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Diversity and habitat characteristics of macrozoobenthos in the mangrove forest of Lubuk Kertang Village, North Sumatra, Indonesia

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Abstract. *Basyuni M, Gultom K, Fitri A, Susetya EA, Wati R, Slamet B, Sulistiyono N, Yusriani E, Balke T, Bunting P. 2018. Diversity and habitat characteristics of macrozoobenthos in the mangrove forest of Lubuk Kertang Village, North Sumatra, Indonesia. Biodiversitas 19: 311-317.* Mangrove plays an important role in coastal ecosystems including ecological, social, and economic aspects. This study aimed to determine the diversity of macrozoobenthos and water quality based on diversity index (H'), similarity Index (E), and dominance index (D) in the mangrove of Lubuk Kertang Village North Sumatra, Indonesia. The samples of macrozoobenthos (biological parameter) and water quality (physical and chemical parameters) were collected from fifteen plots in three different stations. Macrozoobenthos were collected in 1 m × 1 m transect in the mangrove forest. The biota was taken by using a shovel, inserted into a plastic bag, and identified. Results showed that eight species of macrozoobenthos were found and classified into three classes of Gastropod, Bivalvia, and Malacostraca. The highest diversity index (H′) of macrozoobenthos was found at Station II (2.39), the highest evenness index (E) was located at Station I (0.54), and the highest dominance index (D) was found at Station II (0.34). Principal component analysis (PCA) was used to determine the habitat characteristics of macrozoobenthos. PCA confirmed that station III was a habitat with suitable characteristics for the life of macrozoobenthos indicating the negative axis. The present study suggested four parameters namely salinity, clay temperature, and dissolved oxygen that should be preserved to support the survival of macrozoobenthos in the mangrove forests.

Keywords: Macrozoobenthos, mangrove, principal component analysis, water quality

INTRODUCTION

Mangrove plays a vital role in coastal ecosystem including ecology, social, and economic aspects (Blasco and Aizpuru 2002; Dahdouh-Guebas et al. 2005; Duke et al. 2007). In ecology aspect, mangrove is inhabited by various types of biota either living in the waters or from the landward to the seaward. Mangrove forests play an important role in marine fisheries, such as feeding ground, nursery ground, spawning ground for various types of aquatic biota (Able 2005).

Mangrove forests in Lubuk Kertang Village, Langkat, North Sumatra have undergone many land conversion (Basyuni et al. 2015). The areas have been converted to oil palm plantations, settlements, farms, and paddy field that can affect the ecological value of mangroves and food chain cycles (Basyuni et al. 2015). Consequently, those conditions are cut off in aquatic ecology as well as water quality degradation and will have the impact to the inland (Alongi 2002). This circumstance is in a great need of attention from all circles of society to ensure that the management and conservation of mangrove forests can be maintained.

Macrozoobenthos are known to be sensitive to water status alteration, and macroinvertebrates are justifiably the most frequently employed biological elements in monitoring studies (Morse et al. 2007). Macroinvertebrates are found in all aquatic habitats. They are less mobile than most other groups of aquatic organism. They are easily collected, and most of them have relatively long periods of development in the aquatic environment. Thus, macroinvertebrate species should reflect deleterious events that have occurred in the aquatic environment during any stage of their development (Cairns and Pratt 1993).

Macrozoobenthos are living organisms that are crawling, sticking, burying, and burrowing either in the bottom waters or the bottom surface of the waters (Lee 2008). Macrozoobenthos that settled in the mangrove area mostly live on the hard substrate to the muddy environment (Marzano et al. 2003). Macrozoobenthos plays an important role in maintaining the balance of aquatic ecosystems but also very sensitive to changes in water quality of their life. The presence of macrozoobenthos in water is, therefore, strongly influenced by various environmental factors, including biotic and abiotic (Bonzini et al. 2008). The influential biotic factors are producers such as the mangrove plant itself, which is one of the food sources for macrozoobenthos (Basyuni et al. 2007; Wardiatno et al. 2015; Sihombing et al. 2017). The abiotic factor is the aquatic chemical and physical parameters such as temperature, salinity, dissolved oxygen, pH, and substrate of the bottom water (Beuchel et al. 2006).

The significant benefits of mangrove forest in Lubuk Kertang Village make it very vulnerable to over-exploitation and severe environmental degradation. These threats lead to not only reduced mangrove forest area but also decreased ecological function. On the other hand, the life of macrozoobenthos is inseparable from the mangrove fertility and water quality level (Meziane and Tsuchiya 2002). To get more insight into the balance supporting in the mangrove ecosystem, the present study was aimed to analyze the diversity, abundance, and habitat characteristic of macrozoobenthos with special emphasis to water quality and community activities around the mangroves.

MATERIALS AND METHODS

Study area

The study was conducted in Lubuk Kertang Village, Brandan Barat Sub-district, Langkat District, North Sumatra Province, Indonesia. The location for sampling was divided into three different stations. The station I was located at 3º46.44′30.1″-3º46.44′34.17″ North Latitude and between 98º43.89′2.0″-98º43.89′4.5″ East Longitude. Station II was situated at N 3º46.60′44.32″-3º46.60′47.98″ and between at E 98º43.70′0″-98º43.70′2.28″. Station III was located at N 3º46.82′18.33″-3º46.82′21.87″ and between at E 98º43.66′33.3″-98º43.66′36.67″ (Figure 1).

Procedures

Sampling of macrozoobenthos

The method used to determine the station was purposive sampling based on community activities. Three different stations were set with the criteria listed in the description of the area. The samplings of macrozoobenthos were done in two weeks with time interval three times. Each station was further sub-divided into five plots of 1 m × 1 m size. The macrozoobenthos above and below the ground were taken by hand. The samples obtained were cleaned with distilled water and put into a plastic bag containing 70% alcohol for preservation and then labeled. The samples were identified with the identification book of Dharma et al. 2005).

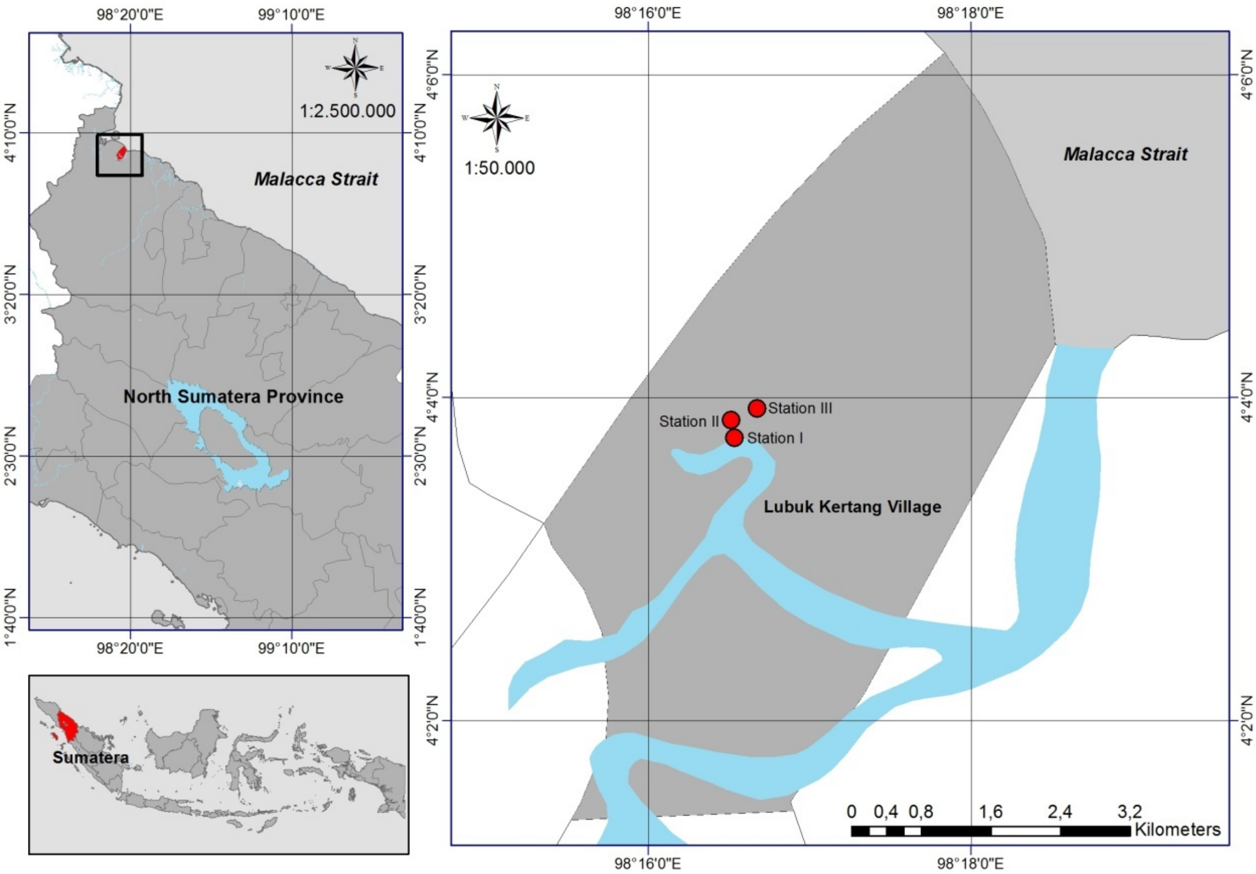


Figure 1. Study location at Lubuk Kertang Village, North Sumatra, indicating the sampling sites of macrozoobenthos consisted of fifteen plots in the three stations

Measurements of water quality parameters

Water temperature measurements were made using a water thermometer. The water thermometer was inserted into the water sample for approximately 10 seconds, and then the scale of the thermometer was observed. Water brightness measurements were performed with a Secchi disk. Secchi disk was inserted into the waters, and the recording was made on how far the disk went into the water until a contrast in colors was not visible. The current was measured using an alleged ball tied to a rope 5 meters long. An alleged ball was released on the surface of the water along with the stopwatch. Then the stopwatch automatically calculated the comparison between the distance (5 meters) and the time required for the ball to reach it. The water velocity was then recorded. The pH of the water was measured using a pH meter. The pH meter electrode section was inserted into the water sample that has been provided in the bucket, and pH value was recorded. Water DO was measured using the Winkler method while the water salinity was measured using a refractometer. The water sample was taken and dripped into the refractometer, and then the salinity value was obtained. Substrate texture and C-organic content were analyzed in the laboratory.

Data analysis

Data obtained from the calculation were descriptively analyzed. Descriptive analysis was used to explain and describe the characteristic conditions of sediment through various parameters as previously described.

Abundance of macrozoobenthos

The abundance of organisms in water is expressed as the number of individuals per unit area or expressed as individuals per m^2. The abundance of macrozoobenthos was calculated using the Shannon-Wiener formula (Odum1993),

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

Where: K = abundance, ni = number of individuals of a type, A = area

Diversity index

The diversity index (H') for each station was calculated by following formula (Odum 1993).

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

Where: H' = Shannon-Wiener diversity index, Pi = Number the proportion of the number of individual species i to the number of individuals. Total Pi = ni/N, with ni= number of species-i, N= total species

Similarity index

The formula for similarity index according to Krebs (1989) was determined as follows:

$$E = \frac{H'}{H\ max}$$

Where: E = similarity index(evenness), H'= Shannon-Wiener diversity index, H max = Log^2S; S = number of species or taxa

Dominance index

The dominance index was a quantitative parameter that was the central level of dominance (mastery) type in a community. The dominance index was calculated using the formula (Odum 1993).

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

Where: D = Simpson's dominance Index, ni = Number of individuals of a type of i, N = total number of individuals, S = Number of genera

Principal component analysis (PCA)

PCA was used to determine the habitat characteristics of macrozoobenthos. The principal component analysis was a descriptive statistical method aimed at presenting data in graphical form, the maximum information contained in a data matrix as previously reported (Bachelet 1996). The data matrix in question consists of substation observation as individual statistics (lines) and aquatic chemistry physics as quantitative variables (columns). The primary purposes of the use of PCA analysis are: (i) extracting essential information contained in a large table/data matrix; (ii) producing a representation of that graph to facilitate interpretation; (iii) studying a table/matrix of data from the point of view of similarity between individuals or relationships between variables (Bachelet 1996).

RESULTS AND DISCUSSION

Water quality parameter

Water sampling was done from 08.00-11.00 am three times in every station during the study. The result showed that the water temperature ranges in the mangrove area of Lubuk Kertang Village were not significantly different among the stations. The measured water temperature was 29℃ at the station I, 30℃ at station II and 29.5℃ at station III. The highest salinity (30‰) was recorded in station II. The highest C-organic was found in station III (8.63%). The fastest current velocity was observed in station III (0.185 m/s). The degree of acidity is one of water quality factors that affect the life of water biota including macrozoobenthos (Abbasi and Abbasi 2011). For the benthos, pH effect is related to the decreasing of stress. If the pH was above six, then the benthic diversity decreased slightly. This finding was supported by the calculated diversity index of the present research, which ranged from 2.30 to 2.39. The diversity of macrozoobenthos in the three stations was classified as medium diversity. Conditions of water that are very acidic or alkaline will disturb the survival of the organism as it can cause respiratory and metabolic disorders. The present study result was also supported by Wang et al. (2012) who found that the pH value of <5 or> 9 is not appropriate for the life of macrozoobenthos.

Abundance of macrozoobenthos

Macrozoobenthos abundance value was obtained from analysis of data from three different stations. The highest abundance (34 individuals m^{-2}) was obtained from Station III while the lowest (26 individuals m^{-2}) was obtained from the station I (Table 2). Table 2 shows that eight species macrozoobenthos were found and classified into three classes of Gastropod, Bivalvia, and Malacostraca. Six species, *C. cingulata, N. lineata, E. aurisjudae, L. scabra, V. cochlidium,* and *T. telscopium* belong to Gastropod. *M. casta* was a member of Bivalvia, and *H. oregonensis* belongs to Malacostraca.

Table 1. Physical and chemical parameters in each station

Parameter	Unit	Station		
		I	II	III
Physical				
Temperature	℃	29	30	29.5
Brightness	m	0.3	0.2	0.35
Current velocity	m/s	0.161	0.140	0.185
Substrate texture	-	sandy clay	sandy clay loam	sandy clay
Chemical				
pH	-	6.6	6.7	6.9
Salinity	‰	22.5	30	28
DO	mg/L	2.2	2.1	2.1
C-organic	%	7.69	7.69	8.63

Table 2. Abundance value (ind m^{-2}) of macrozoobenthos in each station

Species	Station		
	I	II	III
Hemigrapsus oregonensis	2	2	3
Cerithidea cingulata	6	6	10
Nerita lineata	12	13	12
Ellobium aurisjudae	1	0	0
Littoraria scabra	1	1	3
Volegalea cochlidium	3	5	5
Meretrix casta	0	0	1
Telescopium telescopium	1	1	0
Total	26	28	34

Relative abundance of macrozoobenthos

The relative abundance of macrozoobenthos was depicted in Table 3. The highest relative abundance of macrozoobenthos was 42.25% (*N. lineata*), and the lowest was 0.78% (*M. casta*). According to Lee (2008), gastropod class has the highest relative abundance in estuary waters due to its immune system and a hard shell that makes it more likely to survive compared to other classes. Also, Chen et al. (2007) also showed that *N. lineata* has a shell with a very large body whorl. *N. lineata* usually is attached to the root or mangrove stems. In the mangrove area of Lubuk Kertang Village, the most dominant mangrove species was *Rhizophora apiculata* (Basyuni et al. 2017). This species has trunk and branching roots called stilt roots, which makes it possible for *N. lineata* to stick to the roots. *N. lineata* also had the highest density among the macrozoobenthos observed (Table 2).

Diversity index (H'), similarity index (E), and dominance index (D) of macrozoobenthos

Macrozoobenthos diversity was determined by using the Shannon-Wiener Diversity Index. The Diversity Index value ranged from 2.30 to 2.39 belonging to the medium diversity category, and the water quality category was classified as moderate. The similarity index (E) ranged from 0.51-0.54, and the dominance index (D) ranged from 0.33 to 0.35 belonging to the medium version category (Table 4).

The classified dominance index value in this study indicates that there was no any type that remarkably dominated other types. These results show that the condition of the water community was quite stable. It has been reported that an assessed polluted ecosystem is not so easily detected from the relationship between species diversity and community stability (Ilarri et al. 2012). A stable system regarding resistance to disturbance or contaminants may have low or high biodiversity, depending on the function of the energy flow present in the waters (Meziane and Tsuchiya 2002).

As shown in Table 4, the similarity index ranges from zero to one. The closer to zero, the smaller the similarity of the population, meaning that the spread of the number of individuals of each species is not the same, and there is a tendency of one type to dominate. The closer the value to unity (one), then the spread tends to flatten, and there is no dominating type.

Table 3. Relative abundance of macrozoobenthos (%)

Species	Relative abundance
Hemigrapsus oregonensis	7.75
Cerithidea cingulate	24.81
Nerita lineata	42.25
Ellobium aurisjudae	1.16
Littoraria scabra	5.81
Volegalea cochlidium	16.28
Meretrix casta	0.78
Telescopium telescopium	1.16
Total	100.00

Table 4. Diversity index (H′), similarity index (E), and dominance index (D) of macrozoobenthos

Index	**Station**		
	I	**II**	**III**
Diversity (H′)	2.30	2.39	2.35
Similarity (E)	0.54	0.51	0.52
Dominance (D)	0.33	0.35	0.34

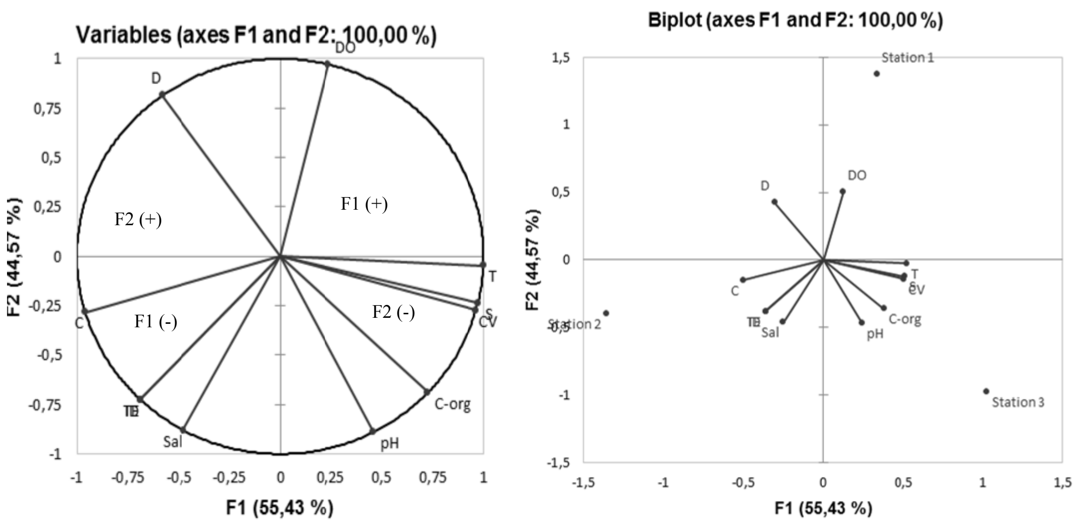
The highest diversity index value (2.39) was found at station II. The number of macrozoobenthos obtained in station II was not higher than other stations, but the spread of individual numbers of each species was quite evenly distributed allowing the station II to have a higher similarity index than the others. Gray (2000) showed that the value of the diversity index is strongly influenced by the number of species, the number of individuals and the spread of individuals in each species.

PCA analysis

Figure 2 shows the results of a principal component analysis (PCA) followed by PCA Biplot. The correlation circle of PCA shows that there are two sets of quasi-independent variables; dominance index, temperature, salinity, and clay on one quadrant (F2+) and DO (F1+), Dust (F2-), Brightness, pH, C-organic, Current velocity, Sand (F1-) on the other quadrant. Dominance index was positively correlated with temperature, salinity, and clay and negatively correlated with DO. These parameters were found to have a considerable effect on the dominance index of macrozoobenthos (Bachelet 1996). On the other hand, other parameters such as flow, pH, C-organic, brightness, current velocity, sand, and dust content were no correlated with dominance index.

The temperature range at each observation station was varied, capable of supporting the life of macrozoobenthos. These results were in agreement with previous findings by Selleslagh et al. (2012) that the value of this range can support descent living in the ecosystems in which they live. The increase in temperature can increase the water metabolism rate since the increased metabolic rate will reduce the consumption of oxygen in the water. Temperature is also affected by the intensity of sunlight, the exchange of heat between the water and the surrounding air, the geographic height and even by the vegetation covering factors of the growing trees on edge (Weber et al. 2017).

The lower clay content, the macrozoobenthic abundance tends to increase. This finding was supported by Kanaya (2014) which suggested that macrozoobenthos (especially mollusks) were present in small amounts in clay type. This is because the clay substrate can suppress the development and life of macrozoobenthos; the clay particles are difficult to be penetrated by macrozoobenthos to carry out their life activities. Besides, clay also has a low nutrient content. Bonzini et al. (2008) reported that the fundamental substrate is one of the leading ecological factors affecting the structure of macrozoobenthos community. If the substrate changes, then the macrozoobenthic community structure will change as well. In the sand substrate type as found in each station observed, the macrozoobenthos from classes of Gastropod and Bivalvia tended to be found. Flach et al. (2002) have shown that the class of mollusks belonging to the Gastropod class is an organism having a wide range of spreads on rocky, sandy or muddy substrates.



A B

Figure 2. A. PCA variables with physical and chemical parameters and dominance index. B. PCA Biplot with physical and chemical parameters and dominance index at the research station. Note: F1(+): DO. F2(+): Dust (D), F1(-): Clay (c), Salinity (Sal), Dominance index (ID), Temperature (TE) . F2(-): Brightness (T), pH, C-organic (C-org), Current velocity (CV), and Sand (S). All physical and chemical parameters were clustered at the three stations.

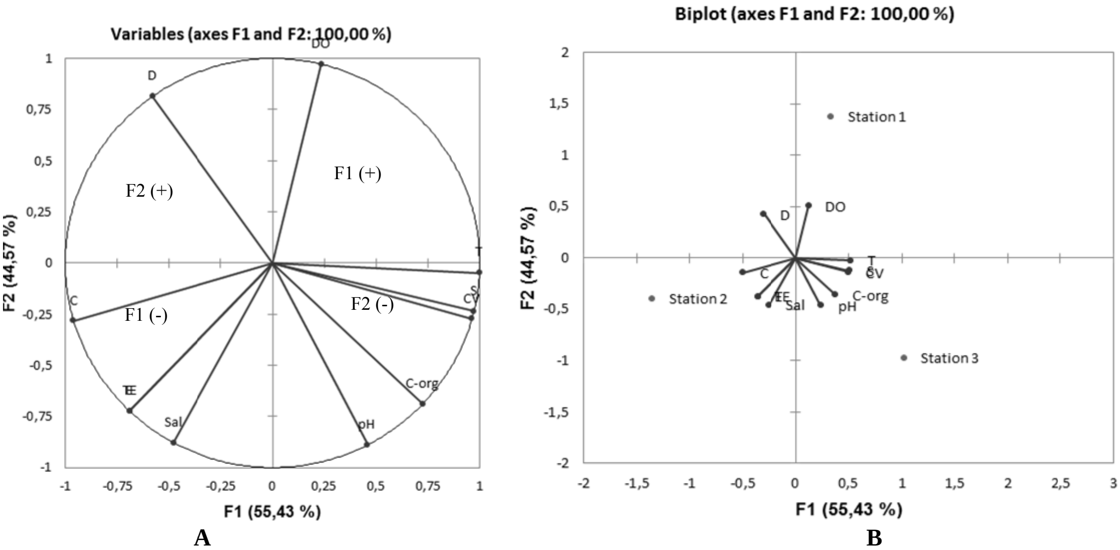


Figure 3. A. PCA variables with physical and chemical parameters and similarity index. B. PCA Biplot with physical and chemical parameters and similarity index at the research station. Note: F1(+): DO. F2(+): Dust (D), F1(-): Clay (c), Salinity (Sal), Similarity index (IE), Temperature (TE) . F2(-): Brightness (T), pH, C-organic (C-org), Current velocity (CV), and Sand (S). All physical and chemical parameters were clustered at the three stations.

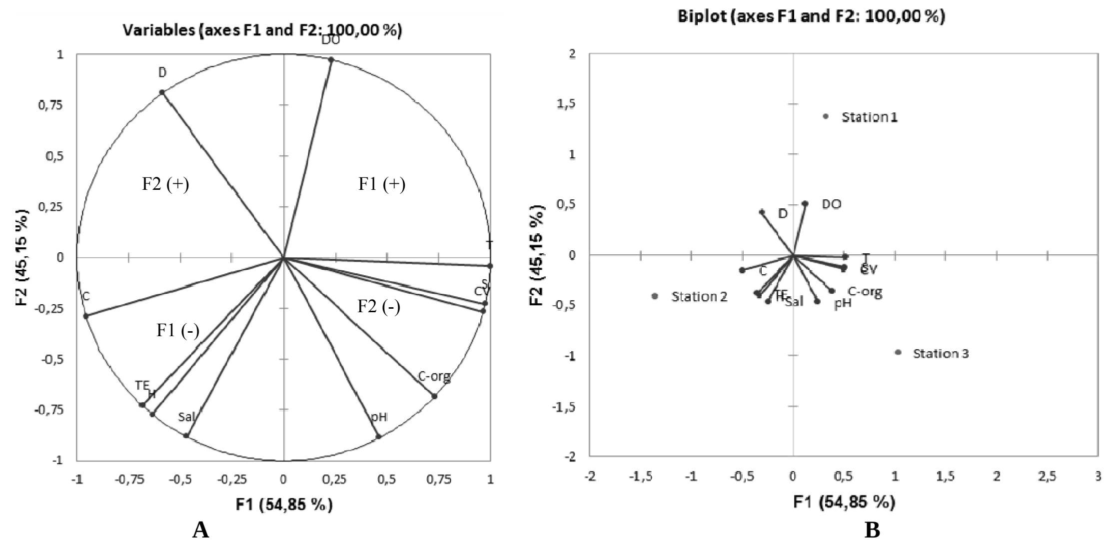


Figure 4. A. PCA variables with physical and chemical parameters and diversity index. B. PCA Biplot with physical and chemical parameters and diversity index at the research station. Note: F1(+): DO. F2(+): Dust (D), F1(-): Clay (c), Salinity (Sal), Diversity index (H'), Temperature (TE) . F2(-): Brightness (T), pH, C-organic (C-org), Current velocity (CV), and Sand (S). All physical and chemical parameters were clustered at the three stations

The dissolved oxygen content affects the amount and type of macrozoobenthos in the water. The higher the oxygen level, the higher the number of benthos. Lim et al. (2006) found that the dissolved oxygen content required by macrozoobenthos ranges from 1.00 to 3.00 mg/L. Figure 3.A illustrates the results of the analysis represented using two principal axes that accounted for 100% of the total variance. Data consists of the main components of 55.43%, and 44.57% for the second element, respectively. The interpretation of PCA had been considered to represent a state that occurs without reducing the information from the data obtained (Rajsekhar et al. 2015).

Figure 4.A shows the habitat characteristics that could be illustrated to have the correlation circle at negative axis 2. The parameters such as DO, temperature, salinity, clay, and diversity index were clustered approaching the X-axis. Our current results had a considerable influence on the diversity index of macrozoobenthos. Meanwhile, the present velocity, pH, and C-organic content showed no correlation to the diversity index that was not approaching the X-axis.

The salinity obtained during the study ranged from 22.5 to 30‰. The highest salinity value was shown at station II (30 ‰) while the lowest value was shown at Station I (22.5 ‰). Based on Minister of Environment Decree No. 51 of 2004, salinity value that meets the standard quality was 0-34 ‰. Wang et al. (2007) reported that the salinity fluctuation gradient pattern depends on season, topography, tides and the amount of fresh water. The range of typical salinity values for macrozoobenthos life in mangrove forests ranged from 20-35 ‰. The salinity range observed in this study is still included in the standard category.

Figure 4.B depicts PCA analysis of physical and chemical parameters of the research site. The results displayed the physical and chemical parameters that had a significant role and an essential habitat for macrozoobenthos at the station III that was on the opposite of axis 2. The station III was medium in diversity index of macrozoobenthos (2.35). The physical parameters of the PCA analysis affected the chemical characteristics of the habitat at the station III which showed smaller value indicating a low uniformity. This result showed that the density of each type could be the same and tended to be dominated by a particular type.

In conclusion, we have confirmed that water quality (physical and chemical parameters) affected habitat characteristics of macrozoobenthos at each station observed. Four parameters namely salinity, clay, temperature, and DO play a significant role in Mangrove area in Lubuk Kertang Village. The four parameters should be preserved to support the survival of macrozoobenthos in the mangrove forests.

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