

Macrozoobenthic community structure in the mangrove aquatic ecosystem and surrounding area of Pejarakan Village, Bali

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Abstract. Change in macrozoobenthic community structure is commonly an indicator of aquatic ecosystem disturbance, due to the macrozoobenthic low mobility and relatively long life cycle. This research aims to analyze macrozoobenthic community structure in the mangrove aquatic ecosystem and surrounding area of Pejarakan Village, Bali. We conducted this research at six stations covering a mangrove-vegetated area and a brackish water pond in September 2022, January 2023, September 2023, and January 2024. Macrozoobenthos samples were taken using a VanVeen Grab, and water quality measurements were carried out in situ with a water analysis kit. Data were analyzed using species composition, ecological index, and PCA. The macrozoobenthos at the research location comprised 6 classes and 60 genera. The highest density was in January 2024 (289 ind/m²). The diversity index (H') was low-medium (1.99-3.17), the evenness index (E) was high (0,69-0,96), and the dominance index (C) was low-medium (0,13-0,38). PCA analysis shows that the distribution of macrozoobenthos was influenced by turbidity/total suspended solid.

1 Introduction

Pejarakan Village, as a coastal village, has an extensive mangrove ecosystem, covering around 160 ha [1]. In addition to mangrove vegetation, there are several land use activities around the mangrove, including logging shrimp ponds, salt ponds, agriculture, and lobster in

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floating net cages. These various activities are presumed to have an impact on the waters, which eventually affect the biota found in mangrove waters, including macrozoobenthos. They influence their distribution, composition, and abundance [2] and disturb the stability of the community [3]. Besides the physical conditions, the macrozoobenthos community is also influenced by biological parameters, i.e., competition, predators, and primary productivity levels [4].

Several research activities in this area were carried out previously which could show the ecological state of the ecosystems, including research on crab diversity as a support for tourism activities in the Pejarakan mangrove forest, Buleleng, Indonesia [1]; analysis of the carbon sequestration and storage capacity of mangrove forests in Pejarakan Village, Buleleng Regency, Bali [5]; diversity and distribution of mollusks in three mangrove zones in Pejarakan, Bali, Indonesia [6]; study of marine ecotourism-based customary village area management in Pejarakan Village, West Bali [7]; mangrove ecosystem management strategy for sustainable marine ecotourism in Pejarakan Village, Buleleng Regency [8], potential suitability and effectiveness support the mangrove ecosystem for ecotourism on the coast of Pejarakan Village [8]. However, no research has been carried out regarding macrozoobenthos. This research is therefore very important to complete basic information for managing mangrove ecosystems. The research aimed to analyze the structure of the macrozoobenthos community as an indicator of the condition of mangrove ecosystems. The study examines changes in the condition of the mangrove aquatic ecosystem and surrounding area from ecological pressure caused by local pond activities by analyzing biological bioindicator parameters.

2 Methods

2.1 Time and location

This research was conducted in September 2022, January 2023, September 2023, and January 2024 in the mangrove aquatic ecosystem and surrounding area of Pejarakan Village, Gerokgak District, Buleleng Regency, Bali (Fig. 1).

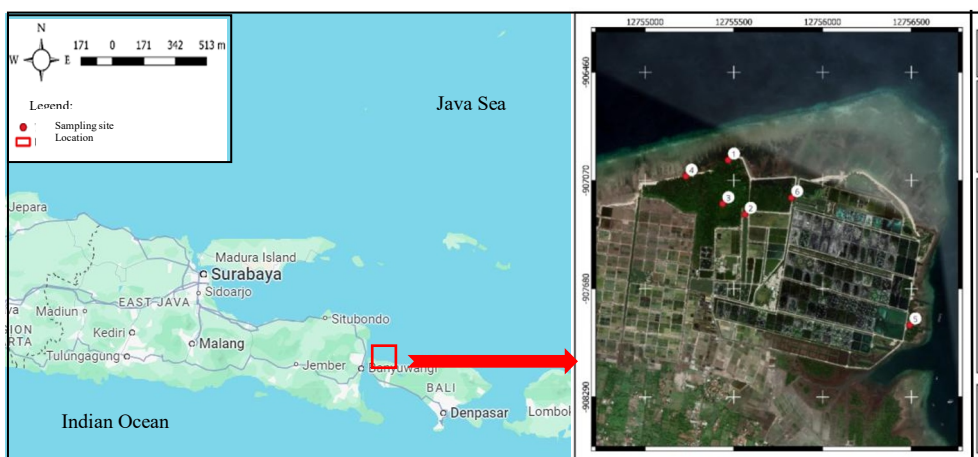


Fig. 1. Map of study location, mangrove aquatic ecosystem, Pejarakan Village, Gerokgak District, Bali.

2.2 Materials and Equipments

The tools used in this research were DO meter, pH meter, turbidimeter, hand refractometer, Van Veen Grab with an opening of 13 x 26 cm, a cool box to store samples before laboratory analysis, and 10% formalin solution, and a macrozoobenthos identification book as a guide in identifying samples.

2.3 Data collection

Macrozoobenthos was collected directly by taking sediment samples at each station. Identification of macrozoobenthos refers to [9], The Living Marine Resources of the Western Central Pacific. Parameters, methods, and equipment are presented in Table 1.

Table 1. Parameters observed (physics, chemistry and biology) as well as methods/tools and location of analysis.

Parameters	Units	Methods/Equipment/Material	Location
Physics			
1. Substrate	%	Millar Triangle/ Pipette	Laboratory
2. Temperature	°C	DO meter	Insitu
3. Turbidity	NTU	Turbidity Unit	Insitu
4. TDS	mg/L	Multiparameter analyser	Insitu
5. TSS	mg/L	Gravimetrik	Exsitu
6. Conductivity	µs/cm	Multiparameter analyser	Insitu
7. Salinity	Ppm	Hand Refractometer	Insitu
Chemist			
1. pH	-	Kertas pH/pH meter	Insitu
2. DO	mg/l	DO meter	Insitu
Biology			
Makrozoobentos		<i>Van Veen Grab</i> , Formalin solution	Insitu

2.4 Data analysis

2.4.1. Macrozoobenthos Density

Density is defined by a formula calculation that aims to obtain an estimate of the number of macrozoobenthos individuals per unit square meter area (ind./m²) [10]. Calculation of macrozoobenthos density can be calculated using this formula [11].

$$K = \frac{N}{A} \times 10.000 \quad (1)$$

Where:

K : Density of macrozoobenthos genera (ind/m²)

- N : Total number of macrozoobenthic individuals caught in A (Individuals)
 A : The total of the sampling area or the area of the grab opening (cm^2) the value 10000 is a conversion from cm^2 to m^2

2.4.2. Diversity Index (H')

The diversity index or diversity index is determined by two important things. Firstly, the number of different species or taxa. Second, uniformity, which reflects the distribution of individuals in one systematic category [12].

$$H = -\sum_{i=1}^n pi \log_2 pi \quad \text{with} \quad pi = \frac{n}{N} \quad (2)$$

Where:

- H' : Diversity Index Shannon-Wiener
 pi : The ratio between the number of individuals of the i -th genera (ni) and the number of individuals of all genera (N)
 ni : Number of genera of individuals i
 N : Number of individuals of all genera
 i : 1,2,3,... n

The diversity index classification criteria according to Shannon-Wiener are based on [12] and are divided into three range classes, including

- $H' < 1$: Low diversity, defined as the aquatic environment has experienced heavy pollution due to the low distribution of the number of individuals per taxa, so that the level of community stability is also low.
- $1 \leq H' \leq 3$: Medium diversity, defined as the water environment being semi-polluted or waters in the moderate pollution category due to the distribution of the number of individuals per taxa being moderate so that community stability is also moderate.
- $H' > 3$: High diversity, defined as the aquatic environment has not experienced pollution due to the high distribution of the number of individuals for each taxon, so that community stability is also high.

2.4.3. Evenness Index (E)

The evenness index is also used to determine the uniformity of macrozoobenthos which is related to the distribution of individuals between different species. The lower the uniformity of the species population, conversely, the greater the uniformity index value. An E value approaching 0 or <0.5 means that the distribution of individuals is uneven or the uniformity of organisms in the waters is not balanced [13].

$$E = \frac{H'}{H \text{ maks}} , \text{ with } H \text{ maks} = \log_2 S \quad (3)$$

Where:

- E : Evenness index
 S : Many genera found or Number of taxon
 H' : Diversity index
 $H \text{ maks}$: $\ln S$ or $\log_2 S$

The magnitude of the species uniformity index ranges from 0 – 1 with the following categories [13]:

$0 < E \leq 0.5$: low population uniformity or depressed community

$0.5 < E \leq 0.75$: moderate population uniformity or unstable community

$0.75 < E \leq 1$: high population uniformity or stable community

2.4.4. Dominance Index (C)

The dominance index is a calculation to estimate that one species can be found to dominate in a population so that the dominating species can determine the presence of other species based on the Simpson dominance index [14]. A dominance value close to 1 means that the distribution of the number of individuals for each type of macrozoobenthos tends to be even. Meanwhile, a dominance index value close to 0 indicates that there is a dominant species [14].

$$C = \sum_{i=1}^s P_i^2 = \sum_{i=1}^s \left(\frac{ni}{N}\right)^2 \quad (4)$$

Where:

C = dominance index

P_i = ni/N

ni = Number of individuals of each type i

N = Total number of individuals or number of individuals of all genera

Dominance index criteria based on [4] are as follows:

- $0 < C \leq 0.30$ is defined as the observed biota community structure having no dominant species or low dominance.
- $0.30 < C \leq 0.60$ is defined in the observed community structure as dominating species but moderate dominance.
- $0.60 < C \leq 1.00$ is defined in the observed community structure as dominating species with high dominance.

2.4.5. Principal Component Analysis

Analysis of the relationship between macrozoobenthos community structure and environmental characteristics was carried out using a PCA (Principal Component Analysis) analysis approach. Principal Component Analysis (PCA) is a multivariable descriptive statistical method for presenting maximum information from an information matrix in graphical form [15]. The data displayed from PCA analysis is in graphical form with information shown in a data matrix from research stations as individuals/rows and environmental characteristics as variables/columns [16]. PCA results show that there is a correlation between parameters at each station [15]. Multivariate analysis was used to correlate environmental parameters such as temperature, dissolved oxygen, pH, and salinity with the abundance and diversity of macrobenthos across observation stations [17]. The aim of using PCA analysis is to describe the relationship formed between the macrozoobenthos and the mangrove habitat and surrounding environment, as well as to understand the correlation between the two components. Principal component analysis in this research was used to determine the characteristics of water quality parameters and subtracts using processed data from the XLSTAT 2019 program.

3 Results and discussion

3.1 Macrozoobenthos composition

The macrozoobenthos composition in mangrove and its surroundings in Pejarakan Village is composed of 6 classes and 60 genera, including 15 genera from the Bivalvia class, one genus from the Echinoidea class, 32 genera from the Gastropoda, one genus from the Nemertea, five genera from the Malacostraca, and six genera of the Polychaeta (Table 2).

Macrozoobenthos studied in Mangrove aquatic ecosystem and its surroundings in Pejarakan Village of Gerokgak District represented two different seasons, namely dry and rainy. The dry season occurs in September 2022 and September 2023. Meanwhile, the rainy season occurs in January 2023 and January 2024. The macrozoobenthos found in both seasons during the study were almost similar class variations. The composition of macrozoobenthos in mangrove aquatic ecosystem and its surroundings in Pejarakan Village, Gerokgak District (Fig. 2) was in sequence from the highest to the lowest percentage, namely Gastropods (67.72%), Bivalves (18.38%), Polychaeta (8.96%), Malacostraca (4.08%), Echinoidea (0.46%), and Nemertea (0.38%).

Table 2. Macrozoobenthos found in mangroves aquatic ecosystem and surrounding area of Pejarakan Village, Gerokgak District, Bali

Class	Genera			
Bivalvia	<i>Anadara</i> sp.	<i>Chlamys</i> sp.	<i>Leporimetis</i> sp.	<i>Tapes</i> sp.
	<i>Antigona</i> sp.	<i>Dosinia</i> sp.	<i>Modiolus</i> sp.	<i>Tellina</i> sp.
	<i>Asaphis</i> sp.	<i>Fragum</i> sp.	<i>Paphia</i> sp.	<i>Vasticardium</i> sp.
	<i>Crassostrea</i> sp,	<i>Gafrarium</i> sp.	<i>Semele</i> sp.	
Echinoidea	<i>Dendraster</i> sp.			
Gastropoda	<i>Aliculastrum</i> sp.	<i>Clypeomorus</i> sp.	<i>Nassaria</i> sp.	<i>Telescopium</i> sp.
	<i>Ancilla</i> sp.	<i>Conus</i> sp.	<i>Nassarius</i> sp.	<i>Terebralia</i> sp.
	<i>Ancillista</i> sp.	<i>Coralliophila</i> sp.	<i>Nerita</i> sp.	<i>Tonna</i> sp.
	<i>Balcis</i> sp.	<i>Cryptospira</i> sp.	<i>Oliva</i> sp.	<i>Trapezium</i> sp.
	<i>Cantharus</i> sp.	<i>Cypraea</i> sp.	<i>Planaxis</i> sp.	<i>Trivia</i> sp.
	<i>Cassidula</i> sp.	<i>Leptopoma</i> sp.	<i>Polinices</i> sp.	<i>Trochus</i> sp.
	<i>Cerithidea</i> sp.	<i>Littoraria</i> sp.	<i>Rhinoclavis</i> sp.	<i>Turridrupa</i> sp.
	<i>Cerithium</i> sp.	<i>Mitra</i> sp.	<i>Strombus</i> sp.	<i>Vexillum</i> sp.
	Nemertea	<i>Amphiphorus</i> sp.		
	Malacostraca	<i>Gammarus</i> sp.	<i>Pagurus</i> sp.	<i>Portunus</i> sp
<i>Metaplax</i> sp.				
Polychaeta	<i>Glycera</i> sp.	<i>Nephtys</i> sp.	<i>Notomastus</i> sp.	<i>Paraonis</i> sp.
	<i>Lumbrineris</i> sp.	<i>Nereis</i> sp.		

The results of processing the species composition values show that at Station 1-6, there were 5 classes, including the Bivalvia, Malacostraca, Gastropoda, Nemertea, and Polychaeta classes. The highest percentage composition found at all stations was the Gastropoda.

Macrozoobenthos classes Bivalvia and Gastropods were found at all observation stations in this study. Many macrozoobenthos from the Gastropod class were found, presumably because of relatively sedentary living habits or slow mobility, with relatively high adaptability [18]. Gastropods adapt to accumulate polluted materials without being killed [19]. Gastropods have a high ability to adapt to environmental changes in mangrove habitats, whether caused by changes in temperature, pH, salinity, or substrate [20]. Gastropods tightly close the shell opening by curling their soft bodies into the shell to avoid predators or environmental threats [21]. Gastropods also close their shells tightly to avoid water shortages at low tide [22].

3.2 Macrozoobenthos density

Biological conditions in the mangrove and its surroundings in Pejarakan Village, Gerokgak District, based on time and observation stations show varying macrozoobenthos density values. The highest temporal density value for macrozoobenthos was obtained in January 2024 (total number 289 ind./m²), while the lowest macrozoobenthos density was found in September 2022 (97 ind./m²). The macrozoobenthos density value obtained at each station shows the highest value at Station 3 (211 ind./m²) and the lowest at Stations 1 and 5 (46 ind./m²). Three other stations obtained the highest and lowest macrozoobenthos density values, respectively, namely at Station 2 (160 ind./m²), Station 4 (83 ind./m²), and Station 6 (71 ind./m²). The macrozoobenthos density graph is presented in Fig. 3.

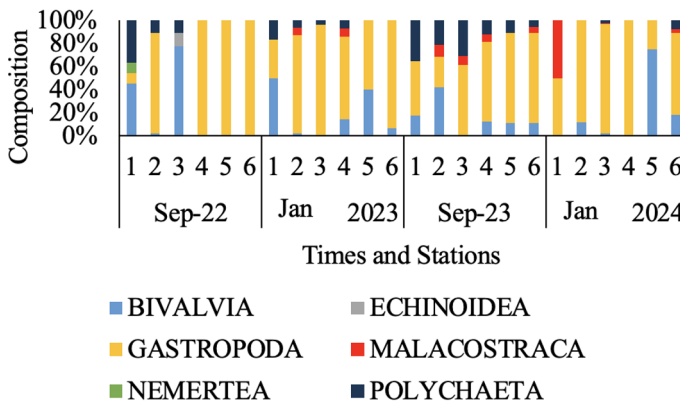


Fig. 2. Composition of macrozoobenthos found in mangrove aquatic ecosystems and surrounding areas, Pejarakan Village, Gerokgak District, Bali.

The density value of macrozoobenthos per observation station in the Pejarakan mangrove waters (4-161 ind./m²) is less than the density of macrozoobenthos on the Cengkok coastal waters (Banten Bay) [23], Segara Anakan lagoon (Cilacap) [24]. However, this density is quite high compared to macrozoobenthos in the waters of the Panjang and Pamujan Besar Islands (Banten Bay) [25] and the Donan River estuary (Cilacap) [16]. Such conditions also depend on the substrate area, where mud substrates are generally more abundant in benthic biota.

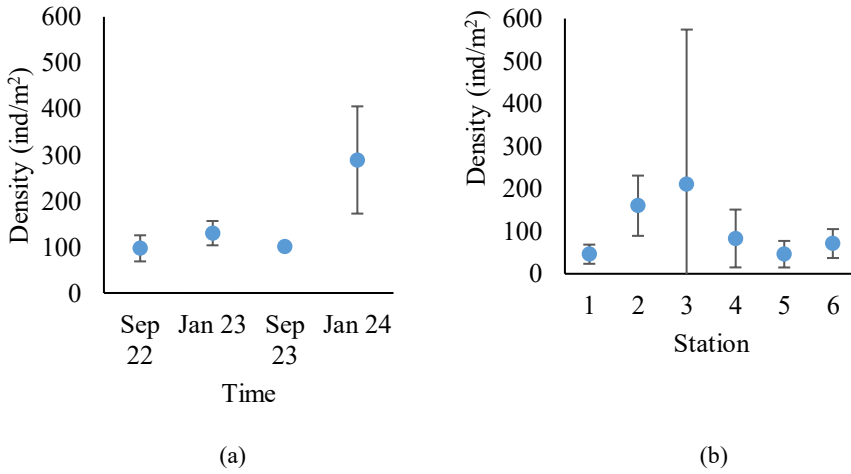


Fig. 3. Macrozoobenthos density based on (a) time and (b) station in mangrove waters ecosystem and surrounding areas, Pejarakan Village, Gerokgak District, Bali.

3.3 Diversity Index (H')

The diversity index (H') of macrozoobenthos in mangroves and their surroundings in Pejarakan Village, Gerokgak District, at six stations based on four observation times is classified as medium ($1 \leq H' \leq 3$) to high ($H' > 3$). Based on sampling time, the diversity index of Macrozoobenthos was 1.989-3.172. The highest value was in January 2023, and the lowest one was in January 2024. Based on sampling location, the value of diversity index (H') varied from 2.052 to 3.171. The highest value was in Station 6, while the lowest one was in Station 4 (Fig. 4).

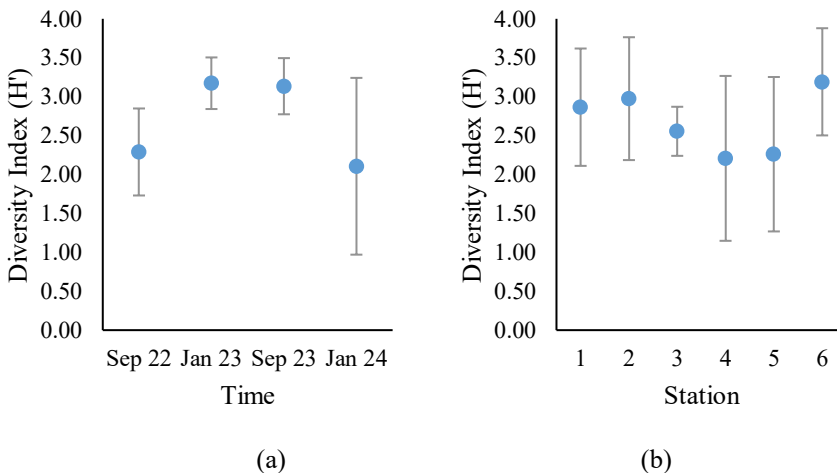


Fig. 4. Diversity index (H') of macrozoobenthos based on (a) time and (b) station in mangrove aquatic ecosystem and surrounding areas, Pejarakan Village, Gerokgak District, Bali.

The diversity value of macrozoobenthos per station in the Pejarakan mangrove aquatic ecosystem varied from 2,052 to 3.171. This condition is different from the results of the study conducted by [16] and [23–25]. The results of the diversity index calculation in the coastal

waters of Pejarakan showed a higher value compared to the previous study conducted in other locations. However, in general, the diversity index in this location is in medium to high diversity.

3.4 Evenness Index (E)

The evenness index (E) of macrozoobenthos obtained based on the sampling time in mangrove waters and surroundings in Pejarakan Village, Gerokgak District, is classified as high ($0.75 < E \leq 1$). Based on the sampling time, the macrozoobenthos evenness index (E) varied 0.666-0.937. The highest value was in September 2023, while the lowest one was in January 2024. Based on the sampling location, the highest value was in Station 1, while the lowest one was in Station 4. The evenness index (E) based on sampling stations and sampling time are presented in Fig. 5. The evenness value of macrozoobenthos per station in the Pejarakan mangrove waters varied. This condition is different from the results of the study conducted by [16] and [23-25]. The results of the evenness index calculation in the coastal waters of Pejarakan show a lower value compared to the previous study. However, in general, these waters are in low to moderately stressed conditions.

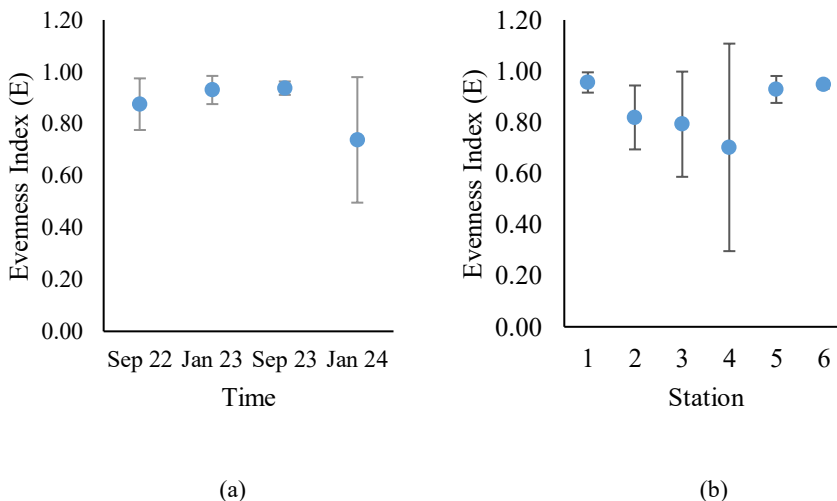


Fig.5. Evenness index (E) of macrozoobenthos based on (a) time and (b) station in mangrove aquatic ecosystem and surrounding areas, Pejarakan Village, Gerokgak District, Bali.

3.5 Dominance Index (C)

The dominance index (C) based on the time of sampling obtained, varied 0.131-0.379. The highest value was in January 2024 (0.379 in the medium category), while the lowest value was in January 2023 (0.131 in the low category). Based on sampling location, the highest dominance index (C) was in Station 4 (0.333 in the medium category), while the lowest dominance was Station 6 (0.133 in the low category). The graph of the dominance index (C) of the macrozoobenthos is presented in Fig. 6.

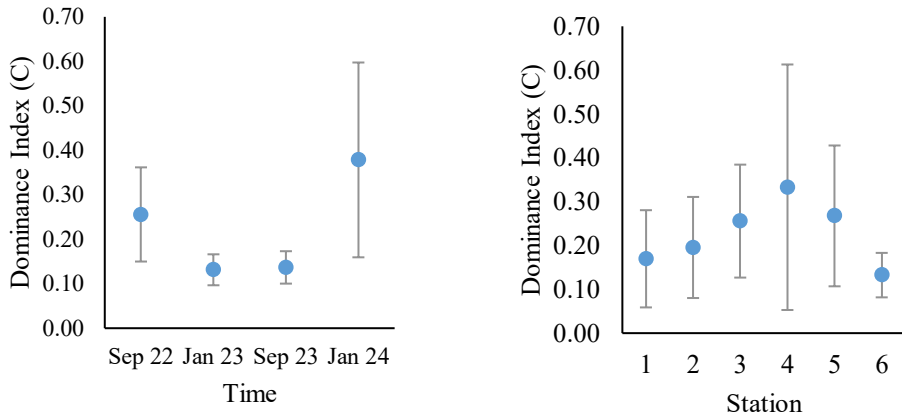


Fig. 6. Dominance index (C) makrozoobenthos based on (a) time dan (b) station in mangrove aquatic ecosystem and surrounding areas, Pejarakan Village, Gerokgak District, Bali.

The dominance index value of macrozoobenthos per station in the Pejarakan mangrove waters varied from 0.133-0.333. This condition is different from the results of research conducted by [16], [23–25]. The results of the diversity index calculation in the coastal waters of Pejarakan showed a lower value compared to the four previous studies conducted. However, in general, these waters are in low to moderately stressed conditions.

3.6 Water Conditions

The survival of aquatic biota such as macrozoobenthos is supported by water quality parameters, including physics, chemistry, and aquatic biology [26]. The results of measuring the physical and chemical parameter values of waters in Mangrove and its surroundings in Pejarakan Village, Gerokgak District, at six stations are presented in Table 3. The results of the physical and chemical parameters are compared by the quality standards for marine biota based on [27]. The distribution of average temperature values from Stations 1, 2, 3, and 6 is relatively the same, namely ranging from 30.10°C to 30.98°C. Station 5 showed a temperature value of 31.33°C, with higher results due to the measurement time being carried out in the mid-afternoon.

The distribution of average turbidity values from Station 1, Station 4, and Station 5 with measurement results ranging from 2.66 to 3.54 NTU is still in accordance with the quality standards for aquatic biota. However, Station 2, Station 3, and Station 6 with measurement results ranging from 6.22 to 30.33 NTU do not meet the quality standards for aquatic biota life. The distribution of average TSS values at Stations 1, 3, 4, 5, and 6 with measurement results ranging from 8.98 to 18.68 mg/L is still in accordance with the quality standards for marine life biota. However, Station 2 obtained a TSS value of 22.20 mg/L, which does not meet the quality standards for aquatic biota life in seagrass and coral reefs because the quality standard limit is 20 mg/L. However, according to Government Regulation of the Republic of Indonesia Number 22 of 2021, the TSS environmental parameters at Station 2 are still in accordance with water quality standards in the form of mangroves for marine biota, with a quality standard limit of 80 mg/L and rivers of 50 mg/L [28].

3.7 Relationship between macrozoobenthos and physicochemical parameters of waters

Principal component analysis (PCA) was used to determine the relationship between macrozoobenthos and the physicochemical parameters of the waters at the observation location (Figure 7). The results of the principal component analysis of the average density component with aquatic physico-chemical parameters show that the biplot graph is 70.55% of the total presentation of F1 at 39.06% and F2 at 31.48%.

The level of correlation of linkages based on biplot graphs is seen from the angle formed or sandwiched between two vectors or variables. If the angle formed is an acute angle ($<90^\circ$), then the resulting level of correlation is greater or higher and has a positive value. On the other hand, if the angle formed is an obtuse angle ($>90^\circ$), then the correlation is lower or smaller and has a negative value. Then, if an angle of 90° is formed between two variables, there is no correlation between the two variables [29].

The results of the principal component analysis (Figure 7) show that the angle formed by the macrozoobenthos type variables, namely Echinoidea and Gastropods, with turbidity, has a positive correlation at Station 3 so that the two components influence each other. The results of the principal component analysis (Figure 7) also show that the angle formed from the Polychaeta and Malacostraca type variables with TSS has a positive correlation at Station 2. The results of the principal component analysis (Figure 7) also show the angle formed from the temperature type variable at Station 4 with DO at Station 6 has a correlation relationship.

The results of the principal component analysis (Figure 7) also show that the angle formed by the Malacostraca type variable with TDS has a positive correlation but as a secondary factor. The results of the principal component analysis also show that the angle formed by the Bivalvia type variable with TSS has a positive correlation at Station 2, but as a secondary factor. The results of the principal component analysis (Figure 7) also show that the angle formed by the Gastropod and Echinoidea type variables with salinity and TDS has a positive correlation relationship as a secondary factor, and between the Echinoidea type variables and conductivity also has a positive correlation relationship but as a secondary factor. The average values of salinity, turbidity, TSS, TDS, and conductivity were obtained during four consecutive data collection times at six observation stations, namely 32.99 ppt, 9.24 NTU, 14.01 mg/L, 24.51 mg /L, and 48.63 $\mu\text{s/cm}$.

Table 3. Average value and standard deviation of physical parameter measurement results-chemistry of mangroves and their surroundings in Pejarakan Village, Gerokgak District, Bali.

Parameter	Units	Stations					
		1	2	3	4	5	6
Physics							
Temperature	$^\circ\text{C}$	30,10 \pm 1,12	30,40 \pm 0,91	30,40 \pm 0,91	33,65 \pm 2,99	31,33 \pm 0,49	30,98 \pm 1,46
Turbidity	NTU	2,66 \pm 2,24	10,24 \pm 7,49	30,33 \pm 1,93	2,43 \pm 2,05	3,54 \pm 1,54	6,22 \pm 8,45
TSS	mg/L	9,80 \pm 8,41	22,20 \pm 13,71	18,58 \pm 12,57	8,98 \pm 7,96	11,20 \pm 5,89	13,32 \pm 12,89
TDS	mg/L	23,55 \pm 3,03	24,28 \pm 3,15	24,93 \pm 2,38	26,08 \pm 2,72	23,23 \pm 3,34	25,03 \pm 2,85
Conductivity	$\mu\text{s/cm}$	47,70 \pm 6,32	45,83 \pm 7,22	49,55 \pm 4,91	52,20 \pm 5,34	46,60 \pm 6,61	49,93 \pm 5,73
Salinity	ppm	29,73 \pm 3,13	32,85 \pm 5,01	34,08 \pm 4,41	35,78 \pm 4,10	31,38 \pm 5,78	34,15 \pm 4,67
Chemist							
pH	-	7,97 \pm 0,36	8,29 \pm 0,15	7,78 \pm 0,33	7,99 \pm 0,31	8,25 \pm 0,17	8,36 \pm 0,04
DO	mg/L	4,43 \pm 1,07	5,83 \pm 0,64	4,60 \pm 1,14	6,13 \pm 0,75	6,25 \pm 0,86	6,78 \pm 0,93

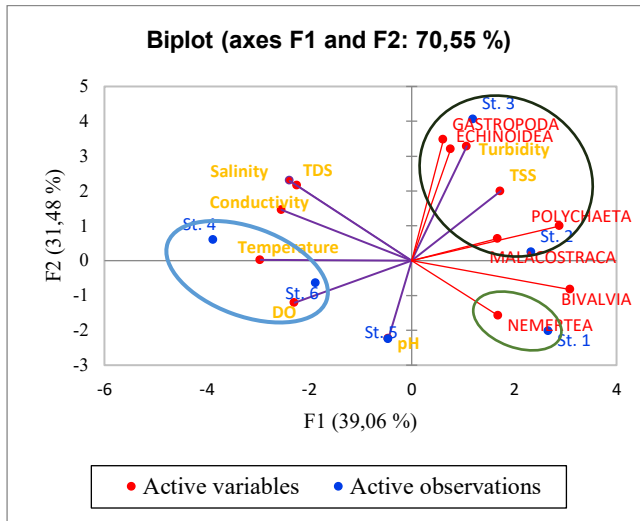


Fig. 7. Biplot of the relationship between macrozoobenthos density and physical parameters chemistry of mangroves and their surroundings in Pejarakan Village, Bali.

Correlation on PCA biplot graphs can be compared numerically or numerically using a correlation matrix (Pearson) table produced from observational data. The correlation matrix (Pearson) seen in the PCA biplot graph shows that there is a correlation between Polychaeta and turbidity, but it is lower than between Echinoidea and Gastropoda and turbidity. The correlation between Polychaeta and Malacostraca with TSS was higher, but the correlation between Echinoidea and TSS was also found to be lower. The correlation between Polychaeta and TSS with Bivalves and TSS was found to have the same value. The correlation matrix (Pearson) also found a correlation between Gastropods and salinity that was greater than between Bivalves and salinity. The correlation matrix (Pearson) also found that the correlation between Gastropods and TDS was greater than between Malacostraca and Echinoidea and TDS.

PCA analysis shows that there is a connection or relationship between Gastropoda, Echinoidea, Malacostraca, and Polychaeta with turbidity and TSS at Stations 2 and 3. The PCA biplot in Figure 7 also shows that there is a relationship between Temperature and DO at Stations 4 and 6. It was also found In the PCA biplot graph in Figure 7, the relationship between Nemertea is only found at Station 1, so this differentiates Station 1 from other observation stations. It can be concluded that water quality still influences the density and diversity of macrozoobenthos. This is because the water depth at each observation location is still below 1 m.

This is in accordance with research by [25], namely that Polychaeta has a positive correlation with dust and clay, so they are found on substrates with a high percentage of dust and clay. This is similar to the results of current research, namely that Polychaeta was found on substrates with a high percentage of dust. The research carried out at this time is also in accordance with the research of [24] that substrates that have a high dust or mud content are often found in Gastropod and Polychaeta macrozoobenthos. However, differences were found, namely, research by [24] showed that Malacostraca is often found on mud or dust substrates, whereas in the current study, Malacostraca was positively correlated with sand and Gastropods did not have a positive correlation with dust [30].

4 Conclusion

The macrozoobenthos found in this research located in the Mangroves and Surroundings in Pejarakan Village were 617 individuals composed of 7 classes and 60 genera. The macrozoobenthos types found consisted of Bivalvia (15 genera), Echinoidea (1 genus), Gastropoda (32 genera), Malacostraca (5 genera), Nemertea (1 genus) and Polychaeta (6 genera). The most common macrozoobenthos found in this study were the Gastropoda class, especially Cerithidea sp. The main macrozoobenthos components of the mangrove ecosystem and surrounding areas of Pejarakan Village, Bali are Malacostraca, Bivalves, Polychaeta, and Gastropods which were found in this research. Macrozoobenthos density ranges from 46-289 ind/m². The diversity index found in this study was based on the time of data collection and each group of stations, including mangrove stations categorized as low to medium, outlet stations categorized as medium, and inlet stations categorized as low. The uniformity index found in this study based on the station is categorized as medium to high, while based on time it is categorized as high. The dominance index found in this study based on the station and time of data collection was categorized as low to medium. The substrates associated with macrozoobenthos in this study are mainly dust textures (%). The aquatic environment related to macrozoobenthos in this study is mainly turbidity and TSS parameters.

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