Development of Macrobenthic Communities in the North Port, West coastal water of Malaysia

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Abstract— The primary objectives of this study were to investigate the distribution and composition of the macrobenthic community and their response to environmental parameters in the North Port, west coastal waters of Malaysia. A total of 25 species were identified, including 13 bivalvia, 4 gastropoda, and 3 crustacea. The other taxa were less diversified. There were no temporal changes in the macrobenthic community composition, but significant effects ($p < 0.05$) on the benthic community composition were found on a spatial scale. The correlation analyses and similarity tests were in good agreement, confirming the significant response of macrobenthic community composition to variations of environmental parameters.

Keywords— Distribution, Macrobenthic community, Diversity, North Port, Malaysia

I. Introduction

Since the beginning of protection biology as academic science in the 70s, biodiversity of living organisms has been considered as the main target for conservation and as one of the important indicators of ecological values. The challenge of biodiversity research is not restricted only to the concept of biodiversity; it is extremely complicated due to the complexity of natural ecosystems in environment [1, 2].

Evaluation of the biodiversity of an ecosystem includes quantification of species abundance, richness, and dissimilarities, and their functional roles in the ecosystem, which must be taken into account by environment managers in making decision for conservation policies [1, 3]. Compared to other coastal ecosystems in Malaysia, the benthic ecosystem in the Klang Strait remains less studied [4]. However, there is no background and updated database on benthic invertebrate communities and their succession process in this Strait because of difficulties in sample collection due to complex current system, heavy waves and tides, and high traffic density of shipping activity.

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Using comprehensive approaches, (1) evaluate the main characteristics of the macrobenthic community composition including abundance, biomass, diversity, and richness at the Klang Strait; and (2) test the correlation between variations of the macrobenthic community composition and selected environmental parameters across a set of hierarchically distributed stations and sampling times.

II. Material And Methods

A. Study Area

This study was perform in the humid tropical climatic zone characterized by seasonal alternation of the Northeast monsoon or rainy season (November to March) and Southwest monsoon or dry season (May to September) that results in the main rainfall pattern along the Klang Strait [5]. Based on reports of the Malaysian Metrological Service (MMS), the rainfall pattern over the west coast of Malaysia with an exception of southwest area is classified into two periods of minimum rainfall patterns and two periods of maximum rainfalls patterns [5, 6]. Generally, the initial heavy rainfall occurs in October – November (first inter-monsoon period), while the secondary heavy rainfall occurs in April – May (second inter-monsoon period). In this study, the 6 sampling points were selected based on their hydro-chemical feature including specific characteristics of water quality and the intensity of anthropogenic activities at each of the stations [7, 8].

B. *Experimental Methods*

Considering the rainfall patterns in Klang Strait, samples were collected 4 times a year (first inter-monsoon (October-November), Northeast monsoon (December-March), second inter-monsoon (April- May), and Southwest monsoon (Jun-September)) during November 2012 to November 2014. Macorbenthos samples were collected in triplicate by a Petersen grab sampler (0.07 m^2). Annual rainfall and river discharge data were obtained from MMS. A multi-parameter probe (YSI 556 MPS) was used to measure physical parameters of surface water such as temperature, dissolved oxygen (DO), salinity, and total solids (TS). Water transparency was measured using a Secchi disc, and a fish finder or sounder was used to measure the water depth and current at each station.

Sediment samples were rinsed and sieved with a 0.5-mm mesh screen to sort macrobenthic organisms (greater than 0.5 mm). Samples were stained with Rose Bengal and preserved in 99.9% ethanol alcohol, then identified their lowest practical taxonomic level using a dissecting microscope [7, 8]. Biomass (wet mass) of the organisms was estimated after putting the samples on blotting paper and recorded with a 0.01 g precision [7, 9]. Multi-wavelength particle size analyzer (model LS 13 320, Beckman Coulter) was used to estimate sediment particle size. Carbon analyzer (Model 8210, Horbia) was used to determine the Total Organic Carbon (TOC) in sediment.

Fig. 1 Location of the sampling stations

C. Data Treatment and Analyses

Statistical analyses of bioassays data were performed using Primer software (EPrimer Ltd.) and SPSS 17 software (SPSS, Chicago, IL) based on statistical tests listed by Johnson and Wichern [9]. Several ecological indices have been applied to assess the impact of environmental parameters on macrobenthic community. Diversity index was estimated using Shannon–Wiener Index (H'= bits individual^{-1}) on the abundance of species and functional groups to provide a single value for multivariate data [10]. Likewise, richness (j) was used to reflect the number of different species in biological communities.

III. RESULT

A. Variation in Environmental Parameters

The Northeast monsoon started in December and lasted until March. The Southwest monsoon started from June until October, and the monsoon break was observed at the end of the September. November, April, and May were considered as the inter-monsoon period with a high daily rainfall.

All environmental parameters from 7 stations are summarized in Table 1. Water quality data showed significant differences *(p* < 0.05 or 0.01) in the spatial scales and seasonal alternation according to the Kruskal-Wallis test, and only temperature presented insignificant differences on a spatial scale. A slight seasonal fluctuation in water quality parameters were observed due to strong water current. Some characteristics of the surface sediment of the Klang Strait are shown in Table 1. Analysis of the sediment particle size demonstrated that fine-particle predominated in sediments from most of the stations (41%- 95%). The TOC varied between 5%-25% and was positively correlated with fine fraction in most of stations. There were significant differences in the values of TOC and fine fraction in sediments among different stations, whereas the variation of these parameters was insignificant at temporal scales (Table 1).

In North Port, significant positive correlation ($r > 0.60$; $p < 0.05$) was observed between macrobenthic community composition (abundance, biomass, diversity, and richness of benthic species) and fine fraction of sediment and TOC, while sand fraction and depth of water showed strong negative correlation with macrobenthic composition (Table 2).

TABLE I

RESULTS OF STATISTICAL ANALYSES FOR ENVIRONMENTAL PARAMETERS IN SPATIAL AND TEMPORAL SCALE

Sites	Station Code	*Find fraction (%)	Sand (%)	TOC (%)	Depth (meter)	Salinity (‰)	TS (mg/L)	DO (mg/L)
North Port	**1**	60.1	39.895	12.445	15.15	30.15	69.26	62.31
	2	49.63	50.36	10.13	20.5	30.81	68.78	62.61
	3	73.77	26.22	17.04	10.3	31.24	72	61
	4	59.78	40.21	11.41	13.5	30.81	65.32	62.19
	5	50.89	49.1	10.08	21.6	31	64.32	62.87
	6	65.19	34.8	14.71	11.2	31.36	71.11	60.39
Control Point	**22**	51.6	48.39	10.46	17.5	31.3	46.41	65.87
Asymp. Sig between stations (KW)		0.00	0.00	0.00	0.00	0.001	0.00	0.003
Asymp. Sig between seasons (KW)		0.09	0.07	0.07	0.23	0.002	0.001	0.00
Asymp. Sig between years (WMW)		0.11	0.09	0.12	0.28	0.08	0.09	0.06

KW: Kruskall-Wallis test; WMW: Wilcoxon-Mann-Whitney test;significant at p< 0.05 or 0.01; DO: Dissolved Oxygen;TS: Total Solid; TOC: Total Organic Carbon; Fine fraction: Silt and clay (<64 µm)%

TABLE II
RESULTS OF CORRELATION ANALYSES IN NORTH PORT RECORDED IN SPATIAL AND TEMPORAL SCALES

Benthic Structure	Fine Fraction	Sand	TOC	Salinity	TS	DO	Depth
Abundance	0.73	-0.73	0.70	0.35	0.47	-0.37	-0.73
Richness	0.79	-0.79	0.83	0.29	0.43	-0.33	-0.79
Biomass	0.70	-0.70	0.77	0.39	0.33	-0.33	-0.70
Diversity	0.73	-0.73	0.87	0.14	0.40	-0.30	-0.73

B. Macrobenthic Composition

A total of 25 species were collected from the 7 sampling stations across eight sampling periods during the two years of study including Individual species of bivalves constituted 35.69% of the total abundance, followed by crustacea (25.78%), polychaeta (15.9%), gastropoda (14.6%). Species of other groups were less diversified (Table 2). Kruskal-Wallis analyses showed significant differences between species richness and diversity at all sampling stations (sig j= 0.0, Sig H' = 0.007). An insignificant difference was observed between species richness and diversity across seasonal alternation (sig j= 0.07, sig H' = 0.12) and years (sig j= 0.06, sig H'= 0.11) (Table 3). The average abundance (individual 100 m^{-2}) and biomass (g m^{-2}) of individual species were 1436±612 and 1.5±0.54, respectively, at North Port. Results showed significant differences in abundance (sig = 0.0) and biomass (sig = 0.0) for all macrobenthic species between stations (Table 3).

TABLE III
RESULTS FOR MACROBENTHIC SPECIES IN NORTH PORT RECORDED IN SPATIAL AND TEMPORAL SCALES

Station Code	1	2	3	4	5	6	22	Mean	Stations (KW)	Years (WMW)	Season (KW)
Mean total abundance (Individuals m^{-2})	1081	676	1584	1180	843	1584	2341	1436	0.00	0.714	0.133
Standard deviation of abundance	296	274	242	434	230	590	502	612	0	0	0
Mean species richness (j)	14	13	15	13	11	17	22	11	0.00	0.06	0.07
Mean species biomass (g m^{-2})	1.2	0.8	2.3	1.5	1.3	2.5	3.4	1.5	0.00	0.701	0.144
Mean Species diversity (H)	3.15	3.06	4	3	2.8	3.17	4	2.7	0.007	0.11	0.12

IV. Discussion

Based on the several research, the key parameters constraining the structure of benthic communities include sediment type, organic compounds, oxygen levels, salinity, food availability, hydrodynamic energy, and anthropogenic stresses [11, 12, 14]. The benthic community's response to these parameters is further complicated by spatial and temporal changes in the community composition [12, 13].

Although the small changes were observed in the abundance, biomass, diversity and richness in temporal scales with an upward trend from November until August, these variations were not significant in temporal scales (Table 1). Abundance and diversity of benthic species are proposed to be controlled mainly by fluctuations in marine and coastal environment [15-17]. This result showed that the climatic variables were insignificant parameters to control distribution macrobenthic communities in the Klang strait coastal area. The correlation analysis was in good agreement to confirm this result because it showed a week negative correlation ($r < 0.4$) between benthic composition and water current in Klang strait.

In spatial scale, sampling stations across the mangrove edge had a same configuration, with high organic content (12-17%), soft and muddy substratum (63-74% fine fraction), and shallow water (7-11 m) that are suitable for settlement for diverse benthic species. In the North, data showed that water depth, sediment particle size and TOC controlled the spatial distribution of benthic species as the macrobenthic composition was strongly correlated with these parameters. This study also showed that the high TOC along the mangrove edge could not suppress the colonization of benthic species because the organic enrichment was not strong enough to result in extreme oxygen depletion, rather it provide a rich food source for the benthic community. In addition, the stations across the mangrove forest are located far (2-3 km) from sources of anthropogenic contamination, which could be another potential reason for high species abundance and diversity.

All the stations along the berth line (100 m after berth line) and in the middle of the strait (1000 m after berth line) had coarser and sandy sediment (40-50%), deep water (12-22 m) that results in decreased abundance (521-1187 individual 100 m^{-2}), biomass (0.8-1.5 g m^{-2}), richness (7-13), diversity (2.30-3.15 bits. $individual^{-1}$). Anthropogenic discharge from industrial outlets and port activities are likely to be the other reasons for reduced macrobenthic abundance, and is likely to suppress macrobenthic community development in these stations. In general, the present study demonstrates that the variation of the macrobenthic community composition was highly related to sediment characteristics (particles size and

TOC), while water depth and anthropogenic discharge were secondary disturbances that hinder macrobenthic community development in the North Port.

V. Conclusion

Macrobenthic composition in control site and stations along the mangrove edge was higher than that in adjacent berth line with different species diversity and functional groups. Similar approaches based on multivariate analysis suggest that environmental parameters such as TOC, fine particle size, and water depth are the main descriptive parameters in terms of the macrobenthic composition especially around mangrove edge. Likewise, this result provides insight into impacts of anthropogenic pollutants (land based runoff, industrial and domestic waste disposal) on benthic community of North Port coastal waters. Outcomes of the present study can be a baseline for creating a management approach and modeling macrobenthic community variation in marine and coastal waters.

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