Periphyton Response Analysis to the Pollution in Seagrass Ecosystem Panjang Island, Banten

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Abstract

Increases in coastal pollutants, largely due to human activity on land, have an impact on seagrass ecosystems. The high sedimentation in the waters causes an increase in the concentration of sludge, organic matter, nutrients, and turbidity which reduce the depth that can be reached by sunlight. The condition affects seagrass ecosystems adversely. Changes in water condition can be illustrated by the presence of water organisms. One dominant organism in seagrass ecosystems is periphyton. The existence of periphyton in the waters is determined by physical and chemical conditions of the waters because it has specific limit of tolerance, which causes different community structure. To analyze periphyton response to the changes of environmental quality in seagrass ecosystems, Shannon Winner diversity and Saprobic Indices were measured at Panjang Island, Banten. The results of water quality assessment indicates the status of aquatic seagrass of the island considered as polluted to heavy polluted. It is observed from some physico-chemical parameters that exceeded the standard quality for the life of seagrass ecosystems and marine life. Based on the classification and saprobic coefficient using periphyton biological parameters, the condition of seagrass land ecosystem in the island is classified into β Mesosaprobic to β/α Mesosaprobic phase, which indicates light to medium pollution with pollutants including organic and inorganic materials. Several types of dominant periphyton were discovered during the observations, including Meridion sp, Navicula sp, Nitzschia sp and Synedra sp. This periphyton species belong to Bacillariophyceae class (Family Chrysophyta) that is commonly used to assess the condition of eutrophication and organic pollution on waters.

Key words: *Periphyton; Panjang islands; Seagrass; Water Quality*

Introduction

The condition of Java coastal seagrass ecosystems has experienced considerable disruption due to serious pollution and population growth (Kawaroe *et al.,* 2016). An estimation 60% of seagrass beds have been damaged and this impact the deterioration in percent cover and density of seagrass species, such as Panjang Island, Banten. The changes in the extent of seagrass ecosystems in this island over a period of ten years starting from the year 1990-2010 has reached 63.9%, in which the biggest changes occurred during the period of 2000-2005, reached 22.9 ha. Panjang Island waters get materials input from the mainland as indicated by the murky conditions and generally caused by the reclamation in Bojonegara area that affect turbidity in the western region of the island. This is reflected by the turbidity gradation in the western waters of the island (Sakaruddin, 2011).

Increase in pollutant loads in coastal areas, where the largest contribution comes from household wastes ultimately affects seagrass ecosystems. The most dominant domestic waste is organic material such as human feces and animal waste. Generally domestic wastes were dumped haphazardly and uncontrolled thus accumulated and caused environmental pollution problems. All of this has negative impact to seagrass ecosystems. Changes in these conditions can be illustrated by the presence of organisms in seagrass ecosystems. Biotas that live in these ecosystems are adapted to the environment changes. If the organisms can not adapt this change, there will be changes in the composition and succession of the biota communities living in this ecosystem.

In relation to pollution in seagrass ecosystem, one of the communities of organisms which adapted to bloom is periphyton. Periphyton is a complex mixture of algae cyanobacteria, heterotrophic microbes and detritus which attached to submerge surface in most aquatic ecosystems. Attached algae are the most important group of periphyton and are usually the focus during perio phyton studies. When

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abundant, periphyton removes nutrients from the water column, thereby reduce the risk algal blooms (Ji, 2008).

Periphyton community usually attaches to the substrate and seagrass leaves, and has very important role in waters, not only as primary producers but also as a source of energy for higher trophic levels. It also affects nutrient requirements and nutrient transfer between organisms in the pelagic zone (Inyang *et al*., 2015). The existence of periphyton in the waters is largely determined by the physical and chemical conditions of the waters because it has a specific tolerance limit that causes the community structure will be different based on the condition of physical and chemical parameters. The existing organisms in contaminated water are different from those who live in uncontaminated water (Iliopoulou-Georgudaki *et al*., 2003). Periphyton is very responsive to contamination so it can be use to assess the condition of nutrients in water (Vilches *et al*., 2014). Dalton *et al*., (2015) mentioned that the enrichment of nutrients in water lead to domination of periphyton of Bacillariophyceae Class. The existence of periphyton of this class is used to assess the condition of eutrophication and organic pollution.

The use of periphyton as bio-indicators of pollution is very good because periphyton is able to grow on contaminated habitat, easily sampled, and easily identify (Vilches *et al*., 2013). Beside its abundant number in the ecosystem, periphyton can also indicate specific reaction to the environment. In addition, periphyton response is needed to determine the condition of biotic and abiotic contained in the waters (Murdock *et al*., 2013). To analyze periphyton response to the environmental quality changes in seagrass ecosystems, Shannon Winner diversity index and saprobic index (SI) are measured. The existence of saprobic organisms as an indicator of water is also determined by the quality of aquatic environment.

Materials and Methods

This study was conducted at Panjang Island waters, Banten Bay with eastern part bordered with Cape Pontang and Ciujung River estuary, to the west bordered with Tanjung Kopo and Grenyang Port, while the northern part directly faces the Java Sea. Data were collected by line transect perpendicular method to the shoreline by dividing the sampling sites into five stations (Figure 1.). The determination of sampling station and transect adapted from SeagrassNet monitoring methods (Short *et al*., 2002), namely: a) location has seagrass communities with homogeneous or similar percentage cover, which is the communities with relatively even coverage; b) far from human interference or damage sources such as ports; and c) accessible location.

Data were collected from three transects with each length of 50m and the distance between transect was 50m, so the total area was 50x100 m^2. Square frames were placed on the right side of transect with the distance between each square was 25m, so the total of squares on each transect was 3. Transect starting point was placed at a distance of 5-10 m from the first time seagrass encountered

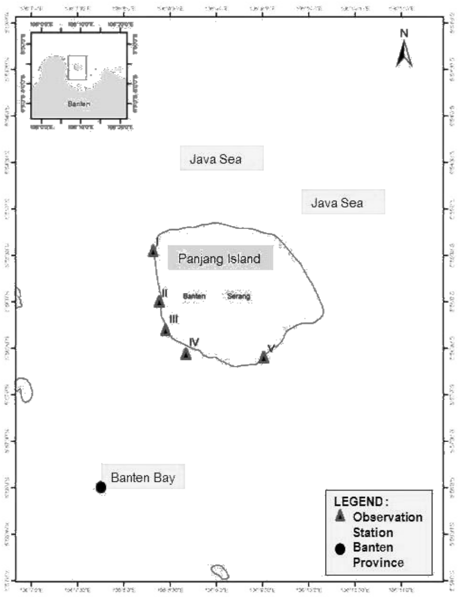

Figure 1. Data were collected at 5 (five) stations at Panjang Island, Banten

(from the coast). Periphyton samples were taken from three large and broad leaves of 5 stands seagrass. Periphyton in the leaves samples were preserved and observed in plankton laboratory, BP2KSI Jatiluhur. The physical water quality such as temperature, transparency, salinity, pH were measure in situ. While total suspended solid, DO, COD, NO_3, NO_2, HN_3, and PO_4 of water were measured in laboratory.

Seagrass data analysis includes species identification, perpendicular measurement value and percentage of seagrass coverage (Rahmawati *et al.*, 2014). The result will show the level of seagrass condition in a particular location within specific time assessed by standard criteria of seagrass damage using percent cover according to State Minister for The Environment of No. 200/2004. The pollution status is determined by the pollution index (IP) according to State Minister for The Environment of No. 115/2003 on Guidelines for Determination of Water Quality Status. See Table 1.

Periphyton data were analyzed using Shannon Winner diversity index and the level of periphyton saprobity using saprobic coefficient (Krebs, 1985). This analysis was used to determine water pollution in seagrass ecosystems of organic material. To determine the effect of water quality on periphyton saprobic coefficient, a statistical analysis approach was used multiple linear regression and correlation (Mahotra, 1996).

Results and Discussion

There were three (3) species of seagrass found in Panjang Island, namely *Syringodium isoetifolium*, *Cymodocea serrulata*, and *Enhalus acoroides*. All the species are native species (www.iucnredlist.org), most species was *C. serrulata* (57%) the rest were, *E. acoroides* (27%), and *S. isoetifolium* (16%) (Table 2). The absence of *S. isoetifolium* at some stations is due to the relatively shallow depth of waters; this species is not found in the low tide areas (Hemminga and Duarte, 2000; Kuriandewa 2009). In contrast to *C. serrulata* and *E. acoroides* which were able to adapt in shallow waters, these species have a vertical stern and grow fast (Koch *et al.*, 2006).

Seagrass coverage showed that the highest was at the station 4 (48.94%) and the lowest was at station 5 (10.28%) (Table 3.). The high percentage of seagrass coverage at the station 4 is because it composed by three species of seagrass. Clean water condition in those area supports the seagrasses to grow and develop properly. While the low percent of seagrass coverage at station 5 due to its quite open, close to population centers, aquaculture, and port activities. Based on State Minister for The Environment of No. 200/2004 about the standard criteria of seagrass damage, seagrass ecosystem in Panjang Island at 1, 2, 3, and 4 stations are at medium levels of damage, while the station 5 is highly damaged.

Overall the physico-chemical condition in seagrass ecosystem of Panjang Island has exceeded the sea water quality standard by State Minister for The Environment of No. 51/2004. See Table 4. Based on the calculation of Pollution Index (IP), showed that the water is ‘moderate to high’ polluted. The highest IP value reaches 14.18 and the lowest reached 9.08 (Figure 2.). IP value showed that the pollution conditions at station 4 is slightly different from other stations (stations 1, 2, 3, and 5), in which station 4 is moderate to high’ polluted. Water conditions at stations 1, 2, 3, and 5 were influenced by the activities in the area. Aquaculture activities can be found in the waters around the station 1, 2, and 5. While port activities, settlements and ship repair are found at station 2, 3, and 5. These activities produce a lot of organic and inorganic waste from its discharge, sewage directly into the water led to several concentration values of water quality parameters in the waters of seagrass ecosystem exceeds its quality standards.

There were 27 species of periphyton found in seagrass leaves of Panjang, belong to four families, namely Chlorophyta, Chrysophyta, Cyanophyta, and Dinophyta, in which dominated by Chrysophyta (<50%). The analyses of periphyton in seagrass ecosystem in the island was carried out during, morning and evening. Base on the highest and lowest tide. Abundance of periphyton in the morning and evening were between 551-1620 and 411-1511 cells.L^{-1} (Figure 3.). The difference abundance in two of the observation time (morning and evening), is due to the difference in flow speed. Swifter water flow may cause the periphyton detached from their attached place. Periphyton diversity index values ranges from 0.60-1.20 in the morning, and 1.64-1.91 in the evening. Overall the

Table 1. Classification of water quality criteria using the IP Method (State Minister for The Environment of No. 115/2003)

IP Value	Condition Description
0≤Pij≤1.0	Meet quality standard (good condition)
1.0<Pij≤5.0	Low contamination
5.0<Pij≤10	Moderate contamination
PIj>10	High contamination

index diversity value in all research station shows strong ecological environment pressure with less periphyton diversity.

This situation shows that there are some dominant periphyton species. Only specific species are able to adapt to the environmental conditions. Several types of dominant periphyton were discovered during the morning and evening observations, including *Meridion* sp, *Navicula* sp, *Nitzschia* sp and *Synedra* sp. These species belong to Bacillariophyceae which is commonly used to assess the condition of eutrophication and organic pollution on waters (Dalton *et al.,* 2015).

Periphyton of Bacillariophyceae has a vast distribution with varying population, have an important role in the food chain, short life cycle, fast reproducing, found in almost all of the substrate so as to record the history of their habitat, many of

Table 2. Distribution of seagrass species in Panjang Island (unit: %)

No.	Seagrass Type	Distribution				
		I	II	III	IV	V
1.	*Syringodium isoetifolium*	-	10	-	6	-
2.	*Cymodocea serrulata*	12	12	12	12	9
3.	*Enhalus acoroides*	6.75	-	6.75	6.75	6.75

Table 3. Seagrass coverage percentage in Panjang Island

Station	*E. acoroides*	*C. serrulata*	*S. isoetifolium*	Total
1	9.58	17.22	0	26.81
2	0	19.79	5.8	25.59
3	5.22	21.72	0	39.38
4	17.71	15.83	15.4	48.94
5	5.36	4.92	0	10.28

Table 4. The range of water quality parameters in Panjang Island

Parameter	Quality Standards*	Morning	Evening
Turbidity (NTU)	< 5	10-21	8-34
Temperature (^oC)	28-30	31-33	28-30
Salinity (‰)	33-34	21.3-21.8	21.3-21.8
pH (unit)	7-8.5	8.2-8.8	5.6-8.3
TSS ($mg.L^{-1}$)	20	56-100.5	63-81
DO ($mg.L^{-1}$)	>5	2.9-5.6	5.1-7.9
COD ($mg.L^{-1}$)	25	141-194	123-176
Nitrate ($mg.L^{-1}$)	0.008	0.557-0.630	0.482-0.697
Phospate ($mg.L^{-1}$)	0.015	0.001-0.025	0.014-0.665

*Quality standards based on State Minister for The Environment of No. 51 of 2004

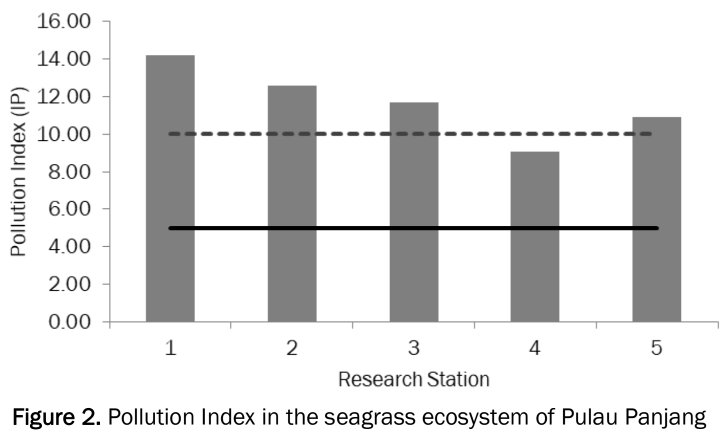

Figure 2. Pollution Index in the seagrass ecosystem of Pulau Panjang
Note. ▬ = Average value; ‒ ‒ ‒ = Lightly polluted; ▬ = Highly polluted

species are sensitive and quick to respond environmental changes, able to reflect changes in water quality in the short term and long term. The high abundance of these species indicates that there has been contamination in aquatic seagrass ecosystems, Panjang Island. Species that have a high tolerance for contaminants such as *Navicula* and *Nitzschia* sp were found abundantly in those environments

Periphyton saprobic coefficient value in all of the research stations on the morning ranges from 0.4-0.8, whereas in the evening ranges from 0.6-1.3 (Figure 4.). The value describes the environmental conditions in seagrass ecosystem categorized as β Mesosaprobik phase to β/α Mesosaprobik, which indicates low to medium pollution such as organic and inorganic materials. The results are based on the nature of periphyton distribution influenced by currents and tidal activity (Sari *et al*., 2014).

The water conditions can certainly change if there is a greater waste input. So it needs good management to not degrade the environmental quality of seagrass ecosystems. Water quality relationship with Periphyton Saprobic Coefficient that effect (especially nutrient), were analyzed using Pearson correlation test. The value of water quality variable will affect saprobic index of periphyton in water. Table 5 presents the value of the test results of Pearson correlation between variables in seagrass, Panjang Island. Data on pearson correlation of TSS, COD, and nitrate, has a negative value indicates that the higher concentration of these variables were the lower the value of periphyton saprobic index. Decrease of periphyton saprobic index indicated the heavily polluted waters condition. Water quality variables such as TSS and COD, can be used to detect pollution in the water (Simanjuntak, 2012). While excess concentration of nitrate and phosphate result in eutrophication stimulate periphyton growth very fast.

Tabel 5. The result of water quality relationship with periphyton saprobic coefficient

Parameter	Morning	Evening
Turbidity (NTU)	0.02	0.008
Temperature (°C)	0.009	-0.030
Salinity (‰)	-0.011	0.015
pH (unit)	0.147	0.128
TSS ($mg.L^{-1}$)	-0.01	-0.002
DO ($mg.L^{-1}$)	0.040	0.017
COD ($mg.L^{-1}$)	-0.003	-0.004
Nitrate ($mg.L^{-1}$)	-0.274	-0.683
Phospate ($mg.L^{-1}$)	0.104	-2.565

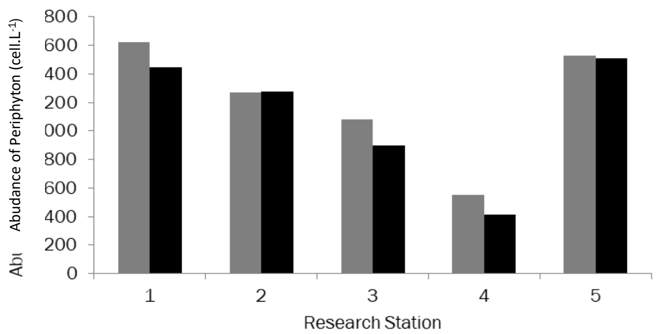

Figure 3. Abundance of periphyton in seagrass ecosystem in Panjang Island in the morning and evening observations
Note. ■ = Morning, ■ = Evening

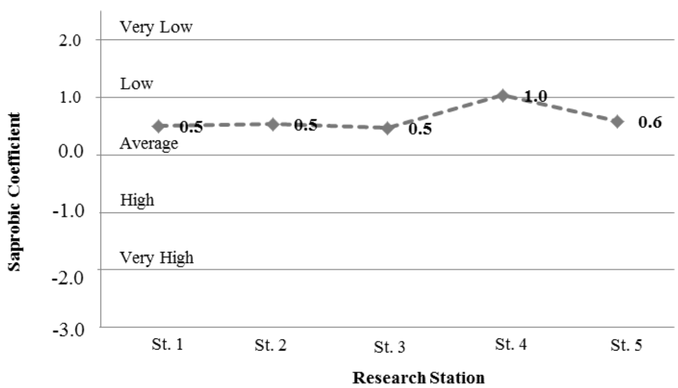

Figure 4. Saprobic index of periphyton in seagrass ecosystem in Panjang Island

Based on the classification and saprobic coefficient using periphyton biological parameters, the condition of aquatic environment of seagrass ecosystem in Panjang Island is classified into β indicates the 'low to medium' pollution with pollutants includes organic and inorganic materials. The study found that dominant periphytons, were *Meridion* sp, *Navicula* sp, *Nitzschia* sp and *Synedra* sp showed the condition of eutrophication and organic pollution in the waters of Panjang Island. Abundance of these species indicates that there has been contamination in aquatic seagrass ecosystems, Panjang Island. Species that has a high tolerance for contaminants such as *Navicula* and *Nitzschia* sp.

Conclusion

Seagrass damage in Panjang island found to be at medium to high levels. Based on the evaluation of water quality, the water condition in Panjang Island seagrass ecosystem is classified as 'polluted to high polluted. Based on saprobic coefficient of periphyton, the seagrass ecosystem of Panjang Island were classified into β mesosaprobic to β/α mesosaprobic level.

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