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Diversity index of Macrobenthos and environmental factors in mangrove and mudflat areas at Klong Khone, Samut Songkhram Province

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Abstract : This study measured the diversity of the macrobenthos at Klong Khone, Samut Songkhram province, to study the environmental condition of the mangrove forest. The main objective of this research was to compare the microbenthic community and environmental factors between mangrove and mudflat areas enthos, seawater and sediment were sampled in September of 2016. The results showed that Annelida was the most abundant phylum, with 37 species, followed by Arthropoda and Mollusca. The diversity indexes were found to be 1.42 and 1.52 for mangrove and mudflat areas, respectively. Densities were 598 and 453 indiv./m^2, respectively. Seawater quality as dissolved oxygen (DO) was found to be lower in the mangrove area than the mudflat area; however, total Kjeldahl nitrogen (TKN) and nitrate-nitrogen were higher. Sediment quality as organic carbon, TKN and total phosphorus were found to be 38%, 0.63 mg-N/g DW and 0.21 mg-P/g DW, respectively. Statistical analysis (t-tests) showed that diversity, density and sediment quality did not differ significantly between mangrove and mudflat areas. We found that *Heteromastus* sp. (Annelida), *Natica vitellus* (Mollusca) and *Halmyrapseudes* sp. (Arthropoda) were the dominant species in the mangrove area. Hence, these macrobenthic species can be used as biomarkers to indicate the condition of the mangrove ecosystem.

Keywords: Marobenthos, Water Quality, Sediment Quality, Klong Khone

Introduction

Biodiversity can indicate ecosystem healthiness. Richness of living organisms demonstrates good environment status due to suitable for life. Macrobenthos is one of the most popular indicators to indicate richness of nutrients which refer to water and sediment quality (Pocklington and Wells, 1992; Dean, 2008; Neave *et al.*, 2013). Some species can indicate pollution; for instance, *Tanaidacean* and *Capitellid* can be found in higher concentration of organic pollutant (Grizzle, 1984; Lucero R. *et al.*, 2006), while the others can indicate abundance of mangrove trees (Sheridan, 1997; Chen *et al.*, 2007; Chapman and Tolhurst, 2007).

Mangrove forest at Klong Khone, Thailand was deforestation to build shrimp farms. Ecosystem, including seawater and sediment quality, was deteriorated and biodiversity was decline rapidly. Now local people started having awareness on the effect of deforestation on mangrove ecosystem. They have been planting mangrove trees and this becomes popular activity for ecotourism. To evaluate healthiness of ecosystem, there are many studies on abundance of organisms after mangrove restoration (Sheridan, 1997; Chen *et al.*, 2007; Chapman and Tolhurst, 2007). However, research on macrobenthos diversity was little and lack of comparison between mangrove and mudflat areas.

Therefore, this study aims to 1) investigate diversity index of macrobenthos in Klong Khone; 2) observe environmental status which included seawater and sediment quality in the study area; and 3) find the differentiation of macrobenthos and these environmental factors between mangrove and mudflat areas. The outcome can effectively assist environmental evaluation status by using macrobenthos as bioindicator.

Methodology

Study area

The research was conducted at Klong Khone, Samut Songkhram Province, Thailand on September 2015. Sample stations were divided into 2 zones. As shown in Figure 1, station KB 1-6 are in mangrove area and station KB 7-12 are in mudflat area. At each sampling station, macrobenthos, seawater and sediment samples were collected.

Species diversity and density

Macrobenthos were sampled duplication per station by using quadrate 50x50 cm with 30 cm in depth. Then, all macrobenthos were separated from the sediment by filtration through sieve size 210 µm. The samples were washed and preserved in 10% formalin waiting for species identification. Species diversity was analyzed using Shanon-Wiener diversity index. Macrobenthos density was calculated as total amount of macrobenthos found in each replication divide by quadrate area.

Seawater quality

In-situ seawater quality was investigated. Water temperature and dissolve oxygen (DO) were conducted by Cybercan DO 110 (EUTECH Instruments, Singapore). Meanwhile, pH was conducted by Cybercan PC 300 (EUTECH Instruments, Singapore). Salinity was checked by using refractometer. Then, seawater was sampled for total suspended solid (TSS), total kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrate nitrogen (NO_3^--N) and phosphate phosphorus (PO_4^{3-}-P) analysis in environmental laboratory at Bansomdejchaopraya Rajabhat University, Bangkok.

All samples were stored in refrigerator (4°C) and fixed with sulfuric acid (H_2SO_4) before analyze. All parameters analysis procedures were described in standard methods for the examination of water and wastewater (APHA et al., 2009).

Sediment quality

Sediment samples (0-1 cm depth form sediment surface) were collected by gravity core. The samples were storage in refrigerator (-4°C). Each sample was determined for organic matter (OM) by using wet oxidation method (Allison, 1965), total nitrogen (TN) by using kjeldahl method (Bremner and Mulvaney, 1982) and total phosphorus (TP) by using $HCLO_4$ digestion (Olsen and Sommer, 1982)

Finally, all parameters were investigated the differentiation between mangrove and mud flat areas by using statistical analysis (t-test) in Microsoft Excel 2010.

Results and Discussion

Macrobenthos diversity index and density

As shown in Table 1, total of 36 macrobenthos species were found in all sampling stations. There were Annilida 21 species, Mollusca 6 species and Arthropoda 9 species. Results for this study found decreasing of species abundance when compared with previous research by Suzuki *et al.* (1997). They found that number of species was 66 in year 1997 when mangrove rehabilitated program had been implemented only 3 years. Normally, younger mangrove forest generally had more macro-benthic fauna species than older ones (Chen *et al.*, 2007). This species loss can be due to changing in environmental factors (Clare *et al.*, 2015). In older mangrove, more litter fall cause accumulation of organic matter and led to sediment property change. Thus, only organic loving

species can be occurred. This litter accumulation also cause increase sulfur, tannins and lignin-derived phenol in sediment. These strong compounds limit growth and survival of some macrobenthos species. In addition, growing mangrove provided home for many living organisms. Increase diversity such as seabird, fish and crab which are macrobenthos predators can be found (Chen *et al.*, 2007; Zou *et al.*, 2008). It was found in this study that there were fish lavae (Gobiidae) only in mangrove area and benthos are one of their food sources. Therefore, these alterations of ecological function over time along with mangrove forest growth can possibly cause reducing number of macrobenthos species.

In this study, diversity index between mangrove and mud flat areas was found to be similar (Table 2). However, the highest density was found in KB 2 and *Halmyrapseudes* sp. was the dominant species. As shown in Table 2, lower macrobenthos density in mud flat area, suggesting that there are more food sources, and more suitable environments for living in mangrove. Concordance with a research in Rookery bay, Florida, USA, by Sheridan (1997) benthic population exceeded in mangrove vegetative areas than seagrass and non-vegetated habitats due to higher organic matter which was the main food source for macrobenthos.

Statistical analysis revealed that there is no difference of macrobenthos diversity and density between mangrove and mud flat areas at Klong Khone, however we found that dominant species were different. Dominant organism which found in mangrove forest were Annelida: *Heteromastus* sp., *Mediomastus sp.*, *Diopatra semperi*, Mollusca: *Natica vitellus* and Arthropoda: *Halmyrapseudes* sp., *Alpheus* sp; and in mud flats were Annelida: *Mediomastus sp.*, *Glycera natalensis*, Mollusca: *Nassarius pullus*, Arthropoda: *Alpheus* sp. This was similar to Sheridan (1997), who also reported that *Halmyrapseudes bahamensis* is one of dominant species commonly found in mangrove area. Even *Mediomastus sp.* and *Alpheus* sp. were found as dominant species in both mangrove and mudflats, they were extremely abundant in mudflats. This result was also similar with Sheridan (1997), who found that *Mediomastus californiensis* was dominant species in all study areas; mangrove forest, seagrass and non-vegetated mud, but it was much more abundance in non-mangrove area. Another research by Chen *et al.* (2007) demonstrated that *Alpheus hoplocheles* was abundant in non-vegetated mudflats. Hence, those macrobenthos species are suitable for mudflats indicator.

Seawater quality

Results of seawater parameters are shown in Table 3. By using statistical analysis (t-test), there were no different among sampling stations except DO, TKN and NO_3^--N. In mangrove area, DO was found to be lower, but TKN and NO_3^--N were higher than mud flat areas. Environmental factors can differ due to coastal characteristics. It was well understood that there was more accumulation of organic matter by mangrove litters and living organisms' excretion than other areas (Chapman and Tolhurst, 2007). Moreover, at Klong Khone, pollutants form river runoff and effluence from shrimp farms could increase organic nitrogen in mangrove. Degradation of these organic by microbial activity resulted in lowered oxygen.

Seawater quality fluctuation can cause disturbances on macrobenthos. However, a study by Pech *et al.* (2007) found that only salinity was the main factor influencing the benthic diversity and abundance, while other variables e.g. temperature, DO, pH, and seawater transparency were no significantly influenced. Their results support that benthos survival and distribution can be affected by salinity variation. Our findings demonstrate that there was no difference in salinity among sampling sites on macrobenthos diversity and density.

Sediment quality

Abundance of organic matter (OM), total nitrogen (TN) and total phosphorus (TP) in sediments at Klong Khone are shown in Table 4. Statistical analysis revealed that there were no difference among sampling sites, and the average values were 2.11% of OM, 0.63 mg-N/g DW of TN and 0.21 mg-P/g DW of TP ($P>0.05$). This very little different of sediment quality might serve no difference of both benthos diversity and density between mangrove and mud flat areas. Nevertheless, slightly higher OM in mangrove was recorded. As previously discussed, mangrove litters associated with living excretory can cause organic matter accumulation (Chapman and Tolhurst, 2007); and accumulated through time (Frid, 2011).

Conclusion

Although our results showed that there were no differences in macrobenthos diversity, density, and sediment quality between mangrove and mud flat areas, their dominant species differed. *Heteromastus* sp. and *Halmyrapseudes* sp. were found extremely abundance in mangrove. While, *Mediomastus sp.*, *Glycera natalensis*, *Nassarius pullus*, and *Alpheus* sp. were found in both mangrove and mudflats; and they were extremely abundance in mudflats. Hence, these species can be used for mangrove and mud flats bioindicator in term of abundance and also help to evaluate healthiness of mangrove. Environmental fluctuations and pollution can cause changing in ecological function and service; subsequently, species occurrence and replacement.

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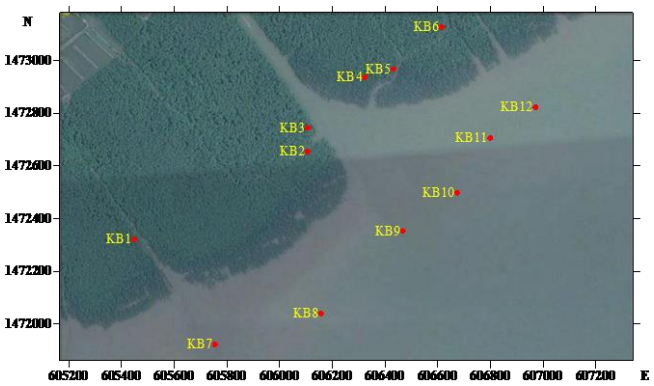

Figure 1. Sampling station at Klong Khone, Samut Songkhram province, Thailand

Table 1. Macrobenthos species at all sampling sites

Species	Mangrove Area					Mudflat Area		
	KB 1	KB 2	KB 3	KB 5	KB 6	KB 7	KB 9	KB 10
Annelida								
Scoloplos(Leodamas) gracilis	+			+				
Para prionospiocf. oceanensis				+	+			+
Para prionospio sp.		+			+		+	+
Magelona conversa					+			
Chaetozone sp.				+				+
Mediomastus sp.					+		+	+
Heteromastus sp. 1		+						+
Heteromastus sp. 2	+		+					
Heteromastus sp. 3				+				
Heteromastus sp. 4	+		+		+			
Axiothella obockensis		+						
Ophelina sp.				+		+		
Armandia sp.							+	
Sigambra sp.							+	+
Neanthes caudate			+					
Glycera natalensis		+		+			+	
Diopatra semperi				+	+			
Diopatra sp.				+	+			
Marphysa macintoshi	+				+	+		
Lanice conchilega					+			
Chone sp.								+
Mollusca								
Mactra olorina						+	+	+
Gari (*Psammotaea*) *elongate*						+	+	
Didimarca tenebricum sp.					+			
Natica vitellus	+		+					
Nassarius pullus			+			+	+	+
Nassarius jacksonianus				+			+	+
Arthropoda								
Philyra olivacea							+	+
Macrophthalmus convexus	+		+		+		+	+
Halmyrapseudes sp.	+	+	+	+	+		+	

Table 1. Macrobenthos species at all sampling site (cont.)

Species	Mangrove Area					Mudflat Area		
	KB 1	KB 2	KB 3	KB 5	KB 6	KB 7	KB 9	KB 10
Alpheus sp.		+	+		+	+	+	+
Anisops sp.		+		+				
Unknown 1			+					
Unknown 2	+		+					
Unknown 3							+	
Unknown 4					+			

Table 2. Macrobenthos diversity index and density at Klong Khone, Samut Songkhram

Mangrove Area			MudFlats Area		
Station	Diversity Index	Density (indv/m^2)	Station	Diversity Index	Density (indv/m^2)
KB 1	1.84	162	KB 7	1.15	70
KB 2	0.50	1572	KB 8	nd.	nd.
KB 3	1.52	258	KB 9	1.51	632
KB 4	nd.	nd.	KB 10	1.90	656
KB 5	1.34	540	KB 11	nd.	nd.
KB 6	1.91	456	KB 12	nd.	nd.
Average	1.42	598	Average	1.52	453
SD	0.57	565	SD	0.38	332

Note: nd. = no data

Table 3. Seawater quality at Klong Khone, Samut Songkhram province in September 2015

Station	Salinity (ppt)	Temp (°C)	DO (mg/L)	pH	TSS (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_3^--N (mg/L)	PO_4^{3-}-P (mg/L)
Mangrove area									
KB 1	20	26.9	3.4	6.98	364	11.2	7.6	0.38	0.63
KB 2	21	26.9	4.1	7.16	240	10.7	7.4	0.34	0.36
KB 3	20	26.9	4.8	6.65	438	10.9	6.2	0.42	0.42
KB 6	21	26.4	3.7	6.91	550	10.7	6.1	0.33	0.67
Mud flats area									
KB 7	21	27.1	5.1	7.64	256	9.1	5.9	0.53	0.16
KB 8	20	27.2	5.1	7.50	268	9.3	5.8	0.54	0.37
KB 9	21	27.9	5.3	6.97	24	9.2	5.6	0.41	0.25
KB 10	25	28.7	5.0	6.57	136	9.0	5.8	0.35	0.14
KB 11	21	27.9	5.8	6.79	166	8.8	5.5	0.50	0.14
KB 12	22	28.7	4.3	6.90	94	8.9	5.7	0.51	0.18

Note: There is no data in KB 4 and 5.

Table 4. Sediment quality at Klong Khone, Samut Songkhram province in September 2015

Station	OM (%)	TN (mg-N/g DW)	TP (mg-P/g DW)
Mangrove area			
KB 1	2.19	0.66	0.21
KB 2	2.05	0.44	0.20
KB 3	2.13	0.43	0.16
KB 4	2.37	0.79	0.39
KB 5	1.61	0.67	0.25
KB 6	3.31	0.51	0.20
Mud flats area			
KB 7	1.49	0.49	0.12
KB 9	1.50	0.86	0.28
KB 10	2.35	0.86	0.06

Note: There is no data in KB 8, 11 and 12.