THE ROLE OF MACROBENTHIC COMMUNITIES AS AN INDICATOR FOR THE FERTILITY OF MANGROVE POND: CASE STUDY AT BLANAKAN, SUBANG, WEST JAVA

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ABSTRACT

Macrobenthic in mangrove ecosystems plays an important role as removal particles from the water column to the sediments. Ecology indexes of macrobenthic communities were used in this study as an indicator for the fertility of mangrove pond ecosystems. The study was carried out at mangrove pond in Blanakan, West Java. Data was collected from four sampling sites: opened pond (TB), sylvofishery pond (TS), sedimented pond (TT), and conservation pond (TP). Some ecological indexes such as Margalef's Index (R), Shannon-Wiener Index (H'), Pielou Evenness Index (E), and Simpson Dominance Index (D) were used to analyze macrobenthic communities. The results showed that infaunal macrobenthic communities were stable at TP with R: 1.91±0.42, H': 1.59±0.30, E: 0.74±0.14, and D: 0.29±0.12. They were unstable at TB with R: 1.63±0.80, H': 1.36±0.32, E: 0.74±0.06, and D: 0.35±0.07. The macrobenthic communities can be used as indicator for the fertility of mangrove pond in Blanakan, West Java.

KEYWORDS*:* macrobenthic, indicator, fertility, mangrove pond, Blanakan

INTRODUCTION

According to the size, benthic organisms are classified as microbenthic, meiobenthic, and macrobenthic. The microbenthic (< 32 µm) is composed of bacteria and protista. The meiobenthic (32 µm - 1 mm) is usually dominated by nematode. The macrobenthic (> 1 mm) is composed of mollusk, polychaeta, echinoderm, crustacean, and other groups. Benthic organisms, based on feeding type, are also classified into two classes: suspension feeders, which filter their food directly from the water column, and deposit feeders, which depend on the physical deposition of food particles on the sediment surface, and the subsequent incorporation of the food particles into the sediment matrix (Herman *et al*., 1998).

Macrobenthic is an important component of mangrove ecosystems. They are both consumers and transporter in the energy flow and materials circulation of the system through activities such as ingesting food and digging (Aller & Aller, 1998; Yi-jie *et al*., 2007). Between 5% and 25% of the annual primary production is consumed by macrobenthic respiration (Harding *et al*., 1986). Macrobenthic in mangrove ecosystems plays an important role as removal particles from the water column to the

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sediments and as an important food resource for crustaceans, fish, birds, and human (Pirzan *et al.*, 2006). Abundance and diversity of macrobenthic depend on several factors such as mangrove structures (Yi-jie *et al.*, 2007), sediment characteristics (Kathesiran & Bingham, 2001), temperature and salinity (Ferrari *et al.*, 1994), as well as organic nitrogen (Tenore, 1988).

Macrobenthic has a unique habit to dig on mangrove sediment and to interact with its surrounding environment. The composition of macrobenthic depends on the sediment characteristics of the individual mangrove (Kathesiran & Bingham, 2001). The structure of macrobenthic community can be used as potential biological or ecological index in order to recognize environmental changes in natural and artificial mangroves (Yi-jie *et al.*, 2007). The diversity index commonly used to characterize species abundance and its relationship in communities. This index composes of two distinct components: the total number of species or species richness, and equitability or species evenness (Pirzan *et al.*, 2006).

Since 1986-2008, Blanakan area is a potential and existing for fish and shrimp culture in the pond. Around the pond in Blanakan is surrounded by mangrove area. It might be the pond has very good fertility because it could be absorbed as nutrient by plankton from the compose of litter mangrove. Therefore the pond around mangrove was mentioned as mangrove pond. The utilization of mangrove forests in the Blanakan into various types of mangrove ponds creates ecological conditions that vary on each type of pond. Therefore, the studies of the ecology of the mangrove ponds are interesting topic to be learned.

The objective of this study was to investigate the role of macrobenthic communities as indicator for the fertility of mangrove pond at Blanakan, Subang, and West Java. This study is useful as a material consideration for the sustainable utilization of mangrove ecosystems.

MATERIALS AND METHODS

This study was carried out on April-June 2008 at mangrove pond in Blanakan, Subang, West Java (Figure 1). The sampling sites were based on percentage of mangrove cover such as opened pond (TB), sylvofishery pond (TS), sedimented pond (TT), and conservation pond (TP).

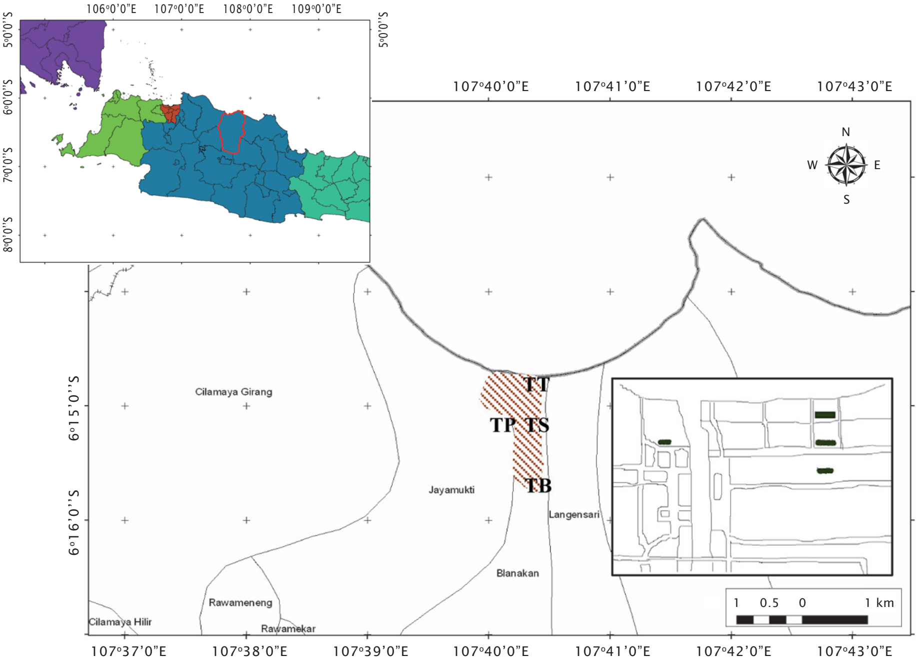

Figure 1. Map of study area at mangrove pond in Blanakan, West Java. TB: opened pond, TS: sylvofishery pond, TT: sedimented pond, and TP: conservation pond

Sampling of macrobenthic was collected by taking the sediment using PVC core with 7 cm diameter and 15 cm height. The benthic samples were sieved using 1 mm meshsize in order to separate the benthic fauna from the substrate. The retained organisms were collected, preserved in 70% alcohol and identified based on Carpenter & Niem (1998). Land cover, temperature, salinity, dissolved oxygen, and pH in water column were also measured at each sampling site. In addition, carbon, nitrogen, and phosphor contents in sediment were also analyzed. Data were analyzed at Soil Research Institute, Bogor.

The ecologycal indexes were used to examine the structure of macrobenthic communities. The indexes were used including richness species index (The Margalef's index/R), diversity index (The Shannon-Wiener index/ H'), evenness index (The Pielou Evenness index/E), and dominance index (The Simpson dominance index/D): The formula for each index as follow (Ludwig & Reynolds 1988):

$$R = (S - 1) / \ln(n)$$

where:
R = Richness species index
S = Total number of species
n = Total number of individuals

$$H' = -\Sigma (pi \times \ln pi)$$

where:
H' = Diversity index
Pi = ni/N
ni = Number individuals of the i^{-th} species
N = Total number of individuals

$$E = H' / \ln S$$

where:
E = Evenness index
H' = Diversity index
S = Total number of species

$$D = \Sigma (ni / N)^2$$

where:
D = Dominance index
ni = Number individuals of the i^{-th} species
N = Total number of individuals

RESULTS AND DISCUSSIONS

Base on characteristics of mangrove pond in Blanakan, West Java, the sampling sites were divided by percentage of mangrove covers at TB, TS, TT, and TP with 0%, 50%, 40%, and 80%, respectively. Water quality at the study site was fluctuated with temperature, salinity, DO and pH ranged of 29.85°C-30.84°C; 8.63-26 ppt; 2.73-7.93 mg/L; 7.71-7.98 respectively (Haryadi *et al*., 2013). Generally, condition of water quality at the study area were indicated suitable for brackishwater culture (Hassan, 1990; Joseph & Gupta, 1996; Chanratchakool, 2003).

Sedimentary nutrient at mangrove pond in Blanakan is shown in Table 1. Based on the nitrogen content, Mintardjo *et al*. (1985) classified the fertility of sediment into four categories: (1) very low, nitrogen content less than 0.10%; (2) low, nitrogen content between 0.11%-0.15%; (3) moderate, nitrogen content between 0.16%-0.20%; and (4) high, nitrogen content greater than 0.20%. According to these categories, the fertility of sediments at TB, TS, and TP were indicated moderate, while at TT was indicated low. These condition might be related to the mangrove covers at each site. This mangrove covers play a potential role as trapper of nutrients (Lin & Dushoff, 2004) and sediment (Kathiseran, 2003; Al-Nafisi *et al*., 2009).

Twenty five species of macrobenthic were indentified at mangrove pond in Blanakan, West Java. The composition of infaunal macrobenthic at mangrove pond is shown in Figure 2. Gastropod was found dominant with percentage coverage of about 38%-71% of the total number of species. The muddy or sandy sediments of

Table 1. Sedimentary nutrient at each sampling site (N = 3) in Blanakan, Subang, West Java

Nutrients	TB (%)	TS (%)	TT (%)	TP (%)
Carbon	2.48±0.78	2.23±0.49	1.70±0.41	2.69±2.02
Nitrogen	0.17±0.06	0.18±0.04	0.14±0.04	0.17±0.03
Phosphor	0.04±0.02	0.03±0.01	0.03±0.01	0.03±0.01

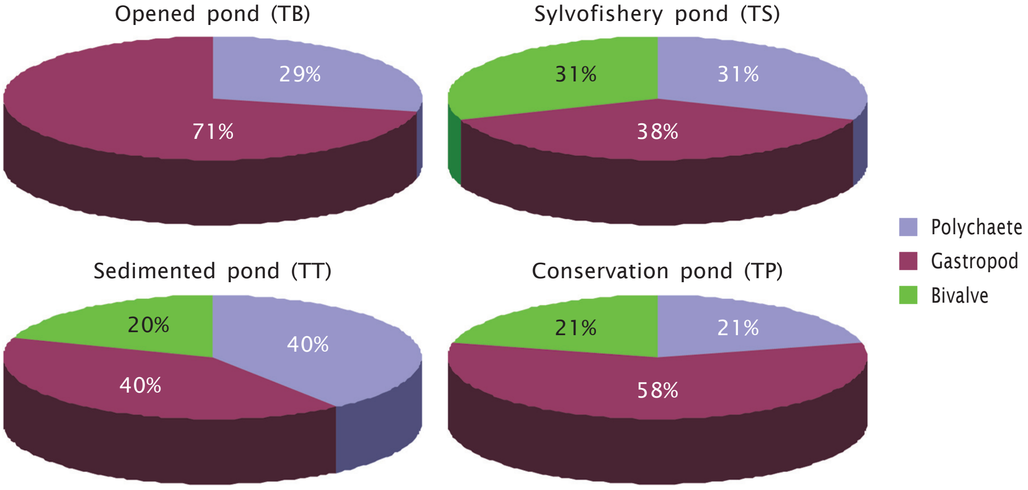

Figure 2. The composition of infaunal macrobenthic at mangrove pond in Blanakan, Subang, West Java

the mangrove may be suitable habitat for macrobenthos fauna, i.e. gastropod (Hutchings & Recher, 1981; Keshavarz *et al.*, 2012). Gastropod could burried their body into sediments for searching food and avoid from predators. Deposit feeders, such as mollusca commonly inhabit in soft bottom of mangrove area (Kumar & Khan, 2013). Similarly, softbottom macrobenthos in Indonesian mangrove ecosystem was dominated by mollusca (Nordhaus *et al.*, 2009). Gastropod was also reported as dominant taxa at some mangrove areas in the world such as Sematan, Malaysia (Ashton *et al.*, 2003), east coast of India (Raut *et al.*, 2005) and Desa Deyao, Zhanjiang, Cina (Yi-jie *et al.*, 2007).

The abundance of infaunal macrobenthic at Blanakan is shown in Figure 3. The abundance of infaunal macrobenthic at TB, TS, TT, and TP was accounted for 20,433±10,051 ind./m^3; 31,342±10,701 ind./m^3; 17,143±9,057 ind./m^3; and 40,346±16,306 ind./m^3, respectively. TP had the highest abundance of infaunal macrobenthic among other sampling sites. This condition might be related with the substrate at TP which is suitable for infaunal macrobenthic growth as well as the condition of mangrove covers. Substrate is an important factor for macrobenthic because of its role as home and source of organic matters (Sahri *et al.*, 2000). In addition, mangrove at TP also play an

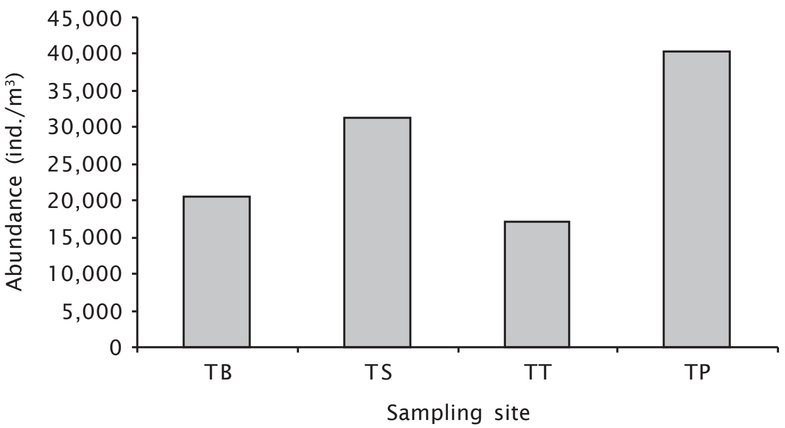

Figure 3. The abundance of infaunal macrobenthic (N = 3) at mangrove pond in Blanakan, West Java

important factor influencing the abundance of infaunal macrobenthic. Bosire *et al*. (2004) found that the abundance of crabs at mangrove area is higher than the area without mangrove. Many physico-chemical parameters affect macrobenthic communities in the mangrove area (Gowda *et al*., 2008), such as mangrove cover (Nordhaus *et al*., 2009; Thilagavathi *et al*., 2013) and sediment composition (Netto & Galluci, 2003).

The structure of infaunal macrobenthic communities is shown in Figure 4. The Margalef's index (R) of infaunal macrobenthic at TB, TS, TT, and TP were 1.63±0.80, 1.91±0.42, 1.61±0.53, and 1.94±0.06, respectively. The Shannon-Wiener index (H') of infaunal macrobenthic at TB, TS, TT, and TP were 1.36±0.32, 1.59±0.30, 1.54±0.24, and 1.47±0.06, respectively. According to Manguran (1988), the diversity (H') at communities can be classified into three categories: (1) low, if H' less than 1, (2) moderate, if H' between 1 to 3, and (3) high, if H' greater than 3. Based on the categories by Manguran (1988), the diversity of infaunal macrobenthic at all sampling sites was classified as moderate. Simillar condition was reported at Kachchh, India (Saravanakumar *et al*., 2007) and mangrove Zhanjiang, Cina (Yi-jie *et al*., 2007).

The Pielou Evenness index (E) of infaunal macrobenthic at TB, TS, TT, and TP were 0.74± 0.06, 0.74±0.14, 0.84±0.08, and 0.66±0.02, respectively. Suwangsa (2006) classified the uniformity at communities into five categories: (1) very high, if E greater than 0, 81, (2) higher, if E between 0.61 to 0.8, (3) high, if E between 0.41 to 0.6, (4) moderate, if E between 0.21 to 0.4, and (5) low, if E less than 0.21. According to these categories, the uniformity of infaunal macrobenthic at TT was classified as very high, while at TB, TS, and TP were classified as higher. The same condition was reported at some mangrove areas such as Zhanjiang, China (Yi-jie *et al*., 2007) and mangrove Kachchh, India (Saravanakumar *et al*., 2007).

The Simpson Dominance index (D) of infaunal macrobenthic at TB, TS, TT, and TP was 0.35±0.07, 0.29±0.12, 0.26±0.07, and 0.32± 0.02, respectively. These results showed that no dominant species was found in the study area. This condition indicated that the structures of infaunal macrobenthic community were indicated stable and also suitable for infaunal macrobenthic.

Table 2 shows the resume of the structure of infaunal macrobenthic communities at mangrove pond in Blanakan, West Java. According to Ludwig & Reynolds (1988), the communities were indicated stable if R, H', and E indexes were high, and D index was low. Based on the Table 2, infaunal macrobenthic communities had the most stable at TS, while the most labile at TB. The stability of infaunal macrobenthic at TS related with the condition of mangrove forests at its location. On the other hand, the degradation of mangrove forests at TB caused the dominance of infaunal macrobenthic at its location to be very high. The main factors influencing the number of species, diversity, and dominance changes were the degradation of natural habitat (Ellison, 2008) and pollution (Bigot *et al*., 2006).

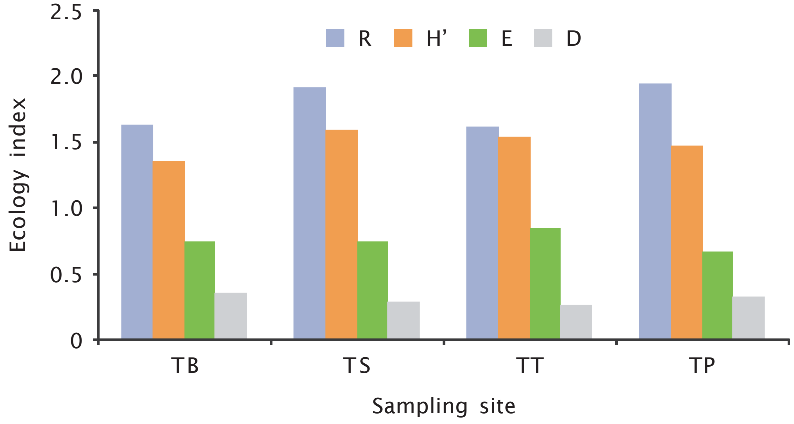

Figure 4. The structure of infaunal macrobenthic communities (N = 3) at mangrove pond in Blanakan, West Java

Table 2. The resume of the structure of infaunal macrobenthic communities at mangrove pond in Blanakan, West Java

Parameter	Trend
R	TT<TB<TS<TP
H’	TB<TP<TT<TS
E	TP<TB<TS<TT
D	TT<TS<TP<TB

At the study area, the dominance of infaunal macrobenthic was highest at TP, whereas the mangrove cover at TP was the highest than other sampling sites. The old mangroves at TP were unsuitable for infaunal macrobenthic. The old mangrove caused lower habitat quality because of accumulation of sediments so that the concentration of dissolved oxygen and water temperature at this location decreased gradually. These were causing reduction of decomposition rate and productivity. The high concentration of tannins resulted by old mangrove showed negative effect on the aquatic organism communities because of it’s toxic containt (Morrisey *et al*., 2007).

The studies on the macrobenthic as indicator for the fertility of pond were also demonstrated by some researchers (Raut *et al*., 2005; Pirzan *et al*., 2006; Yi-jie *et al*., 2007). Macrobenthos is the best bio-indicator for determining sediment quality because of three main reasons: sedentary, low natural variability, and responsive to organic enrichment (Mucha *et al*., 2003). Furthermore, macrobenthos show a perceptible respond to organic enrichment through some actions: (1) a decrease in species richness, (2) an increase in abundance of opportunistic species, and (3) a shift in size classes from large to small-sized species (Chintiroglou *et al*., 2006).

The relationship between sedimentary carbon and nitrogen with abundance and diversity of infaunal macrobenthic at mangrove pond in Blanakan, West Java is shown in Figure 5. The abundance of infaunal macrobenthic increase with increasing sedimentary carbon and nitrogen. These can be understood because sedimentary carbon and nitrogen were a source of food for benthic animals, particularly mollusca (Herman *et al*., 1998; MacDonald *et al*., 2010).

The sedimentary organic matter together with sediment textures influence the diversity of macrobenthic at some mangrove areas (Yi-jie *et al*., 2007; Sivadas *et al*., 2013). Increasing sedimentary nutrients could increase the diversity of macrobenthic at Mamuju pond (Pirzan & Gunarto, 2004), Tampinna lagoon, East Luwu (Pirzan *et al*., 2006). However, increasing sedimentary carbon and nitrogen could decrease the diversity of infaunal macrobenthic at mangrove pond in Blanakan. This is causing the requirement of carbon and nitrogen at each infaunal macrobenthic was different. Infaunal macrobenthic species may be very responsive to sedimentary carbon and nitrogen so their growth are very fast and dominate to the other species. The same case was reported by Lestari *et al*. (2005) that increasing BOD_5 was caused organic matter pollution could decrease the diversity of macrobenthic.

Organic matters and community structures were an indicator for the fertility of ecosystems. Results of this study showed that the fertility at TS was moderate, while at TT was

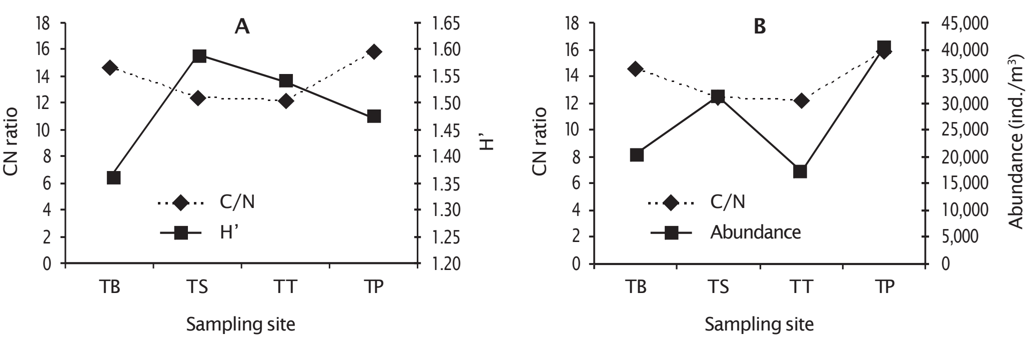

Figure 5. The relationship of sedimentary C/N with abundance (A) and diversity (B) of infaunal macrobenthic at mangrove pond in Blanakan, West Java

low. On the other hand, the community of infaunal macrobenthic was the most stable at TS, while the most labile at TB. These showed that locations with high fertility tend to have more stable community. Therefore, the ecology index of infaunal macrobenthic communities can be used as an indicator for the fertility of mangrove pond at mangrove pond in Blanakan but this study still requires some additional data and information as well as further studies to obtain a detail role of infauna macrobenthic for determining the level of stability and fertility of mangrove pond in Blanakan.

CONCLUSION

The structure of infaunal macrobenthic communities can be used as an indicator for the fertility of Blanakan pond. In this study, the community of infaunal macrobenthic was the most stable at sylvofishery pond (TS), while the most labile at opened pond (TB). Finding from this study could be used as a material consideration for the sustainable utilization of mangrove ecosystems.

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