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The Abundance and Spatial Distribution of Soft Sediment Communities in Tanjung Bungah, Malaysia: A Preliminary Study

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Abstract: Benthic faunal communities are important components in the intertidal zones. The diversity and abundance of the benthic communities are subjected to different natural and anthropogenic disturbances. The study was conducted as one off sampling on 6th November 2013 (1) to investigate the abundance and distribution of soft sediment communities in relation to environmental variables and (2) investigate the changes of population structure and diversity using spatial scales of 1 m, 10 m, and 100 m. Results indicated a total of 110 individuals of macrobenthos consisting of 7 different groups (Annelida, Bivalvia, Crustacea, Gastropoda, Nematoda, Nemertea, Polychaeta) and 4 different groups of meiobenthos (Copepoda, Nematoda, Ostracoda, Polychaeta) consisting 920 individuals were recorded. Dissolved oxygen played the most significant role in affecting the distribution of soft sediment communities while ammonia concentrations only affected marcobenthic organisms. However, sediment grain size did not show significant correlation (p>0.05) on soft sediment communities. Hence, understanding how different properties of benthos respond to changes in environmental variables is crucial in determining how the impacts on the sediment are tolerated by the benthic organisms.

Keywords: Macrobenthos, Meiobenthos, Environmental Factor, Sediment Grain Size

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INTRODUCTION

The structure of benthic communities in intertidal areas is determined by the biological, chemical, and physical factors of the environment. This interaction determines the final community structure and the biodiversity in the benthic communities (Chapman & Tolhurst 2007). They act as an environmental indicator which is widely used to detect any marine environment disturbance caused by anthropogenic sources. Benthic faunal communities are important components in the intertidal zones as the presence or absence of benthic communities provide valuable information about a marine ecosystem's health over time.

Very little is known about the distribution of soft sediment communities in the tropical countries, particularly Malaysia. Previous studies mainly focused on the temperate regions and even then few have studied the spatial variation, abundance, and distribution of soft sediment communities. The objectives of this present study of soft sediment communities is to gather information about the benthic interactions and their relation to marine environments. They are complex communities and are often affected by abiotic factors such as sediment grain size, sediment organic content, pore water content, water quality, current velocity, and water depth (Thurman & Trujillo 2002).

Tanjung Bungah beach is an intertidal area located in the North Coast of Pulau Pinang. Originally a fishing village, it has become a commercially important asset for the country especially in the tourism sector. This area is considerably polluted due to high human settlements and activities, hence the reason for our sampling location. This study was conducted to investigate the abundance and distribution of soft sediment communities in Tanjung Bungah, Pulau Pinang, in relation to environmental variables, and to determine the spatial variability of soft sediment communities at three different scales within 1 m, 10 m, and 100 m along horizontal shore of Tanjung Bungah. Spatial scale was used to avoid bias during sampling and to show the relationship between benthic communities and their environment.

MATERIALS AND METHODS

Pulau Pinang is located within latitudes 5°12' to 5°30' N and longitudes 100°09' to 100°26' E. It is bounded on the North and East by the state of Kedah, to the South by the State of Perak and to the West by the Straits of Malacca and Sumatra (Indonesia). Sampling was conducted at Tanjung Bungah (N05°28.048' E100°16.730'), Pulau Pinang intertidal area on the 6th November 2013 at different spatial scales of 1 m (sites A1 and A2), 10 m (sites B1 and B2), and 100 m (sites C1 and C2).

All field samplings and analyses of soft sediment communities were carried out during low tide and were based on Ranasinghe *et al.* (2012) methods. Sediment samples (n=3) were collected for macrobenthos and meiobenthos analysis using a PVC corer (10 cm diameter × 10 cm depth) and a modified syringe (3 cm diameter × 5 cm depth) respectively. In situ physical parameters for pore water were taken during the field sampling at each site. Soil temperature

(n=3) was taken using a soil thermometer (Thermo, KTJ, TA-288), salinity was taken using a refractometer (Atago, S/Mill-E), pH was taken using a pH meter (Hanna Instruments, HI98129), dissolved oxygen was taken using a DO meter (YSI Pro20), and light intensity was taken using a light meter (Li-COR Biosciences). Pore water samples (n=3) were collected using 500 mL polyethylene bottles for pore water quality analysis.

In the laboratory, macrobenthic sediment was sieved using a 0.5 mm mesh sieve (Tagliapietra & Sigovini 2010). Meiobenthic sediment was sieved using 0.45 mm and 0.042 mm mesh sieves (Rosa & Bemvenuti 2005). The samples were preserved using 70% ethanol and stained using Rose Bengal. The level of taxonomic identification was conducted until species level whenever possible. Main reference was based on Barnes *et al.* (2001) and Giere (2009) for macrobenthos and meiobenthos, respectively. Sediment was classified according to Folk (1954). Pore water quality analyses such as chlorophyll *a*, nitrite, nitrate, ammonia, and ortho-phosphate were carried out by using standard titration method based on Strickland and Parsons (1972).

Statistical Analysis

Kruskal-Wallis test was used to determine the significance of the results. Spearman's correlation coefficient was used to determine the significant relations between sediment compositions, environmental parameters such as salinity, pH, dissolved oxygen, and soil temperature with population density and benthic groups.

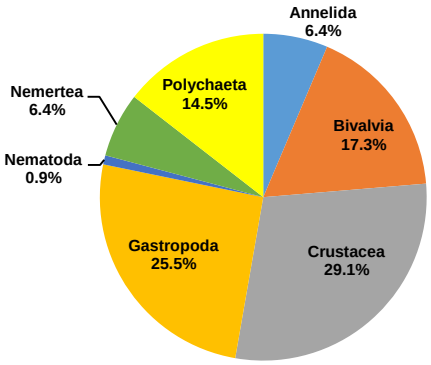
RESULTS AND DISCUSSION

Diversity, Abundance, and Distribution of Soft Sediment Communities

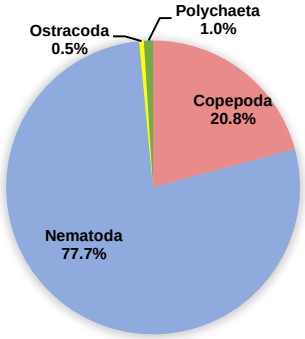
Macrobenthos were distributed unequally displayed by J'<0.5 while meiobenthos were distributed equally displayed by J'>0.5 (Table 1). Soft sediment communities displayed significant difference (p<0.05) for Shannon-Wiener index (H'), Margalef's richness index (d), and Pielou's evenness index (J') within all scales. Figure 1 shows the relative abundance of macrobenthos and meiobenthos in Tanjung Bungah.

Table 1: Shannon-Wiener diversity (H'), Margalef's richness (d), and Pielou's evenness (J) indices of microbenthic (macro-) and meiobenthic (meio-) communities at three spatial scales (1 m, 10 m, and 100 m) in Tanjung Bungah.

Scale (m)	Site	Shannon-Wiener diversity index, H'		Margalef's richness index, d		Pielou's evenness index, J	
		Macro-	Meio-	Macro-	Meio-	Macro-	Meio-
1	A1	0.28	0.38	0.91	0.37	0.40	0.35
	A2	0.50	1.14	1.25	0.68	0.36	0.82
10	B1	0.71	1.16	1.52	0.43	0.39	1.06
	B2	0.47	0.67	1.30	0.22	0.34	0.97
100	C1	0.70	1.28	1.25	0.78	0.39	0.92
	C2	0.45	0.65	1.44	0.51	0.41	0.47



(a)



(b)

Figure 1: Relative abundance of (a) macrobenthos and (b) meiobenthos in Tanjung Bungah. The highest abundance for macrobenthos and meiobenthos were recorded for crustaceans (29.1%) and nematodes (77.7%), respectively.

Macrobenthos

A total of 110 individuals belonging to 7 groups of macrobenthos (Annelida, Bivalvia, Crustacea, Gastropoda, Nematoda, Nemertea, and Polychaeta) were recorded in this study. Crustaceans represent 29.1% of the total individuals and it has the highest relative abundance compared to other groups of macrobenthos. This was probably due to a relatively high salinity (30 psu) and high dissolved oxygen (7.40 mg/L) at Site C1 (Table 2) which was a suitable habitat for crustaceans. In Southern African lakes, chironomids and ostracods (Crustacea) are capable of occurring in hypersaline lagoons (Boltt 1975).

Table 2: Mean ± SE of soil temperature, salinity, pH, and dissolved oxygen (n=3) in Tanjung Bungah at different scales and sites.

Scale (m)	Site	Parameter			
		Soil temperature (°C)	Salinity	pH	Dissolved oxygen (mg/L)
1	A1	28.90 ± 0.06	16.00 ± 0.58	7.79 ± 0.01	4.27 ± 0.07
	A2	28.93 ± 0.09	15.00 ± 0.00	7.78 ± 0.00	5.60 ± 0.35
10	B1	29.20 ± 0.00	25.67 ± 0.33	8.06 ± 0.02	8.23 ± 0.57
	B2	29.63 ± 0.09	20.00 ± 0.00	7.86 ± 0.01	5.97 ± 0.62
100	C1	30.37 ± 0.07	30.33 ± 0.33	8.43 ± 0.01	7.40 ± 0.58
	C2	31.67 ± 0.09	30.00 ± 0.00	7.82 ± 0.01	5.47 ± 0.07

Meiobenthos

A total of 927 individuals belonging to 4 groups of meiobenthos namely Nematoda, Copepoda, Polychaeta, and Ostracoda were identified. Nematoda was the dominant group found at almost all sites with relative abundance of 77.7%. Present results also show that nematodes were found to dominate all types of sediments, hence, sediment grain size probably played a major role. According to Giere (2009), they have many features that enable them living in sands and muds.

In-situ Physical Parameters

Dissolved oxygen played the most significant role in affecting the distribution of soft sediment communities as almost all macrobenthic and meiobenthic groups were affected by dissolved oxygen concentration. There was a moderate positive significant correlation between distribution of annelids ($r=0.491$, $p<0.05$), crustaceans ($r=0.565$, $p<0.05$), and nemerteans ($r=0.528$, $p<0.05$) with dissolved oxygen while nematodes show a moderate negative significant correlation in dissolved oxygen ($r=–0.543$, $p<0.05$) in Tanjung Bungah.

This study will provide a detailed baseline of the composition, abundance, and diversity of the benthic community in the intertidal zone in

Tanjung Bungah, vital for long term monitoring as well as providing information needed to answer fundamental questions concerning benthic fauna.

CONCLUSION

Benthic community studies are generally considered good environmental indicators. Hence, further investigations are needed to confirm the factors affecting the soft sediment communities' diversity and abundance of Tanjung Bungah. Projects with monthly sampling and larger scale (>100 m) may be carried out to further investigate the effects of sediment type, spatial variability, and physical parameters on the abundance and composition of soft sediment communities. Therefore, this current study will provide a baseline data for further research in monitoring and assessing the health ecosystem of Tanjung Bungah.

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