Omni-Akuatika, 16 (1): 62 - 68, 2020
ISSN: 1858-3873 print / 2476-9347 online
Research Article
journal homepage: http://ojs.omniakuatika.net

A Survey of Macrozoobenthos Assemblages in a Tropical Mangrove Estuary in Brebes, Java Island

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Received 4 November 2019; Accepted 13 February 2020; Available online 31 Mei 2020

ABSTRACT

The mangrove forest in Brebes is one of the mangrove areas that were degraded due to abrasion and excessive logging in the North Coast of Java Island, Indonesia. This research aimed to analyze macrozoobenthos community structure in the mangrove forest that has not been documented. Surveys were carried out in the rainy season. In this study, a total of 10 sampling locations were divided into two different groups that represent “control” (station) and “disturbed” sites. The main structural parameters of the macrozoobenthos identified at each station were specific richness S (number of species), abundance N (number of individuals.m^{-2}), the Shannon-Wiener index N1. A total of 346 specimens were counted from the two different stations (“control” and “disturbed”). These specimens were belonged to five animal classes, namely, Bivalvia, Gastropod, Malacostraca, Polychaeta, Cephalopoda. Pairwise comparison of the site groups with one-way analysis of similarity (ANOSIM) was not significant for between “control” and “disturbed” groups (p=0.062), where the average dissimilarity between the two stations was 88.42%. This result provides macrozoobenthos diversity and ecological information that may contribute to further conservation management in the mangrove forest in Brebes, Indonesia.

Keywords: *Mangroves, Macrozoobenthos, Diversity, Density, community structure, Brebes*

ABSTRAK

Hutan mangrove di Brebes adalah salah satu daerah hutan mangrove yang terdegradasi akibat abrasi dan penebangan berlebihan di Pantai Utara Pulau Jawa, Indonesia. Penelitian ini bertujuan untuk menganalisis struktur komunitas makrozoobentos di hutan Mangrove yang belum terdokumentasi. Survei dilakukan pada musim hujan. Dalam penelitian ini terdapat 10 lokasi pengambilan sampel dan dibagi menjadi dua kelompok berbeda yang mewakili stasiun "kontrol" dan "terganggu". Parameter utama makrozoobentos yang diidentifikasi di setiap stasiun adalah S (jumlah spesies), kelimpahan N (jumlah individu.m^{-2}), indeks Shannon-Wiener N1. Dari hasil penelitian di dapatkan sebanyak 346 spesimen dari dua stasiun yang berbeda ("kontrol" dan "terganggu"). Spesimen ini termasuk dalam lima kelas hewan yaitu, Bivalvia, Gastropoda, Malacostraca, Polychaeta, Cephalopoda. Perbandingan antara 2 kelompok stasiun dengan analisis keseragaman (ANOSIM) tidak berbeda nyata antara kelompok "kontrol" dan "terganggu" (p = 0,062), di mana perbedaan rata-rata antara kedua stasiun adalah 88,42%.

Kata kunci: *Mangrove, Macrozoobenthos, diversitas, keseragaman, struktur komunitas, Brebes*

http://dx.doi.org/10.20884/1.oa.2020.16.1.754

1. Introduction

Mangrove habitats play a significant role as a transition area, which link freshwater marshes to estuarine biomes (George, et al., 2009). Mangrove also have been recognized for their physical and biological attributes to their role as refuge for macrozoobenthos (George et al., 2009; Olomukoro & Azubuike, 2009; George et al., 2010), and habitat for fish fauna (Rehage & Loftus, 2007). The dirty or sandy soil of mangroves may be home to a number of macrobenthos, (Khatiresan and Bingham, 2001). Therefore, conservation management of mangrove habitats is extremely important to protect the biota within, ecological functions and other socio-economic services (Aheto, 2011).

Basic information regarding the community structure of macrozoobenthos in mangrove habitats is highly important to understand the functional role of mangroves, which may influence the form of management and conservation decisions. Such conservation practice is extremely important to overcome ongoing mangrove degradation both at local and global scales (Bosire et al., 2008). Mangrove habitats in the North Coast of Java Island have been degraded for years due to overexploitation and conversion to aquaculture ponds (Akbar et al., 2017). Deforestation of mangrove habitats has been seriously affecting the intensity of coastal erosion and largely affects the local communities that inhabit the coastal area. In several sites, reforestation efforts have been conducted yet little is known about the baseline data regarding macrozoobenthos community structure as one of the key biological parameters in mangrove rehabilitation. However, information on the biodiversity of marine organisms including macrozobenthos from this region is still scarce.

Macrozoobenthos are often used for assessment of the ecological quality status (EcoQ) due to their position at the sediment-water interface, which allow them to act as powerful indicators of marine ecosystem health (Blanchet et al., 2008; Lavesque et al., 2009). Additionally, macrozoobenthos have relatively long and sedentary life (Dauer et al., 2000). These organisms are unable to escape disadvantageous conditions, thus they are likely useful in the evaluation of accidental and chronic variations which allows relatively low-frequency surveys (Kroncke and Reiss, 2005). The last but not least, macrozoobenthos have different levels of tolerance to stresses, numerous feeding guilds and a diversity of life-history characteristicss (Glémarec and Grall, 2000).

In the present study, we aim to provide the baseline information regarding the community structure of macrozoobenthos in the mangrove habitat in Pandansari region in the North Coast of Java Island. We also use the community structure of macrozoobenthos to assess the status of Pandansari mangrove habitats in relation to external stressors.

2. Materials and Methods

2.1. Study Site

The mangrove forest in Brebes is one of the mangrove areas that were degraded due to abrasion and excessive logging in the North Coast of Java Island. Based on data from the Ministry of Fisheries and Maritime Affairs, Brebes Regency in Suyono 2015, From 2000 to 2008 the beach abrasion in Brebes reached 640.45 hectares with a coastline length of 27,043 km, which means that during 8 years of coastal erosion around 237 m or equal to 29 6 m / year.

Brebes Subdistrict is the region with the highest abrasion rate, especially in Kaliwlingi Village reaching 385.98 ha. The rehabilitation of mangrove forests in the coastal area of Brebes Regency was carried out since 2004 and coordinated by the Department of Agriculture, Forestry and Soil Conservation of the Regency of Brebes (Suyono 2015).

2.2. Sampling and Laboratory Procedures

Surveys were carried out in rainy season. In this study, a total of 10 sampling locations were divided into two different groups that represent “control” (station) and “disturbed” sites (Table 1, Figure 1). Macrozoobenthos sampling at each station was carried out at low tide about 10 m from the lowest watermark. Samples were taken using a hand corer on a quadrant transect (20 cm x 20 cm) which was randomly thrown. Furthermore, samples were sieved in the field using a set of siever of mesh size 4, 2 and 0.5 mm. The retained organisms were then preserved in 10% formalin for detailed examination in the laboratory. Prior to identification, the samples were stained with Rose Bengal in order to enhance their visibility. The macrozoobenthos were identified morphologically to the species level by using the standard macrozoobenthos identification books from Fauchald (1977) and Dharma (2005). Additionally, the nomenclature writing of identified organisms was arranged following the database from the international World Register of Marine Species (WoRMS: http://www.marinespecies.org/index.php)

2.3. Enviromental Parameters

Table 1. Characteristics of sampling stations

Station	Latitude	Longitude	Category
1	6°47'6.46"S	109° 2'16.34"E	Disturbed
2	6°47'7.37"S	109° 2'16.51"E	Disturbed
3	6°47'9.20"S	109° 2'17.29"E	Disturbed
4	6°47'10.77"S	109° 2'18.04"E	Disturbed
5	6°47'10.74"S	109° 2'19.28"E	Disturbed
6	6°47'9.59"S	109° 2'20.31"E	Control
7	6°47'10.80"S	109° 2'21.78"E	Control
8	6°47'11.26"S	109° 2'23.99"E	Control
9	6°47'11.81"S	109° 2'25.07"E	Control
10	6°47'11.43"S	109° 2'26.65"E	Control

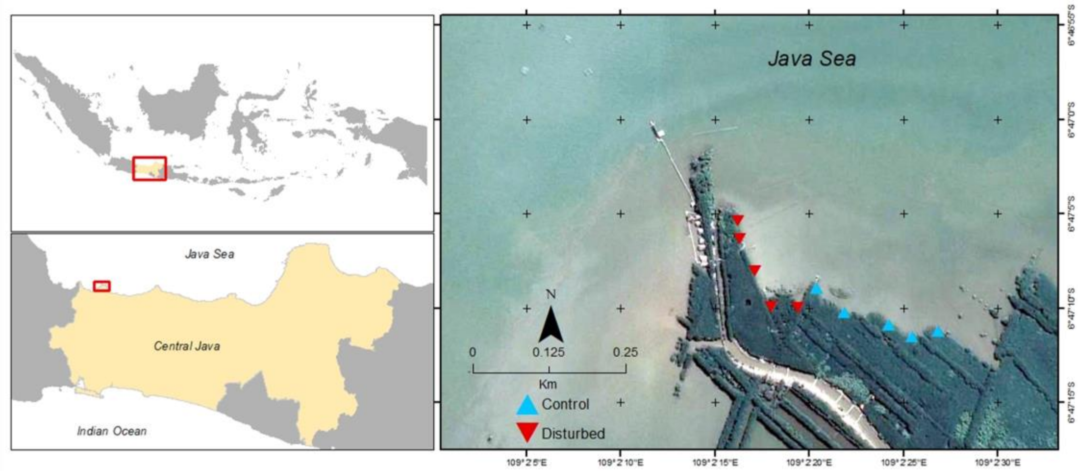

Figure 1. Map of study area with location of sampling sites in Pandansari mangrove forest

In this study, measurement on environmental parameters was carried out in 10 stations as previously described in the section "Sampling and laboratory procedures" and Table 1. Salinity was measured in situ by a refractometer (type ATAGO Master-S/Mill 2491), pH by a pH-meter (type Lutron PH-208), Water Temperature and Dissolve Oxygen by a DO Meter (type Lutron DO-5519). Sediment samples were analyzed in the laboratory. Sediment grain size was analyzed by using sieve-shaker (type AG-515, 8"Sieve) and grain size composition was determined following the protocol (Hoare and Gale, 1991). Furthermore, Total organic carbon (TOC) from sediment samples was analyzed according to (Schumacher, 2002).

2.4. Data Analysis

The macrozoobenthos community structure identified at each station is the specific wealth S (number of species), N abundance (number of individuals.m^{-2}), Shannon-Wiener index N1 (Shannon and Weaver, 1963), Simpson's reciprocal N2 dominance index (Simpson, 1949) and the opposite of the proportional abundance of the most common Ninf species. This parameter is calculated using the PRIMER v6 package.

Assumptions of analysis of variance (ANOVA) were examined using box and normal probability plots. Homogeneity of variances was analyzed using Levene´s test. The parametric analyses of variance (ANOVA) was used to test for significant differences in the densities and diversities of the different sites using GraphPad PRISM 5 for MacOS software.

The non-parametric procedures multidimensional scaling (MDS) two-dimensional plot and one-way analysis of similarity (ANOSIM) were used to compare sample similarity based on species composition. For each sample, data were standardized to relative abundance data and square root transformed prior to analysis. The MDS diagram was produced based on Bray-Curtis similarities between samples, calculated using the PRIMER 5 software.

3. Results and Discussion

In this study, a total of 346 specimens were obtained from two different stations (control and disturbed). These specimens belong to five classes of animals, namely, Bivalvia, Gastropoda, Malacostraca, Polychaeta, Cephalopoda. Among these classes, a total of 58 species were identified. In terms of classes representation, Gastropoda constituted the highest relative density (65.61%) and then followed by Malacostraca, Bivalvia, Polychaeta and Cephalopoda with 16.47, 15.90, 1.45 and 0.58%, respectively (Figure2).

The average of macrozoobenthos density in the study area ranged between 80 and 266 ind m^{-2}. In general, a decreasing pattern of macrozoobenthos (Gastropoda, Bivalvia, Malacostraca, and Cephalopoda) density between sampling stations was observed. The highest density was observed in the "control" site where 170 ind m^{-2} of Gastropoda was counted (Figure 3). This number was significantly higher compared to the density of similar class in the "disturbed" site (57 ind m^{-2}, $p < 0.05$). The density of Bivalvia lowered by 92% in the "disturbed" station compared to the "control". Similar cases were also found in Malacostraca and Cephalopoda where their density dropped by 43 and 100%, respectively (Figure 3).

The type of gastropod moving has the ability to move in order to avoid low salinity, but the sessile bivalve will die if the effects of fresh water last for a long time. (Symanowski and Hildebrandt, 2010).

The non-parametric procedures multidimensional scaling (MDS) two-dimensional plots were used to compare sample similarity based on species composition. The Bray Curtis similarity with square-root transformation from two different sites ("control" and "disturbed") was calculated and showed on the Figure 4. The MDS graph at species level showed that all of the two sites were not so clustered separately from each other (Figure 4). Pairwise comparison of the site groups with one-way analysis of similarity (ANOSIM) was not significant for between "control" and "disturbed" groups (p=0.062), where the average dissimilarity between the two stations was 88.42%. Additionally, the similarity of percentage-species contribution (SIMPER) analysis showed that *Cassidula nucleus* (9.91%), *Scylla serrata* (9.84%), *Cerithidea obtusa* (7.79%), *Pinna murricata* (7.41%), *Littorina* sp. (7.27%), and *Polymesoda*

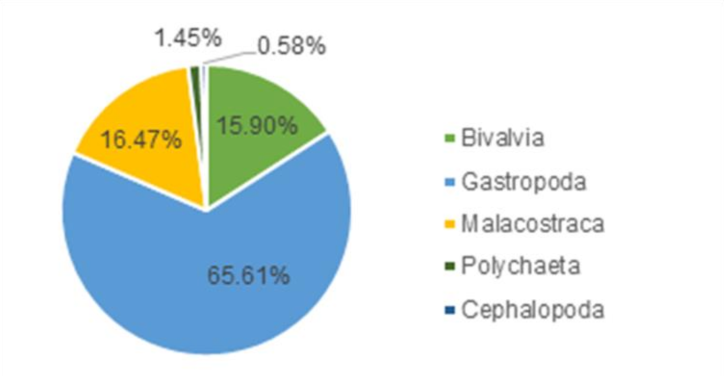

Figure 2. Relative density of macrozoobenthos in all sampling stations

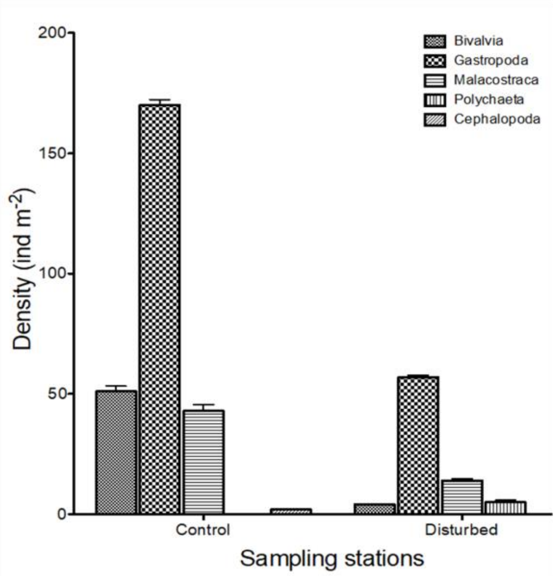

Figure 3. Density of macrozoobenthos classes at different sampling stations

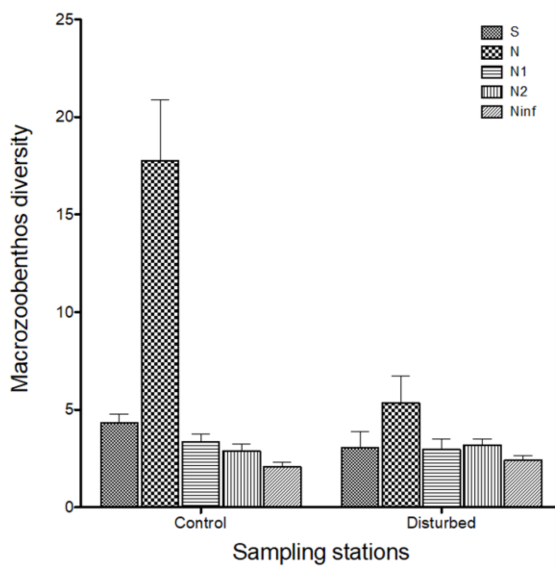

Figure 4. Macrozoobenthos diversity at two different sampling stations. Diversity calculation using Hill's indices of macrozoobenthos.

caroliniana (6.29%) explained the dissimilarity of species composition between "control" and "disturbed" stations. Similarity in species composition in "control" station was mainly due to *Scylla serrata*, *Littorina* sp. *Gelonia* sp. with the contribution of each as much as 26.16 and 12.42%, respectively. As for the similarity of species composition in the "disturbed" station, was mainly explained by *Cassidula nucleus* (27.68%) and *Polymesoda caroliniana* (26.52%).

Environmental parameters are very influential on the habitat and structure of existing biota communities in an ecosystem. In this case, the physical, chemical and biological nature of the waters is very influential on the distribution of macrozoobenthos. Physical parameters that directly affect the macrozoobenthos are depth, current speed, turbidity, and type of substrate as well as water temperature. Whereas, the chemical properties that directly influence on macrozoobenthos are the degree of acidity, salinity and dissolved oxygen content.

Salinity can affect the distribution of macrozoobenthos both horizontally and vertically. In our study, salinity in "control" sites ranged from 22 to 25‰. On the other hand, the "disturbed" sites had wider range of salinity, which is from 20 to 34‰. The he ideal range of salinity for macrobenthos fauna is range from 15 to 35‰ (Wardiah et al., 2012). Thus, the range of salinity observed in this study was still in the normal range.

pH is a limiting factor for aquatic organisms. In this study, pH in the "disturbed" sites ranged from 6.35 to 7.55. This range is relatively lower than that of "control" sites (7.25 to 8). Indeed, both alkaline (where the pH is too high) and acid (low pH) waters may affect the survival of inhabiting organisms (Mushthofa, 2014). Most aquatic organisms are sensitive to changes in pH and prefer a pH range of around 7 - 8.5. This could be one of the explanations why the abundance of macrozoobenthos in "disturbed" sites was significantly lower than the abundance in the "control" sites. Indeed, distribution and diversity of macrozoobenthos in aquatic environment are affected by pH. A very acidic or basic water conditions will endanger the survival of the organism due to disruption of metabolism and respiration (Yeanny, 2007).

Each organism has a different temperature tolerance limit for its survival and growth. In this study, temperature in "control" site ranged from 29.8 to 33.7 °C while the temperature in "disturbed" sites ranged from 29.5 to 33.4 °C. This range of temperature is still comparable to the previous studies. A good temperature range for the life of aquatic organisms is between 18-30 °C.

Substrate is one of the most important parameters for organisms that live in the waters. Substrate can be classified into mud substrate, sandy substrate, and sand substrate. In general, muddy base substrates are more favored by benthos than bases in the form of sand (Khatiresan and Bingham, 2001).

The biological parameters that affect the macrozoobenthos community are competition, predators and the level of primary productivity (Tarwotjo et. al, 2018). Each of these biological factors can either stand-alone or interact with each other, which can affect the community of macrozoobenthos.

High organic matter content can also be affecting the abundance of certain types of organisms that are facultative, where the

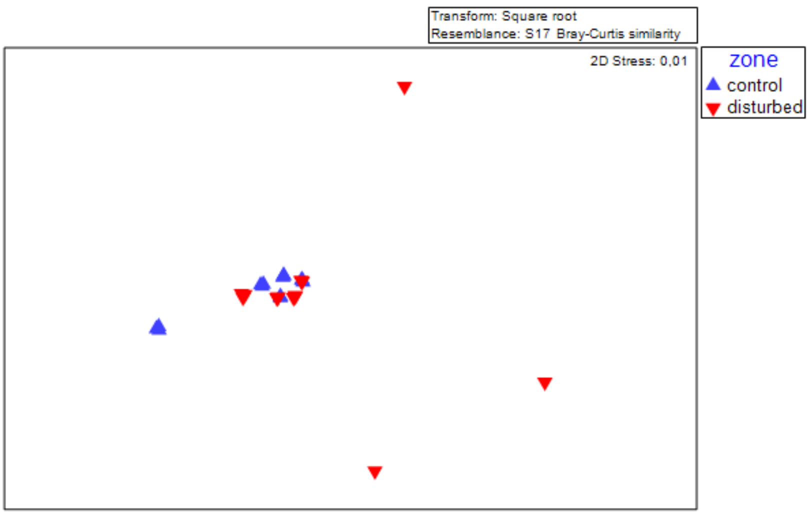

Figure 5. Community structure of macrozoobenthos at two different sampling sites in mangrove habitats. The nMDS two-dimensional ordination plot was constructed based on the Square root transformation of Bray-Curtis similarity with stress value indicated.

organism is resistant to the high content of organic matter so that the amount will be abundant, even allows the domination of certain species to occur. It also relies on the environmental conditions, and inputs from the mainland through the channel, which comprises of various industrial waste including organic compounds (Patty et. al, 2015).

4. Conclusion

The present study demonstrated that the community structure of macrozoobenthos between control and disturbed sites is varying, where a total of 346 specimens were counted from these two different sites. The species richness (S) in the control site is significantly higher than the disturbed sites, while other indicators such abundance (N) and Shannon-Wiener Index (N1) were not significantly different. Gastropoda, Bivalvia, Malacostraca and Cephalopoda can be used as important discriminators between control and disturbed sites. This study improves our understanding of macrozoobenthos diversity and ecological information that may be used for further conservation management in the mangrove forest in Brebes, Indonesia.

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