinjau Dari Aspek Produktifitas Primer Menggunakan Pengideraan Jauh. [Tesis]. Semarang (ID): Universitas Diponegoro.

Higgins RP, Thiel H. 1988. Prospectus *dalam* Higgins RP & Thiel H. (ed). *Introduction to the Study of Meiofauna*. London (UK): Smithsonian Institution Press. 11–13 pg.

Hilmi IR, Munawar A. 2020. Biomonitoring makrozoobentos sebagai indikator kualitas air sungai. *Jurnal Envirotek*. 12(1): 1–13. https://doi.org/10.33005/envirotek.v12i1.43

Insafitri. 2010. Keanekaragaman, keseragaman dan dominansi Bivalvia di area buangan lumpur Lapindo Muara Sungai Porong. *Jurnal Kelautan*. 3(1): 1907–993.

Khairijon K, Fatonah S, Rianti AP. 2013. Profil biomassa dan kerapatan vegetasi tegakan hutan mangrove di Marine Station Kecamatan Dumai Barat Riau. Lampung (ID): *Prosiding* Semirata FMIPA Universitas Lampung. 41–44.

Macintosh DJ, Ashton EC, Havanon S. 2002. Mangrove rehabilitation and intertidal biodiversity: A study in the Ranong Mangrove Ecosystem, Thailand. *Estuarine, Coastal, and Shelf Science.* 55: 331–345. https://doi.org/10.1006/ecss.2001.0896

Munandar RK, Muzahar, Pratomo A. 2014. Karakteristik sedimen di perairan Desa Tanjung Momong Kecamatan Siantan Kabupaten Kepulauan Anambas. Tanjung Pinang (ID): Universitas Maritim Ali Haji.

Mulyadi A. 2017. Mangrove di Kampus Universitas Riau Dumai. Pekanbaru (ID): UR Press. 70 pg.

Mulyadi A, Amin B. 2016. Vegetation structure and mangrove ecosystem threats in the coastal zone of Dumai Riau Indonesia. *International Journal of Applied Environmental Sciences*. 11(3): 785–798.

Nurnaningsih. 2000. Struktur komunitas makrozoobentos di perairan Sungai Banjaran dan Sungai Kranji Kabupaten Banyumas, Jawa Tengah. [Skripsi]. Bogor (ID): Institut Pertanian Bogor.

Nybakken JW. 1988. *Biologi Laut, Suatu Pendekatan Ekologi*. Jakarta (ID): Penerbit PT Gramedia Pustaka Utama.

Odum EP. 1993. *Dasar-dasar Ekologi*. Yogyakarta (ID): Universitas Gajah Mada Press.

Printrakoon C, Temkin I. 2008. Comparative ecology of two parapatric populations of Isognomon (Bivalvia: Isognomonidae) of Kungkrabaen Bay, Thailand. *The Raffles Bullettin of Zoology*. 18: 75–94.

Pringle JD. 1984. Efficiency estimates for various quadrat size used in bnthic sampling, *The Canadian Journal of Fisheries and Aquatic Sciences*. 41: 1485–1489. https://doi.org/10.1139/f84-182

Rangan JK. 2010. Inventarisasi Gastropoda di lantai hutan mangrove Desa Rap-Rap Kabupaten Minahasa Selatan, Sulawesi Utara. *Jurnal Perikanan dan Kelautan*. 6(1): 63–66. https://doi.org/10.35800/jpkt.6.1.2010.163

Ridwan M, Fathoni R, Fatihah I, Pangestu DA. 2016. Struktur komunitas makrozoobenthos di empat muara sungai Cagar Alam Pulau Dua, Serang, Banten. *Al-Kauniyah Jurnal Biologi*. 9(1): 57–65. https://doi.org/10.15408/kauniyah.v9i1.3256

Ridho A, Siregar YI, Nasution S. 2012. Habitat dan sebaran populasi kerang darah (*A. granosa*) di Muara Sungai Indragiri Kabupaten Indragiri Hilir. Riau (ID): Universitas Riau.

Rosdatina Y, Apriadi T, Melani WR. 2019. Makrozoobentos sebagai bioindikator kualitas perairan Pulau Penyengat, Kepulauan Riau. *Jurnal Pengelolaan Lingkungan Berkelanjutan*. 3(2): 309–317. https://doi.org/10.36813/jplb.3.2.309-317

Supriadi D, Zulfikar A, Raza'i TS. 2015. Pola Sebaran Gastropoda Berdasarkan Kerapatan Lamun dan Tipe Substrat di Perairan Pantai Dolpin Desa Teluk Bakau Kepulauan Riau. Tanjung Pinang (ID): Universitas Maritim Raja Ali Haji.

Sudarja. 1987. *Ekosistem Estuari*. Jakarta (ID): Djambatan.

Susilowati E. 2017. Struktur komunitas makrozoobentos sebagai bioindikator biologi perairan di hulu Sungai

Cisadane Bogor. [Skripsi]. Bogor (ID): Institut Pertanian Bogor.

Ulfah Y, Widianingsih W, Zainuri M. 2012. Struktur komunitas makrozoobenthos di perairan wilayah Morosari Desa Bedono Kecamatan Sayung Demak. *Journal of Marine Research*. 1(2): 188‒196.

Wahyuningrum ES, Muskananfol MR, Suryanto A. 2016. Hubungan tekstur sedimen, bahan organik dengan kelimpahan biota makrozoobentos di perairan delta Wulan, Kabupaten Demak. *Management of Aquatic Resources.* 5(1): 46‒51.

Wahab I, Maduppa H, Kawaroe M, Nurafni. 2019. Analisis kepadatan makrozoobentos pada fase bulan berbeda di lamun, Pulau Panggang, Kepulauan Seribu Jakarta. *Jurnal Teknologi Perikanan dan Kelautan.* 10(1): 93‒107. https://doi.org/10.24319/jtpk.10.93-107

Wetzel RG. 1975. *Limnology*. Philadelphia (US): WB Saunders.

Yanto F, Susiana, Muzammil W. 2020. Utilization rate of brown strip red snapper (*Lutjanus vitta*) on Mapur Waters that landing in Kelong Village, Bintan Pesisir Subdistrict, Bintan Regency. *Journal of Tropical Fisheries Management*. 4(2): 1‒9. https://doi.org/10.29244/jppt.v4i2.31955

Zulkifli H, Setiawan D. 2012. Struktur komunitas makrozoobentos di perairan Sungai Musi Kawasan Pulokerto sebagai instrumen biomonitoring. *Jurnal Natur Indonesia*. 14(1): 95. https://doi.org/10.31258/jnat.14.1.95-99.

Zulfiandi, Zainuri M, Hartati R. 2012. Struktur komunitas makrozoobentos di perairan Pandansari Kecamatan Sayung Kabupaten Demak. *Jurnal of Marine Research*. 1(1): 62‒66.