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MACROZOOBENTHIC COMMUNITY STRUCTURES IN SEAWEED CULTURE PONDS IN MUARA GEMBONG ESTUARY, BEKASI, WEST JAVA PROVINCE, INDONESIA

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ABSTRACT

The study of macrozoobenthic in seaweed culture in Muara Gembong Estuary, Bekasi District, West Java Province, was conducted in May to July 2018. The study was aimed at understanding the roles of macrozoobenthic organisms as ecosystem engineering in seaweed habitat by identifying macrozoobenthic community structures using various biological indices. Sampling sites were conducted at three selected intertidal ponds used for seaweed culture at different distances and perpendicular to the coastline. Samples of macrozoobenthic organisms were collected using an Ekman grab during low tide periods. The study results showed that the macrozoobenthic community from the three ponds were consisted of 9 major benthic families and 14 genera with a total of 139 individuals. The results also showed that gastropod of the genus *Cerithiidae* was the dominant taxa found in every pond which contributed to 42.45% of the total macrozoobenthic found in the three ponds and became the main contributing taxa to the macrozoobenthic community structure. In addition, genus *Platynereis* of the Polychaeta Class was found to be another important taxon which contributed to 14.39% of the total macrozoobenthic found in the three ponds. The genus *Platynereis* were mostly found in the second pond with muddy coarse sandy sediment substrate containing more silt compared to the other two ponds. The rare taxon was the genus *Lithophaga* from family Mytilidae represented by 1 individual. Our study concluded that the macrozoobenthic community structure in the three ponds was categorized as poorly diverse indicating that the pond system was unstable. The Shannon-Wiener Diversity Index (H') was only 0.87 on average with the highest diversity index (H'=1.47) was found in the third pond located at the farthest area of the coastline. Meanwhile, the average of Evenness Index was 0.34 indicating that the distribution of the taxa was uneven with a tendency of being dominated by certain taxa.

Keywords: biological indices, community structure, macrozoobenthic, seaweed aquaculture

INTRODUCTION

Indonesia is the among the largest global producers of seaweed and supplies around two-third of the global demand (Deswati & Luhur 2014). *Gracilaria* sp. and *Eucheuma cottonii* are the two popular species of seaweed out of the 50 cultured seaweeds species in Indonesia (Deswati & Luhur 2014). West Java provincial authorities claimed that seaweed is one of the primadonna of the aquaculture export commodities with Bekasi District contributing 10,000 tonnes of dried seaweed, in which 7,000 tonnes was produced from the Muara Gembong seaweed culture area (Mujiyanto *et al.* 2014). Seaweed is often cultivated in polyculture system with milkfish (*Chanos chanos*) and/or tiger shrimp (*Penaeus monodon*). These practices cause multiplying effects to the environment, economy growth and food security, if this practice is done properly. A case study in the Gulf of Castelamarre, Italy reported valuable polyculture practices as a reliable economic tool through increasing fish production and sustainable environmental management (Zenone & Sara 2007). As an ecological engineering practice, seaweed polyculture can reduce the impact of wastes from fish cultivation through recycling of particulate and dissolved matters and enhancing the total productivity for both commodities (Troell *et al.* 2013).

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The growth of *Gracilaria* sp. mostly depends on the availability of nutrients as this species need nutrient uptake of around 0.0082 -0.0149 ppm/day which in turn can eliminate the excessive fish food (Komarawidjaja & Kurniawan 2008). Thus, water quality parameters such as the level of nutrient content, suspended organic matter as well as weeds- and diseases-free environment are important requirements for culturing *Gracilaria* sp. to attain maximum growth (Reksono *et al.* 2012; Mujiyanto *et al.* 2014). In aquatic ecosystem, nutrients availability was maintained by macrozoobenthic organisms. The macrozoobenthic community has a complex structure consisting of a wide range of invertebrate animals inhabiting the bottom of aquatic ecosystem. Macrozoobenthic have critical roles in maintaining energy flow and mineralization cycles ensuring that the aquatic ecosystem is functioning at an optimum level (Indarjani 2003). Macrozoobenthic are mostly found as sessile animals, crawling, burrowing and digging the sediment, permanently or temporarily. Macrozoobenthic's live is associated with substrates. Macrozoobenthic is favorable as bioindicator organisms due to its capacity to record the environmental changes. The distribution of macrozoobenthic is determined by physical, chemical and biological parameters which will influence the abundance and composition of the macrozoobenthic as well as the producers, herbivores and predators (Snelgrove 1998; Indarjani 2003).

Seaweed and macrozoobenthic perform a mutualistic relationship referring to nutrient-cycling and food web, even though the magnitude and mechanism of this relationship is still limited. Thomsen *et al.* (2013) reported that the increase biomass of seaweed *Gracilaria vermiculophylla* is associated with the abundance of benthic invertebrates because the root system of the seaweed facilitated a creation of a 3D mosaic structures and interstitial spaces that provide spaces for different sizes of invertebrates to live and grow. In addition, Cummin *et al.* (2004) suggested that seaweed *Enteromorpha intestinalis* influences the structure of macrobenthos communities compared with unvegetated plot in an Australian Estuary. The thickness of algal and oxygen concentration at the bottom layer explained the best structure of macrozoobenthic community and enhanced the species richness (Lauringson & Kotta 2006).

Muara Gembong is located at the north of Bekasi District adjacent to Jakarta Bay. In 2008, the *Gracilaria* sp. polyculture system was introduced and became one of the potential local commodities for the livelihood of the local community and strengthening the food security in that area. The Muara Gembong Estuary is around 13,205,702 ha and has been developed intensively causing impact that may influence the macrozoobenthic communities (Pirzan & Pong-Masak 2008). Looking at the potential of increasing the productivity of seaweed culture, this study aimed to gain understanding on: 1) the roles of macrozoobenthic organisms as ecosystem engineering in the habitat of *Gracilaria* sp. by identifying macrozoobenthic community structure using several biological indices and 2) the effect of physicochemical variables on the types of macrozoobenthic community.

MATERIALS AND METHODS

Study Site and Time

The study was conducted from May to July 2018, in an urban estuarine called Muara Gembong, that located under the administration of Muara Gembong Subdistrict which lies at latitude 6°10'53"-6°30'6" S and 106°48'28"-107°27'29" E.

Sampling Site Determination

The location of sampling site was Pantai Sederhana Village, one of the six villages under the administration of Muara Gembong Subdistrict (Fig. 1). In this location, seaweed culture was carried out in intertidal ponds with varying substrates of the pond bottom. The ponds have separate inlet and discharge sluice gates and water canals surrounded by various densities of mangrove trees, i.e., *Avicennia* sp., *Sonneratia* sp., *Rhizophora* spp. and *Bruguiera* sp.

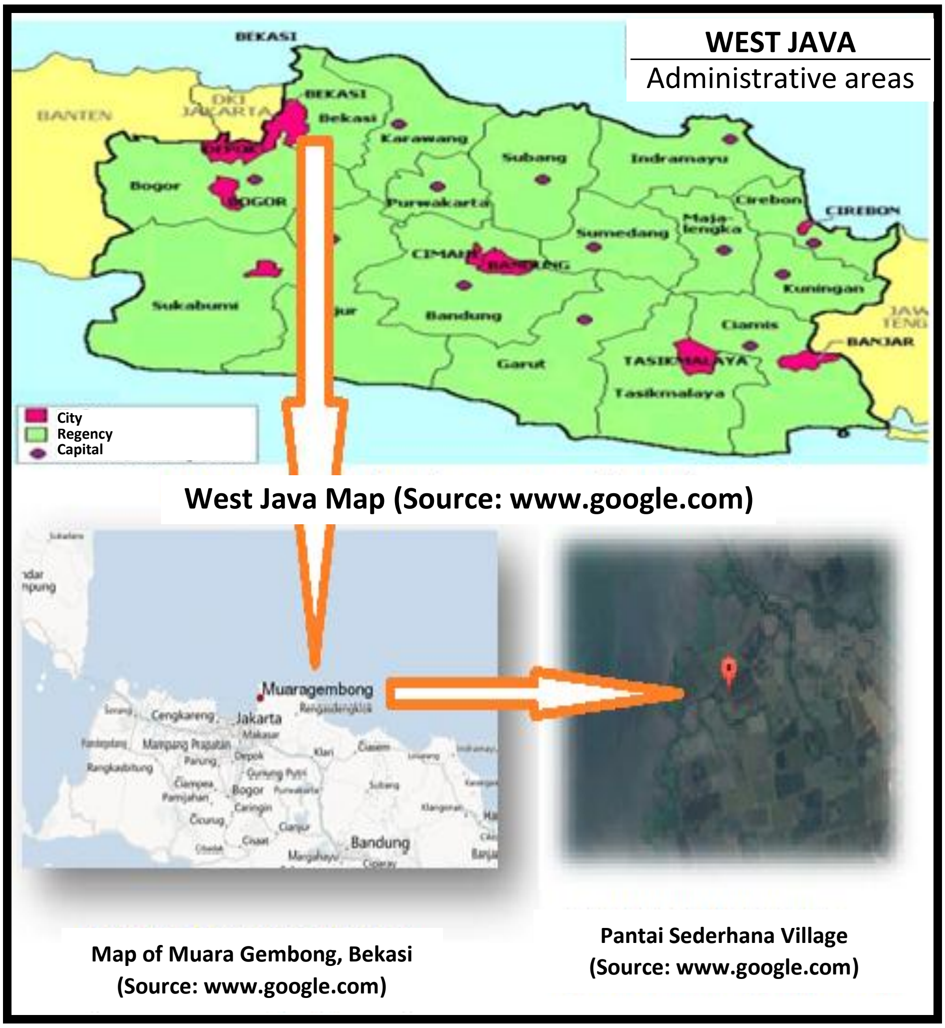

Figure 1 Sampling sites located in Pantai Sederhana Village, Muara Gembong Estuary, Bekasi District, West Java Province, Indonesia

The first pond was located at 100 m from the coastline and has an area of approximately 1.3 ha surrounded by low density of mangrove tress. At this location, the *Gracilaria* seaweed seemed to be well maintained. Visually, the substrate type of the pond bottom was fine sandy sediment. The second pond was at 250 m from the coastline with an area of 3.7 ha. The *Gracilaria* sp. seaweed seemed to be poorly grown. The substrate type of the pond bottom was muddy coarse sandy sediment. Mangrove trees with low density were planted around the second pond. The third pond of around 4.0 ha was located at 500 m from the coastline and was close to the fishermen's residential area. The *Gracilaria* sp. seaweed in the third pond seemed to be better maintained when compared with the seaweed in the second pond. Due to the closeness of the third pond's location with the fishermen's residential area, household wastes may overflow to the third pond during high tide. The third pond may also receive less seawater compared to the other two previous ponds because of its distance from the coastline. The substrate of the third pond bottom was fine sandy sediment. A high density of mangrove tress was found around the third pond.

Sample Collections

Samples of macrozoobenthic organisms were collected from each seaweed culture pond during low tide. Five replicates of macrozoobenthic samples were taken at each pond (a total of 15 samples) by using the Ekman grab sampler having a diameter of 152 x 152 x 152 mm, which was suitable for fine sediment (Putro 2011). The samples were then stored in airtight plastic bags and preserved in 10% buffered formalin before being transported to the laboratory. In the laboratory, the samples were washed through a 0.5 mm mesh sieve. The subsequent identification of macrozoobenthic organisms was carried out up to the genus level, referring to Indarjani (2003) and Bremmer (2005). After the identification process, the macrozoobenthic samples were preserved in 70% alcohol.

Water quality parameters such as pH, dissolved oxygen, water temperature, water clarity and salinity were recorded *in situ*. pH was measured using pH meter, salinity using refractometer, water clarity using Secchi Disk, dissolved oxygen using DO meter. The water sample collection were also done in five replications.

Data Analysis

Data analysis was conducted using descriptive statistics to describe and summarize the data. The data analysis may show certain patterns of macrozoobenthic distribution.

To examine ecological function of macrozoobenthic community, several biological indices were calculated, as suggested by Pakpahan *et al.* (2013) such as: 1) Shannon-Wiener Diversity Index (H') to calculate the taxa diversity (Odum 1971); 2) Evenness Index (E) to examine the distribution of taxa (Elliott 1971); 3) Simpson Dominance Index (D) to observe the dominance of taxa related to the macrozoobenthic community (Odum 1971); and 4) Abundance Relative Index (R) to examine the population degree of certain taxa that support to the total abundance of macrozoobenthic community. The total abundance (N) was then standardized by dividing the total of biota of each pond to densities per m^2 resulted in a value in number of abundances of each taxon per m^2 (Cox 1995).

RESULTS AND DISCUSSION

Water Quallity Parameters

One of the most important factors in marine culture fisheries is the quality of seawater which act as growth medium for benthic organisms, both flora and fauna. Results of water quality paramaters measurement are presented in Table 1.

The results showed that water quality among the culture ponds was quite varied. Data of temperature, salinity and pH were considered to be suitable for culturing *Graciliaria* sp., even though water clarity and dissolved oxygen was found not suitable (Mujiyanto *et al.* 2014). Data of water clarity in all ponds were lower than the suitable range. The low water transparency may have been caused by the period of low tide when the measurement was carried out. During the measurement, the Secchi Disk may have been covered by seaweed plants, while the pond water may have been murky due to high suspended organic matter from the fish food wastes, fertilizers, floating debris from the surrounding mangrove trees and household wastes. The lower dissolved oxygen value could be explained as a result the shallowness of the pond, high decomposition process, disturbed water, residue of organisms' respiration during the night, and relatively high temperature during the day when water sampling was conducted. Data of abiotic water quality parameters showed that temperature was around 31.6-31.8 °C, which nearly reached the highest temperature for suitable range of seaweed culture. The depth of each culture pond was around one meter due to dry season when the sample collection was conducted. In addition, Mujiyanto *et al.* (2014) stated that the Muara Gembong Estuary was classified as having shallow waters. However, in regard to the existence of macrozoobenthic communities, the water quality parameters were within the acceptable range (Marpaung *et al.* 2014; Syamsurisal 2011).

Macrozoobenthic Compositions

Our study found 4 phyla, 5 classes, 6 ordos, 9 families and 14 genera of macrozoobenthic with a total number of 139 individuals in Muara Gembong seaweed culture ponds (Table 2). Previous research conducted by Wijaya and Indriatmoko (2019) reported that 44 genera of benthic organisms was identified from the Muara Gembong Waters and dominated by the Class Polychaeta that made up 52.50% of macrozoobenthic community. The high yield of macrozoobenthic organisms obtained presumably due to large area of sampling sites, while in this study the macrozoobenthic organisms were collected from three selected seaweed culture ponds. In addition, the abundance of macrozoobenthic organisms and taxa richness were relatively different among the three ponds which could influence the macrozoobenthic community structures in this area.

Table 1 Average values of water quality parameters at each seaweed culture pond

No	Abiotic water quality parameters	First pond	Second pond	Third pond	Suitability range of water quality parameters for seaweed culture
1	Temperature (^oC)	31.8	31.6	31.6	29-32
2	Secchi Disk transparency (cm)	16.3	17.7	16.7	75-153
3	Salinity (‰)	20.8	20.6	19.4	16-25
4	pH	7.6	7.5	7.8	7.5-8.5
5	DO (mg/L)	3.20	3.20	3.25	6.5-8.5

Table 2 Composition of macrozoobenthic assemblages collected during the study

No	Genus	First pond (individuals)	Second pond (individuals)	Third pond (individuals)	Total (individuals)
1	*Telescopium*	2	0	0	2
2	*Cerithiidae*	43	2	14	59
3	*Cerithideopsilla*	0	1	1	2
4	*Cerithium*	0	1	5	6
5	*Tarebia*	0	0	9	9
6	*Sermyla*	0	1	5	6
7	*Terebralia*	1	1	4	6
8	*Melanoides*	0	0	4	4
9	*Hydrobia*	0	0	5	5
10	*Lithophaga*	0	1	0	1
11	*Platynereis*	5	9	6	20
12	*Notomastus*	0	0	2	2
13	*Sipuncula*	0	0	1	1
14	*Litopenaeus*	1	3	12	16
Total (individuals)		52	19	68	139

Results of our study indicated that the existing macrozoobenthic communities in seaweed culture ponds were mostly dominated by marine gastropods *Cerithiidae* (59 individuals or 42.45%) which was extremely abundant in the first pond. The second dominant taxon was *Platynereis* of the Class Polychaeta (20 individuals or 14% of the total macrozoobenthic found in this study) which was abundant in the second pond. In addition, marine bivalve of *Lithophaga* and unsegmented marine worm *Sipuncula* could be reckoned as rare taxa. Only one *Lithophaga* was found in the second pond and only one *Sipuncula* was found in the third pond. The second pond inhabited by 19 individuals of 8 taxa or 14% of the total macrozoobenthic organisms seemed to be an unfavorable habitat for macrozoobenthic compared with the other two ponds. Conversely, the *Platynereis* was found quite many in the second pond where the seaweed culture was poorly maintained. In contrast, the third pond inhabited by 68 individuals of 12 taxa or 49% of the total macrozoobenthic found in this study was considered as a favorable habitat for macrozoobenthic where the seaweed culture was well maintained and surrounded by dense mangrove trees. Meanwhile, the first pond which was situated adjacent to the coastline had the lowest taxa richness (52 individuals of 5 taxa) with gastropods *Cerithiidae* as the most abundant macrozoobenthic organisms (82%) in the first pond. Different compositions of macrozoobenthic communities may have been caused by the types of substrates and the microenvironment factors where the macrozoobenthic organisms live. Based on visual (qualitative) observations, the first pond has the fine sandy sediment substrate which is relatively similar to the type of substrate in the third pond. The second pond has the muddy coarse sandy sediment substrate. Wiyaningtiyah *et al.* (2014) stated that fine sandy sediment has a better capability in accumulating organic materials compared with coarse sandy sediment. The different types of substrates influence abundance and types of macrozoobenthic community structures (Hadiyanto 2018).

Community Structure of Macrozoobenthic Assemblages

The macrozoobenthic community structure was assessed using various biological indices, i.e., the Shannon-Wiener Diversity Index, the Evenness Index and the Dominancy Index. The calculated indices indicated that the macrozoobenthic community structure was categorized as poorly diverse which suggested that the community system was unstable (Fig. 2).

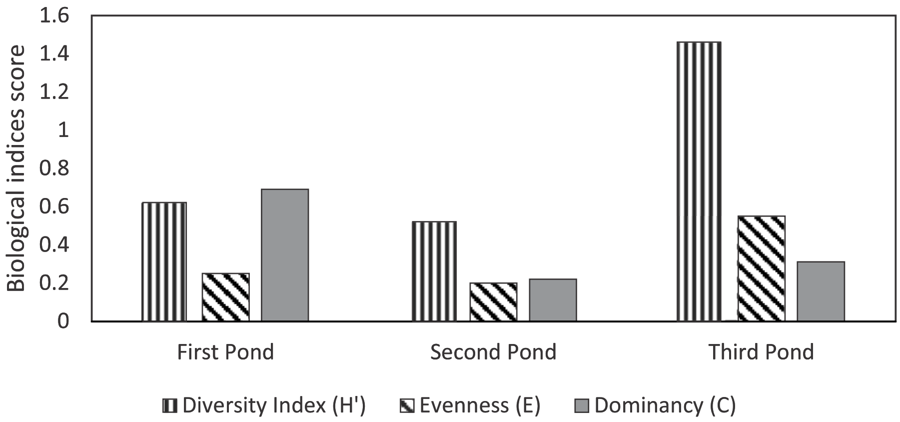

Figure 2 Macrozoobenthic community structure showing irregular trends

The average of Shannon-Wiener Diversity Index (H') was 0.87 with the highest index of 1.47 was found in the third pond which was the farthest pond from the coastline. Snelgrove (1998) predicted that species diversity is mainly controlled by the fluctuations of environmental factors and tends to be low in physically controlled environment, such as in seaweed culture pond. Meanwhile, the Evenness Index value ranged from 0.25 to 0.55 with an average of 0.34. The low value of Evenness Index indicated the uneven distribution of the taxa in which the community tends to be dominated by certain taxa. In our study, the *Cerithiidae* dominated the macrozoobenthic community structure in the first pond, located adjacently to the coastline. The existence of *Cerithiidae* contributed significantly to the macrozoobenthic community structure in the Muara Gembong seaweed culture ponds. This finding is in agreement with the work of Ludwig and Reynolds (1988) which indicated that the Evenness Index should be maximum when all species in the samples were equally abundant. The Evenness Index can drop to zero when the relative density of species diverges away from the evenness.

Referring to the values of the calculated biological indices, the third pond was considered as the favorable habitat for macrozoobenthic organisms, having the highest score of the Shannon-Wiener Diversity Index (H' = 1.46) and the Evenness Index (E = 0.55). The low Dominancy Index (C = 0.31) indicated that macrozoobenthic organisms had relatively similar opportunity to grow and the population was distributed accordingly. The third pond occupied by seaweeds and surrounded by dense mangrove trees with fine sandy sediment substrate may have been contributed to the richness of macrozoobenthic taxa. Seaweed root system might facilitate a creation of a 3D mosaic structure and interstitial spaces of substrate so that different sizes of invertebrates organisms could live and grow (Thomsen *et al.* 2013). The curve linearity of the macrozoobenthic species living in a densely algal environment has higher increasing slope compared with macrozoobenthic assemblages in a poorly vegetated area (Lauringson & Jonne 2006). In addition, mangrove debris around the pond might become potential food resources for the macrozoobenthic functioning as wastes decomposer (Palanisamy & Khan 2013).

Dominant Taxa Examinations

The first pond in this study was dominated by gastropods *Cerithiidae* and had density of 8 individuals per meter square with relative abundance of 82%. The gastropods *Cerithiidae* is considered as the characterized macrozoobenthic assemblages of seaweed culture in Muara Gembong. Previous research reported by Ardli *et al.* (2015) and Kamaluddin (2017) showed that the distribution and density of *Cerithiidae* were influenced by types of substrates and other various supporting factors such as dietary factors, water conditions, predators and competition. Those factors also influenced the abundance of *Cerithiidae* in our study which were varied among the three ponds. Thus, in this case, the *Cerithiidae* can be reckoned as a cosmopolitan taxon and has a good adapting capability to live and grow in the fine and muddy sandy sediment substrates. The fine sandy sediment may be favorable for the digging and burrowing macrozoobenthic organisms, like gastropods *Cerethiidae* (Schirjvers *et al.* 1998). Besides, the fine sandy sediment substrate is effective in trapping organic materials that stimulate the optimum growth of macrozoobenthic organisms.

Another important taxon in our study that contributed to the macrozoobenthic community structure was *Platynereis* of the Polychaeta Class. This organism was found in every pond with the highest relative abundance of 47.37% and became the main contributing taxa to the macrozoobenthic community structure in the second pond. The type of substrate in the second pond may have been more suitable for *Platynereis* than for other taxa. Taqwa *et al.* (2014) confirmed that Class Polychaeta can easily be found in muddy as well as fine sandy substrates, which is relatively similar with the second pond's substrate type. According to Cambi *et al.* (2000) *Platynereis dumerii* as mezograzer species prefers the brown seaweed *Sphacelaria*. Our study showed that the density of *Platynereis* in every pond were not much different indicating that the environment of the three ponds was suitable for *Platynereis* to grow.

CONCLUSION

The study of macrozoobenthic community inhabiting seaweed culture ponds in Muara Gembong Estuary showed that the macrozoobenthic community structure was characterized with low diversity, low evenness and high dominance indices, which indicated that the environmental condition was unstable and the macrozoobenthic community structure was dominated by certain taxa. Marine gastropod *Cerithiidae* seemed to be the main contributing taxa to the macrozoobenthic community structure as this organism was found in every pond. The second abundant macrozoobenthic organisms was *Platynereis.* This study also showed that the third pond located at the farthest distance from the coastline seemed to be the favorable habitat for macrozoobenthic organisms. Seaweed in this pond was grown luxuriant and surrounded by dense mangrove trees, with a higher diversity index, high taxa richness, and high evenness index, indicating that organisms in this pond have similar opportunities to grow. The first pond located adjacent to the coastline was considered favorable for gastropode genus *Cerithiidae,* even though this pond had the lowest taxa richness, lower evenness index and high dominance index values. The second pond can be seen as the "transition" pond between the first and the third ponds considering its biological indices values were in between.

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