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Biodiversity of epiphytic periphyton in the leaves of the seagrass bed of Talawaan Bajo Estuary, North Sulawesi, Indonesia

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Abstract. *Ogi NLIM, Herawati EY, Risjani Y, Mahmudi M. 2021. Biodiversity of epiphytic periphyton in the leaves of the seagrass bed of Talawaan Bajo Estuary, North Sulawesi, Indonesia. Biodiversitas 22: 4857-4864.* This study aimed to analyze the diversity of epiphytic periphyton on the leaves of the seagrass bed of Talawaan Bajo estuary North Sulawesi Indonesia. The study was performed in three sampling points by using the line transect method with 50x50 cm^2. The sampling points were located in front of the residential area, the mangrove forest, and in budo Cape. Seagrass and periphyton communities were analyzed for species density, relative frequency, diversity, evenness, and dominance index. Water quality and heavy metal Hg were also measured. The results showed that *Cymodocea rotundata* was the dominant seagrass based on species density and frequency distribution. Periphyton composition on the leaf of *C. rotundata* consisted of Bacillariophyceae (16 genera), Cyanophyceae (3 genera), Chlorophyceae (9 genera), Dinophyceae (1 genus), and Rhodophyceae (1 genus). The water quality, such as phosphate, current, nitrate, dissolved oxygen, and Hg content in the water, contributed to changing the environmental condition of Talawaan Bajo waters. Therefore, the efforts to manage coastal resource conservation in the Talawaan Bajo estuary require more concern from the government and stakeholders of Talawaan Bajo.

Keywords: Environmental changes, heavy metal, periphyton diversity, seagrass ecosystem

INTRODUCTION

Coastal and marine areas play a crucial role in Indonesia as the primary provider of natural resources and environmental services (Sugianti et al. 2018). They also host the immeasurable biodiversity of marine life. One of the marine and coastal habitats is Seagrass beds. Seagrass beds have many functions, including providing physical habitat for small invertebrates such as shrimp, crabs and other crustaceans, small fish and juveniles of larger fish (Nadiarti et al. 2012). The root and rhizome of seagrass could stabilize sediments, reduce erosion and enhance water quality and cycling of nutrients (Ambo-Rappe 2016). It also plays a role in carbon sequestration (Macreadie et al. 2012) and decreasing the bacterial pathogen in the marine ecosystem (Lamb et al. 2017). Habitat provided by seagrass beds also acts as a nursery ground for numerous juvenile fish (Saenger et al. 2013).

Seagrasses also provide essential ecological linkages with the adjacent coral reefs and/or mangroves, in which seagrass communities support the existence of coral reefs through the export of organic materials (Campbell et al. 2011) and also provide grazing grounds and/or nurseries for coral reef fishes and another reef fauna (Nordlund et al. 2014; Flaherty-Walia et al. 2017). The presence of seagrass beds is closely related to the abundance and diversity of marine organisms (Ambo-Rappe 2016), especially Periphyton (Razali et al. 2019) which serve as a vital food source for amphipods and gastropods (Segovia-Rivera and Valdivia 2016). Therefore, the presence of a seagrass bed is crucial for the sustainability of marine biodiversity.

Although seagrass ecosystems have many physical and ecological functions, their decline has been reported in many countries worldwide (Kawaroe et al. 2010; Shelton et al. 2016). Natural disturbance, such as grazing and storm (van Tussenbroek et al. 2014) was the common factor that is an inherent part of the seagrass ecosystem dynamic. However, anthropogenic factors (Otero 2015), such as eutrophication (Schmidt et al. 2012), overfishing (Pitanga et al. 2012) and conversion of coastal habitats, were the greatest cause of seagrass disturbance. In other words, the increase of pollutants in the coastal area also contributes to seagrass diversity. Of course, these kinds of seagrass threats will lead to the extinction of some organisms at a higher trophic level (Ambo-Rappe 2016). Hence, seagrass conservation is needed to cope with this case.

The population which is still adapted to environmental changes and has a symbiosis with seagrass is periphyton. Periphyton is a micro-ecosystem composed of a mixture of autotrophic and heterotrophic microorganisms attached to a matrix of organic detritus (Yadav et al. 2017). Periphytons living on the seagrass leaves are the source of autochthonous energy in the water and support the primary producer of the seagrass bed. Furthermore, periphytons can be used as a bio-indicator of water quality (Khan and Firuza et al. 2012) and environmental changes (Sugianti et al. 2018). However, Indonesia's periphyton abundance and diversity study were limited to Bangka Belitung (Rosalina et al. 2018a, 2018b, 2019a, 2019b).

The study of the importance of seagrass ecosystems and the impacts of anthropogenic disturbances is urgently needed to improve the management and conservation. Therefore, this study aimed to analyze the diversity of epiphytic periphyton on the leaves of the seagrass bed of Talawaan Bajo estuary North Sulawesi Indonesia and demonstrate the estuarine environmental condition based on the oceanographic parameters. This study is expected to determine the relationship of periphyton diversity and environmental changes, especially heavy metal (Hg) in the Talawaan Bajo estuary.

MATERIALS AND METHODS

Study area

This study was carried out in the estuary of Talawaan Bajo, North Sulawesi, Indonesia (Figure 1). Observations on seagrass occurrence were focused on three stations, in front of the residential area (Station 1), in front of a mangrove forest (Station 2), and around Budo Cape (Station 3) (Figure 1).

Field sampling and data collection

Seagrass

Samples collection was carried out during the low tide period in coherence with the full moon phase. The sample collection was performed using the line transect method with 50x50 cm^2. Three 50 meter-transect lines were randomly set perpendicular to the coastal area depending upon the density of seagrass beds in the study site. A total of thirty quadrats (10 quadrats per transect) were employed. All samples covered in the quadrat were separated, placed in plastic bags, then brought to the Laboratory of Faculty of Fisheries and Marine Science, Sam Ratulangi University, for further analysis. Species identification was referred to Lanyon (1985) and Larkum et al. (2006) methods.

Periphyton

Epiphytic periphyton was collected from seagrass leaves. The collections were obtained by cutting 2 sheets of dominant seagrass leaves from each transect in all study sites. The periphytons were collected by gently scraping the leaf surface as wide as 10 cm^2 at the base, the mid, and the tip of the leaves. The scraped material was then put in a sample bottle, labelled, and preserved in Lugol's solution (Merck KGaA, Darmstadt, Germany). The periphytons were observed under the microscope with magnification 400x using the Luckey Drop method. The identification was performed according to the classification literature book of Bold and Wynne (1985) and Kozloff (1990).

Data analysis

Seagrass

Seagrass community analyses focused on species density, relative frequency, diversity, evenness, and dominance. Species density was estimated using formula 1:

$$Di = \frac{Ni}{A} \quad (1)$$

Where, D*i* is the number of individuals i per unit area, Ni is the number of individuals *j* in quadrat transect, and A is the width of quadrat transect.

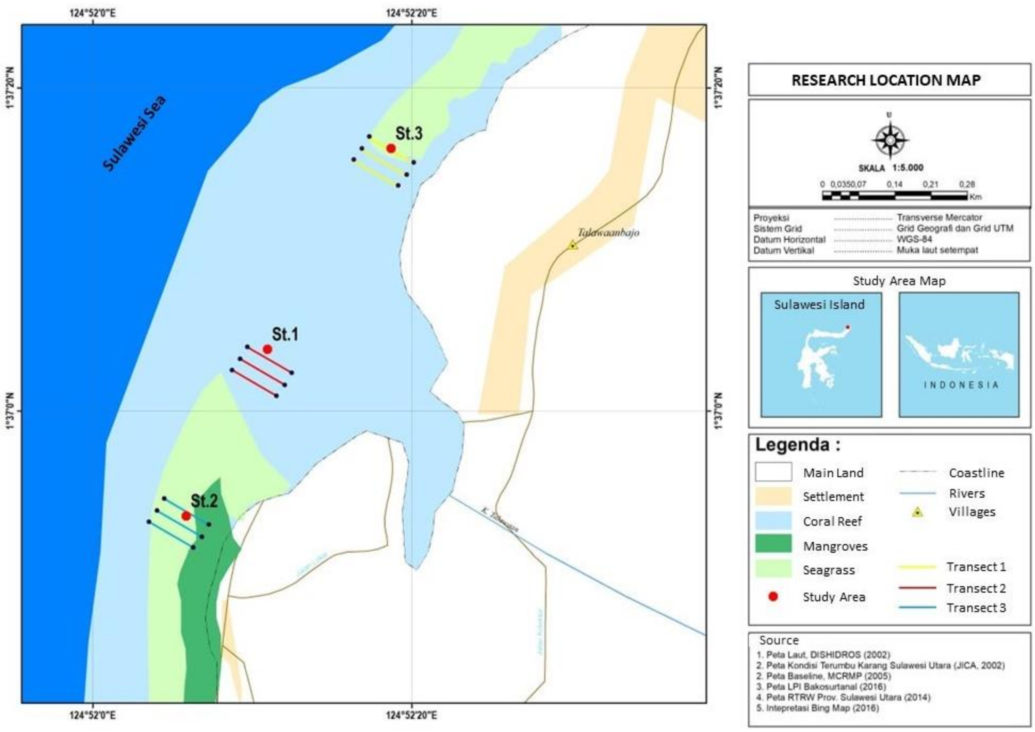

Figure 1. Research location map of Talawaan Bajo, North Sulawesi, Indonesia

Relative frequency (RFi) was calculated as follows:

$$RFi = \frac{Fi}{\sum_{i=1}^{P} Fi} \text{ x } 100 \qquad (2)$$

Where, RFi is relative frequency, Fi is frequency species-i, and $\sum_{I=1}^{F} Fi$ is the number of frequencies of all species.

Species diversity applied the Shannon-Wiener index to measure the community abundance based on the number of species and number of individuals per species.

$$H' = -\sum_{i=1}^{s} \frac{pi}{N} \, x \ln \frac{pi}{N} \qquad (3)$$

Where, H' is diversity index, Pi is the proportion of the number of species i to total the number of individuals (ni/N), N is the total number of individuals of all species, S is the number of species taxa.

Species evenness (E) was calculated by dividing the diversity index and the maximum diversity index to measure the ecosystem equilibrium. Species evenness estimation using formula 4:

$$E = \frac{H'}{Hmax} \qquad (4)$$

$$Hmax = \ln(S) \qquad (5)$$

Where, E is the Shannon evenness index, H' is the Shannon-Wiener diversity index, H'max is the maximum diversity index, and S is the number of species.

Dominance index employed Simpson dominance index (D) to describe the most genus/species occupying a certain area Dominance was calculated using the following formula:

$$D = \sum_{i=1}^{s} \frac{ni(ni-1)}{N(N-1)} \qquad (6)$$

Where, D is Simpson dominance index, ni is the number of species i, and N is the total number of individuals of all species.

Periphyton

The periphyton density was estimated based on plankton calculation by modifying Lackey Drop Microtransecting Methods (APHA 1989). Species diversity, evenness, and dominance of the periphyton were also assessed.

Environmental variables

Measurements of water quality parameters focused on temperature, current water, depth, substrate, turbidity, pH, salinity, dissolved oxygen (DO), phosphate, nitrate, and mercury (Hg). Environmental measurement was conducted with three replications. The bottom sediment was collected using one unit of Sediment Grab. Temperature, current water, depth, pH, salinity and DO were measured using U-50 Multiparameter Water Quality Checker (Horiba, Ltd., Japan). The Brusin method with a spectrophotometer (SNI 06-2480-1991) at a wavelength of 410 nm was used to determine nitrate levels in the range of 0.1 mg/L - 2.0 mg/L. Determination of phosphate levels was carried out by the ascorbic acid spectrophotometer method (SNI 06-6989.31-2005) in the range of 0.0 mg P/L to 1.0 mg P/L. The ascorbic acid spectrophotometer method (SNI 06-6989.31-2005) was used to measure phosphate levels in the range of 0.0 mg P/L to 1.0 mg P/L. The production of a blue-colored phosphomolybdate complex is the basis of this approach. The Molybdenum complex is further reduced using ascorbic acid to produce a blue color. The intensity of the color produced is proportional to the phosphorus content. A spectrophotometer was used to measure the blue color produced at a wavelength of 700nm-880nm. Mercury (Hg) content was analyzed using an Atomic Absorption Spectrophotometer (AAS).

A correlation analysis was performed to identify the study site with the environmental characteristics that affect seagrass and periphyton biodiversity. A principal component analysis (PCA) was used to determine the correlation between oceanographic parameters with seagrass and periphyton.

RESULTS AND DISCUSSION

Community structure of seagrass

This study found 6 species of seagrasses belonging to 2 families and 7 genera in two different sites of Talawaan Bajo estuary (Table 1). *Halodule uninervis* was the common seagrass found in all stations (Table 1), whereas *Halophila ovalis* is the rare seagrass since it was only found in station 2.

Table 1. Seagrass distribution in Talawaan Bajo estuary, North Sulawesi, Indonesia

Species	Code	Station 1			Station 2			Station 3		
		1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
Enhalus acoroides	Ea	-	-	-	+	+	+	-	+	+
Thalassia hemprichii	Th	-	-	-	-	+	+	+	+	+
Cymodocea rotundata	Cr	-	-	+	+	+	+	+	+	+
C. serrulata	Cs	-	-	-	+	+	+	+	+	+
Halodule uninervis	Hu	+	+	+	+	+	+	+	+	+
Halophila ovalis	Ho	-	-	-	+	+	+	-	-	-
No. species		1	1	2	5	6	6	4	5	5

Note: (+) present; (-) absent

Seagrass density and relative density

Seagrass density is highly correlated with space and bottom substrates (McCloskey and Unsworth 2015). The presence of a suitable substrate could make the seagrass grow well. Most seagrass species develop in sandy to the muddy bottom, but some other species grow on corals, such as *Phyllospadix* spp, *Thalassodendron* spp and *Posidonia oceanica* (Guannel et al. 2016).

In all study sites, the seagrass density was varied, as shown in Figure 2. The lowest was found in the station I occupied by 2 species, *C. rotundata* and *H. uninervis*. At the same time, the highest was recorded in station II with mixed vegetations consisting of *E. acaroides*, *T. hemprichii*, *C. rotundata*, *C. serrulata*, *H. uninervis*, and *H. ovalis*.

Species frequency

Species frequency is the number of times a species occurs in the given sampling point. The high frequency of species, in general, has higher adaptation to different environmental conditions. However, a species with a high-density value cannot be guaranteed to have a high-frequency value. The relative frequency (RFi) of seagrass species is presented in Figure 3, in which *C. rotundata* has the RFi of 35% since it was found evenly in all stations. The lowest RFi value was observed in *H.ovalis*, with an RFi value of 4%, only found in stations 2 and 3.

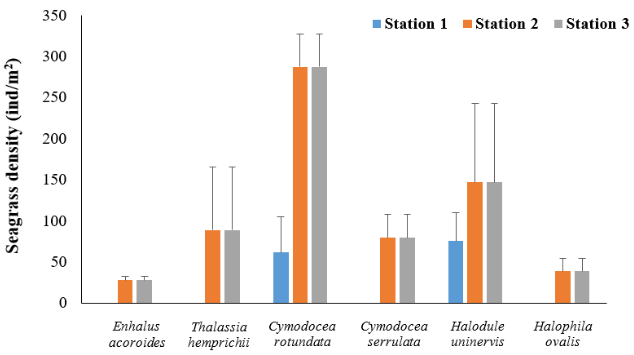

Figure 2. Seagrass density (ind/m^2) in Talawaan Bajo estuary, North Sulawesi, Indonesia

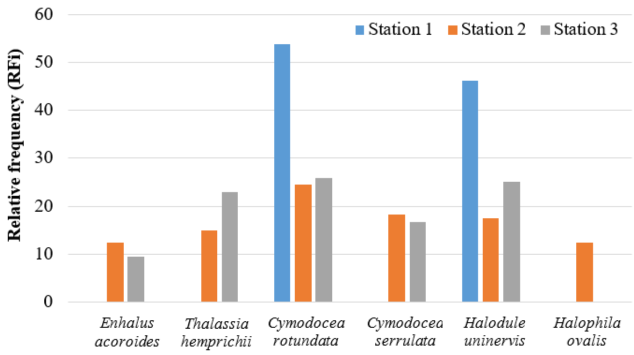

Figure 3. Relative frequency (RFi) of seagrass in Talawaan Bajo estuary, North Sulawesi, Indonesia

Diversity index (*H'*), evenness (*E*), and dominance (*D*)

The higher index value of diversity showed high species variations in the community, not dominated by one or more specific species. Evenness index ranges from 0 to 1, in which E<0.4 indicates the ecosystem under pressure and low evenness, E = 0.4-0.6 is moderate evenness and low stability, and E>0.6 reflects stable ecosystem and high evenness. The diversity analysis is presented in Table 2.

Community structure of epiphytic periphyton on *Cymodocea rotundata*

Periphyton composition

The presence of periphyton is highly dependent on sunlight intensity, temperature, current, substrate type and nutrient availability. Uniform temperature distribution in the water and light intensity helps the plant to photosynthesize effectively up to the sea bottom. Periphytons were found on all leaf surfaces of *C. rotundata* with different densities. Based on laboratory observations, it revealed that the periphyton composition on the leaf varied with stations. This study found 5 classes, Bacillariophyceae (16 genera), Cyanophyceae (3 genera), Chlorophyceae (9 genera), Dinophyceae (1 genus), and Rhodophyceae (1 genus) (Table 3).

Bacillariophyceae had a diverse genera composition among the classes. Most of the genus Bacillariophyceae can adapt to various water environments. In the worst condition, these family members can survive in environments with more mucous. Besides, most of the genera of Bacillariophyceae produce gelatin stalk-like tools to adhere to the specific substrate. With this assistance, members of Bacillarriophyceae can sustain the strong currents (Kuczynska et al. 2015). The periphyton composition is also remarkably affected by the substrate type for attachment.

The epiphytes of Bacillariophyceae (Diatom) on the seagrass leaf are genus Nitzschia and Cocconeis (Al-Harbi 2017). Since the periphyton composition is almost the same on various seagrass leaves, the present study concluded that the leaves of the seagrasses had similar characteristics as the substrate for the periphyton. The periphyton composition on the seagrass leaf is strongly influenced by the seagrass morphology, age, position or habitat. The seagrass possessing large leaf-like *E. acoroides* is more selected by the periphyton than the small leaf because the seagrass of large leaves will have a more stable substrate condition. Similarly, older seagrasses will hold different periphyton composition and density than the younger since the attachment process and colony formation of the periphyton need enough time.

Table 2. Seagrass diversity index (H'), evenness index (E), and dominance index (D)

Index	Station		
	I	II	III
H' = Shannon Diversity Index	0.56	1.55	1.15
E = Similarity Index	0.80	0.87	0.72
D = Dominant Index (Simpson's)	0.63	0.26	0.37
H-max = Diversity Maximum	0.69	1.79	1.61
D' = Simpson Diversity Index	0.37	0.74	0.63

Table 3. Periphyton distribution in Talawaan Bajo estuary, North Sulawesi, Indonesia

Periphyton	Station		
	I	II	III
Chlorophyta			
Chlorella	+	+	-
Cylindrocapsa	+	+	+
Echinosphaerella	+	-	-
Gongrosira	-	+	-
Mougeotia	-	+	-
Prasinocladus	+	-	-
Scenedesmus	+	+	+
Ulva flexuosa	+	-	+
Stigeoclonium	+	+	+
Bacillariophyta			
Achnanthes	-	+	-
Cocconeis	+	+	+
Coscinodiscus	+	-	-
Cyclotella	+	+	+
Cymatopleura	+	+	+
Cymbella	+	+	+
Diatoma	+	+	+
Fragilaria	-	+	+
Gyrosigma	-	+	-
Melosira	+	+	+
Navicula	+	+	+
Nitzschia	+	+	+
Pinnularia	+	+	+
Surirella	+	+	+
Synedra	-	+	+
Tabellaria	+	+	+
Cyanophyta			
Agmenelum	-	+	-
Oscillatoria	+	+	+
Plectonema	+	-	+
Dinophyta			
Gymnodinium	+	-	+
Rhodophyta			
Sirodotia	-	+	+

Notes: + = present, - = absent

In the station I, II and III, the highest density of periphyton was Cocconeis (3,378,045.6 cell/cm^2), Nitzschia (751,549.8 cell/cm^2), Navicula (7,096,514 cell/cm^2), respectively. The mostly periphytons belonged to Bacillariophyceae as major epiphytes on the seagrass. The seagrass density could directly or indirectly impact the presence and density of periphyton due to its close relationship with the substrate stability (seagrass leaf) from flushing effect, water circulation, and the chance of the periphyton in obtaining sunlight for photosynthesis (McCloskey and Unsworth 2015).

McCloskey and Unsworth (2015) stated that the leaf length and the seagrass density could affect the distribution and the abundance of seagrass-associated biota. Factors influencing the change in seagrass beds could also determine the periphyton distribution and abundance. The diversity index in this study describes the richness/number of periphyton genera, in which the higher the diversity index, the higher the periphyton variations. Station II had a diversity index of 2.759, indicating that individual distribution was low and ecological pressures were high. In contrast, station III, with a diversity index of 3.006, reflected high individual distribution and had high ecological pressures (Table 4). It could be derived from the higher periphyton genera in station III than in other stations. The physical factor, such as current, highly affects the periphyton attachment. Station III had the lowest winds, so periphyton could strongly attach and develop well in this area.

The highest evenness index is station I (0.647), followed by station III (0.576) and station II (0.497). The high evenness index indicates that the individual distribution of each genus/species in the community is uniform and followed by a low dominance index, 0.137-0.191. The dominance index exhibited no species that significantly dominate other species. It is supported by the distribution index < 1.0, reflecting uniform distribution or random distribution.

PCA analysis-based relationship of oceanographic parameters with seagrass and periphyton

Parameters used for PCA analysis were periphyton density, seagrass density, dissolved oxygen, salinity, phosphate (P), nitrate (N), temperature (T), and current. These parameters were integrated to obtain a matrix value of the relationship among parameters and the cumulative variance value. The considered variables were environmental components and the number of seagrass individuals in 3 stations. This analysis applied 2 axes that gave a significant contribution to the water characteristics. In the environmental characteristics, the first axis (F1) gave a contribution of 76.65% (Figure 3) to the entire environmental parameter characteristics in all stations, wherefrom the total value, phosphate contributed 27.7%, current velocity 27.2%, nitrate 23.0%, and dissolved oxygen 22.0%. In contrast, water temperature and salinity did not give a remarkable contribution with the same value in all stations. Furthermore, for seagrass species characteristics, the first axis contributed 70.69% (Figure 4) to the entire characteristics of the seagrass species individual numbers. The highest was found in *T. hemprichii* 23.0%, and the lowest in *H. ovalis* 4.8%.

Figure 3 demonstrates the different species and individuals affected by phosphate content, current, nitrate, and dissolved oxygen in all stations. Water temperature and salinity do not influence the number of species and individuals indicated with similar values. Seagrass density affects the presence and the density of periphyton. It is closely related to substrate stability (seagrass leaf) from flushing effect and water circulation on the ability to absorb nutrients and chance to obtain the sunlight for photosynthesis. Therefore, the more the seagrasses occur, the higher the possibility of the periphyton attaching. Interspecific competition of periphyton for space, sunlight, and food could also determine the periphyton attachment on the leaf, where the more potent species would have a high abundance.

Table 4. Density (N), diversities (H'), dominance (D), and evenness index (E) of Periphyton from Talawaan Bajo, North Sulawesi, Indonesia

Index	Station		
	I	**II**	**III**
Density (N)	13.695487	38.921.719	26.456.993
Diversity (H')	2.864	2.759	3.006
Dominance (D)	0.137	0.191	0.151
Evenness (E)	0.647	0.497	0.576

Mabrouk et al. (2014) found that the epiphyte abundance on the seagrass individual varied depending on the bottom's distance. Our observation indicated that the periphyton density on *C. rotundata* was higher than the other species. The possible reason is *C. rotundata* has shorter leaf morphology, and the distance is near the bottom, so the opportunity of the periphyton attachment occurs not only because of the periphyton's colonization process but also the effect of the periphyton's colonization process water movement that brings the sediment and benthic organisms. In addition, suitable physical and chemical conditions for the seagrass and periphyton growth in the seagrass ecosystem with different densities could also increase the abundance of several periphyton species.

PCA analysis revealed that seagrass density has a negative correlation with current, nitrate, and phosphate. The denser the seagrass, the lower the current speed, nitrate, and phosphate will be. Huang et al. (2019) also claimed that shallow waters greatly influenced slowing down the current. Current velocity is considered to be related to the periphyton community development in the seagrass ecosystem, in which it could determine the periphyton community-building organisms.

Strong currents in the low-density seagrass area make the seagrass leaves upright to penetrate the water, while in the high-density seagrass area, the sunlight could only reach the water surface. It concerns photosynthesis done by the seagrass and the periphyton. Current velocity indirectly affects the nutrients absorbed by the seagrass root. The oxygen transport to the root could aerobically result in metabolisms so that the nutrient absorption could increase. Our observations agree that the growth of larger plants with extensive roots and rhizome systems will benefit the metabolism. Gillis et al. (2014) found that the concentration of organic materials in the sediment with seagrasses was higher than that in the sediment without seagrass. This high organic content will also affect the organism abundance, including the seagrass-associated periphyton.

Environmental condition

Aquatic environmental conditions affect all forms of all living species in water, directly or indirectly. Physical and chemical characteristics also influence the community structure of living biota in the water, especially the seagrass bed. The aquatic environmental conditions of the Talawaan Bajo estuary were still perfect for the seagrass to grow. Station I is near the local residential area and used as a mooring site for the fishermen's boats. Station II is a mangrove forest as a nutrient trap area, while station III is downstream of the river. The aquatic environmental condition in the present study reflects the relationship between the seagrass characteristics and human activities in the estuary of Talawaan Bajo. These values could also describe the water quality supporting the seagrass density (Table 5).

Mercury (Hg) concentration

Table 6 presented the Hg concentration obtained from AAS analysis. The normal and maximum concentration of heavy metal mercury (Hg) entering the aquatic environment is 0.1 ppb and 1.2 ppb, respectively (APHA 1989). The present study found higher concentrations than that of normal and maximum levels (Table 6). The waste from the mining industry (which requires Mercury (Hg) for gold refining) is channeled through the Talawaan watershed, where it will eventually be deposited and absorbed by the Talawaan Bajo estuary waters.

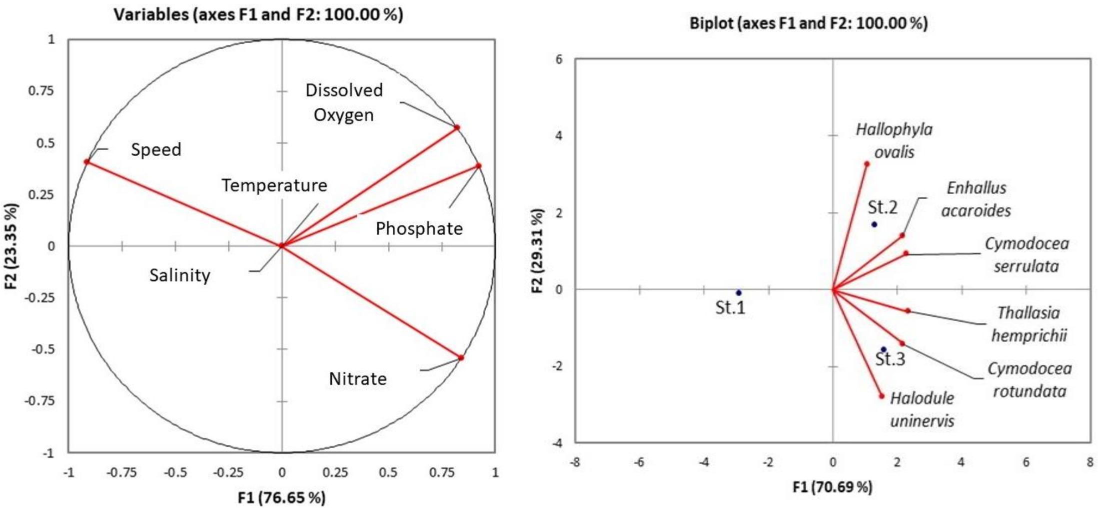

Figure 4. Projection of station and benthic component in two dimensions (axis 1 and axis 2) using PCA

Table 5. Several oceanographic parameters in the study sites

Station	Transect	Temp (°C)	Salinity (‰)	Current (m/s)	Dissolved oxygen (ppm)	Nitrate (mg/L)	Phosphate (mg/l)
I	I	32.00	31.25	0.02	4.85	2.0010	0.0000
	II	31.86	32.40	0.02	4.86	2.1512	0.0031
	III	31.98	32.25	0.02	4.86	2.2035	0.0000
	Mean	31.95	31.96	0.02	4.86	2.1186	0.00103
II	I	31.86	32.85	0.02	3.55	1.8584	0.0062
	II	30.03	31.82	0.02	4.85	1.8526	0.0060
	III	29.92	32.74	0.02	4.85	2.0670	0.0061
	Mean	30.60	32.47	0.02	4.42	1.9260	0.00610
III	I	30.01	30.75	0.03	5.44	2.1029	0.0000
	II	30.00	31.82	0.03	5.43	2.1565	0.0000
	III	30.06	32.74	0.03	5.44	2.3909	0.0016
	Mean	30.02	31.77	0.03	5.44	2.2168	0.00053

Table 6. Mean mercury concentration (ppm)

Type	Station		
	I	II	III
Seagrass	3.11	4.56	4.75
Periphyton	7.95	20.02	24.17

The present study found 6 species of seagrasses (*E. acoroides*, *T. hemprichii*, *C. rotundata*, *C. serrulate*, *H. uninervis*, and *H. ovalis*) in Talawaan Bajo estuary with dominant species of *C. rotundata*. The periphyton composition on the leaf of *C. rotundata*, consisting of Bacillariophyceae (16 genera), Cyanophyceae (3 genera), Chlorophyceae (9 genera), Dinophyceae (1 genus), and Rhodophyceae (1 genus), respectively. In addition, the water quality, such as phosphate, current, nitrate, and dissolved oxygen, and Hg content in the water, contributed to changing the environmental conditions in Talawaan Bajo waters. In conclusion, the efforts to manage coastal resource conservation in the Talawaan Bajo estuary requires more concern from the government and stakeholders of Talawaan Bajo.

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