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HEALTH STATUS OF RECREATIONAL BEACHES IN ISKANDAR DEVELOPMENT REGION, JOHOR, MALAYSIA

(Status Kesihatan Pantai-Pantai Rekreasi di Wilayah Pembangunan Iskandar, Johor, Malaysia)

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Abstract

This study aims to evaluate the health status of recreational beaches in Wilayah Iskandar development area Johor. The nematode/copepod ratio may be used as useful tool for assessing the environmental quality of the beaches. The meiobenthos samples were collected using a PVC corer at three stations at intertidal zone along beaches in Wilayah Iskandar. Four sampling sessions were conducted in March, April, May and June 2009 during low tide. Physico-chemical parameters including salinity, pH, dissolved oxygen and temperature were measured *in situ* at each station using YSI multi probe MPS 556 and sediment samples were collected for chlorophyll *a* analysis. The chlorophyll-a concentrations were determined based on the spectrophotometric method using 665 nm wavelength. The ratio showed a wide variability between stations with highest values recorded at Station 3 (2.25 to 131.1) and lowest at Station 2 (0.99 to 15.53). The overall ratio of nematode/copepod could be related to the increase of potentially polluted area along the beaches such as at Station 3. The presence of pre-diapause copepod which is able to survive **in** the environment condition stress becomes a good indicator for the health status of beaches in Wilayah Iskandar development area.

Keywords: Iskandar Development Region, beach, nematode/copepod, ratio, meiobenthos

Abstrak

Kajian ini dilakukan untuk menilai status kesihatan pantai-pantai rekreasi di kawasan Wilayah Pembangunan Iskandar. Nisbah nematod/kopepod boleh digunakan sebagai alat yang berguna untuk menilai kualiti persekitaran pantai-pantai tersebut. Sampel meiobentos diambil dengan menggunakan tiub pengorek PVC pada tiga stesen di zon pasang surut sepanjang pantai-pantai di Wilayah Iskandar. Empat sesi penyampelan telah dilakukan pada bulan Mac, April, Mei dan Jun 2009 semasa air surut penuh. Parameter fizikokimia termasuk kemasinan, pH, oksigen terlarut dan suhu diukur secara *in situ* di setiap stesen dengan menggunakan YSI multi probe MPS 556 dan sampel sedimen diambil untuk analisis klorofil *a*. Kepekatan klorofil-a ditentukan berdasarkan kaedah spektrofotometrik menggunakan gelombang 665 nm. Nisbah tersebut menunjukkan kepelbagaian yang tinggi di antara stesen-stesen dengan nilai yang tertinggi dicatatkan di Stesen 3 (2.25 to 131.1) dan nilai terendah di Stesen 2 (0.99 to 15.53). Keseluruhan nisbah nematod/kopepod berkemungkinan berkait rapat dengan peningkatan kawasan yang berpotensi tercemar di sepanjang pantai tersebut contohnya seperti di Stesen 3. Kehadiran kopepod di peringkat *'pre-diapause'* yang mampu hidup dalam keadaan tekanan persekitaran dapat dijadikan penunjuk yang baik untuk status kesihatan pantai-pantai di kawasan Wilayah Pembangunan Iskandar, Johor.

Kata kunci: Wilayah Pembangunan Iskandar, pantai, nisbah nematod/kopepod, meiobenthos

Introduction

Tourism and recreational activities have been known to represent disturbances and been linked to pollution and industrialization that may affect spatial heterogeneity, structure and dynamics of natural community [1]. The impacts caused directly by recreational activities are becoming important environmental issues [2]. To date, most tourism-impact studies have been mainly focused on changes in abundance and diversity of large macrobenthos, loss of individual species or decreasing populations of shore birds, whereas smaller animals were largely neglected

[3,4]. However, Kennedy and Jacoby (1999) indicated the meiobenthos are more diverse than any other marine benthic component and moreover as an excellent indicator of marine environmental quality [5]. At present, many studies have been carried out on the use of meiobenthos as biological indicators and they have been widely used as tools for environmental monitoring. The use of meiobenthos as tools in monitoring environmental changes has been discussed by several authors in previous studies [6,7,8].

Raffaelli and Mason (1981) were the first who proposed the use of nematode to copepod ratio as a tool for biomonitoring [9]. They showed that the overall ratio of nematode/copepod increased with increasing degree of pollution. Recently, the nematode/copepod ratio is suggested as a potentially useful for biomonitoring habitats and it has been use as an indicator of pollution in harbour ecosystems [10]. However, the validity of this technique subsequently argued by several authors that it is not universally applicable to all habitats [11,12]. Lambshead (1984) concluded that the ratio is unreliable due to the difficulties in separating the effects of pollution on the ratio from the effects of other environmental variables [12]. The present study was carried out to examine the nematode/copepod ratio and the spatial distribution of the meiobenthic communities in determining the health status of recreational beaches in Wilayah Iskandar development area, Johor.

Experimental

Study area

Facing the Johor Straits, the recreational beaches in Wilayah Iskandar development area, Johor Bharu is one of the most famous tourist attractions of Johor. It covers an area of approximately 450-acre (1.8 km^2). Three stations (Figure 1) were chosen for the study area. Station 1 (01°27′23.44″N, 102°42′49.0″E) which is close to War Memorial in the lower part of the bay consisted of white medium sand on the beach. Station 2 (01°27′54.34,″N 103°43′47.20″E) is about 2 km away from Station 1 is covered with scattered patches of seagrass beds and macroalgae, *Padina sp*. The sediment textures primarily consist of coarse sand in the uppermost beach. Station 3 (01°28′38.78″N, 103°43′16.64″E) is situated near to the boats and ferries parking spot with medium sand and hard clay sediment.

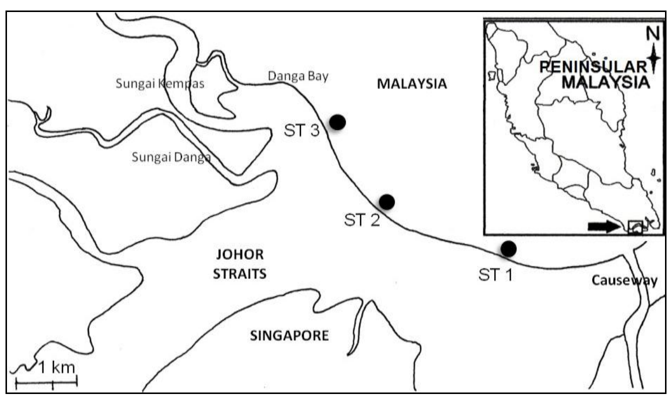

Figure 1: Map of sampling stations at Wilayah Iskandar development area

Sampling

Sampling sessions were carried out in intertidal zone at Lido beach (March, April, May and June 2008) during low tide. At each site, the meiobenthos samples were collected by inserting the PVC hand core with 3.4 cm of inner diameter on the sediment down to 10 cm depth [13]. Five replicates of sediment samples were collected at three quadrates (Q1, Q2, Q3) along a transect laid from uppermost to the low tide level of the beach. Q1, Q2, and Q3 are located at the upper, middle and lower level of the beach. Core samples were then transferred into labelled plastic bags and immediately fixed with 10% buffered formaldehyde [14].

An additional sediment samples at each sampling station were taken and brought back to the laboratory for chlorophyll *a* analysis. Environmental parameters of the overlying water such as temperature, salinity, dissolved oxygen concentration and pH were measured *in situ* at each station using YSI 556 Multi-probe meter.

In the laboratory, meiobenthos was extracted from the sediment using decantation method [14]. The samples were sieved with a 63 µm sieve and all the organisms specimens were preserved in labeled bottles containing 5% neutralized formalin mixed with Rose Bengal stain. Samples of meiobenthos were sorted and enumerated into different taxa under a stereo microscope.

Chlorophyll-a concentration was determined using spectrophotometric method [15]. The sediment of 2.5 cm section were weighed, thawed and placed in a screw cap dark glass bottle with addition of 20 ml of 100% acetone at 4^oC in the dark for 24 hours for the complete pigment extraction. Then 3 ml of clarified extract were added to the cuvette, measured at 665 nm using Perkin Elmer Spectrophotometer. A drop of 0.1 N HCI were added and re-read at 665 nm after 2 min. The concentration of chlorophyll *a* in the extract solvent was calculated using the equations [16].

Data analysis
The density of meiobenthos was expressed as number of individuals (N) per unit area ($10\ cm^2$) based on the mean of five replicate cores. Analysis of similarities one-way ANOSIM was used to test the significant differences between multivariate groups of samples from different sampling stations. The similarity matrices for cluster and MDS analysis was generated using Bray-Curtis similarity of a square-root transformed data. All univariate indices and multivariate measures were performed using the PRIMER (Plymouth Routines in Multivariate Ecological Research) software v5 package [17].The nematode to copepod ratio (N:C ratio) was calculated by dividing the number of nematodes in a sample by the number of copepods [9]. It was calculated as mean of all N:C values found in the sedimentary environments at each sampling location.

Results and Discussion

The environmental parameters of sampling stations are shown in Table 1. Temperature and pH showed small variations between the three beaches at Wilayah Iskandar development area. Low dissolved oxygen of overlying water was noted at certain area at Station 3 (3.66 mg/L). The water quality at these areas was observed to be in poor conditions as the area was polluted by oil and grease from the boat activities near to the beaches. Low concentration of chlorophyll-a in the sediment at the area also showed the worse environmental conditions and almost totals absence of other groups of meiobenthos. Less water circulation resulting less dilution of contaminant, thus increase the effect of pollution to the area.

Table 1: Environmental parameters at each sampling station in Wilayah Iskandar.

Environmental parameters	Station 1	Station 2	Station 3
Salinity (psu)	20.57±2.63	18.66±7.32	8.54±8.2
Temperature (^oC)	28.74±1.14	29.63±0.64	28.51±1.3
pH	7.57±0.32	7.58±0.2	7.32±0.47
Dissolved oxygen (mg/L)	7.47±3.34	6.5±1.62	3.66±1.1
Chlorophyll-a ($mg\ m^{-3}$)	0.14±0.05	0.55±0.13	0.05±0.06

Five taxa were recorded from the meiobenthic samples in Wilayah Iskandar development area beaches; Nematoda, Harpacticoida, Oligochaeta, Polychaeta and Isopoda (Figure 2). At all sampling stations, nematodes were the most abundant taxon with a mean density ranged from 54.03 to 263.8 ind.10 cm^{-2}. They numerically dominated all stations, accounting for 68% of the total meiobenthos (Figure 3). Polychaetes were the second dominant group at

Station 1 (13.4 to 76.7 ind.10cm^{-2}), accounting for 9% of the total meiobenthos while harpacticoid copepod for 8%. Higher average total meiobenthos densities were noted at Station 2 (141.7 to 444.2 ind.10 cm^{-2}) followed by Station 1 (183.5 to 325.5 ind.10cm^{-2}) while Station 3 recorded lowest values (69 to 192.4 ind.10cm^{-2}). Only pollution-tolerant taxa as polychaetes and nematodes recorded high in density at Station 3 [18]. The low values of density if compared to other studies [19,20,21] and the dominance of pollutant-tolerant group such as nematodes and polychaetes [22,23,24,25] suggest the existence of pollution at the recreational beaches.

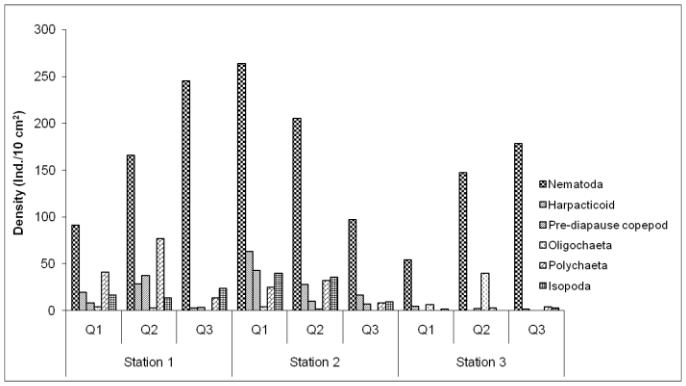

Figure 2: Mean density (Ind.10cm^{-2}) of meiobenthic taxa at the three sampling stations

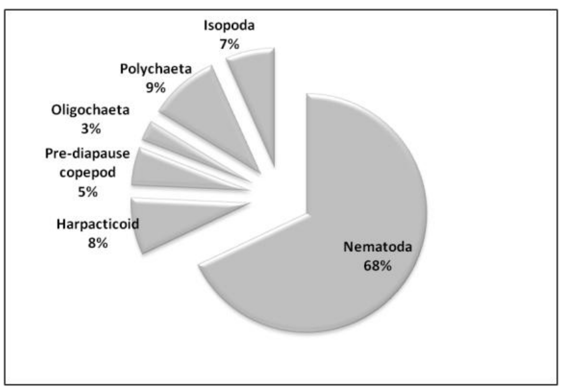

Figure 3: Composition of meiobenthos group at three sampling stations

Gheskiere *et. al* (2005) reported that tourism related activities are particularly affecting the sandy beach meiobenthos in the upper beach zone [26]. The lowest density of meiobenthos (Figure 2) as shown in the upper beach zone (Q1) (Station 1 and Station 3) was found to correlate to such disturbances. Effects of tourist at upper beaches are characterized by a lower percentage of total organic matter (% TOM), lower densities and diversities of meiobenthos compared to non-tourists locations. The one-way ANOSIM tests showed that the meiobenthic communities at sampling stations differed significantly between stations (R: 0.29, P: 0.04) but no significant differences was found between the tide levels (R: 0.05, P: 0.3). The MDS ordination plot of meiobenthic community did not show any clear trend across samples (Figure 4). However, the samples from Station 3 showed high dispersion in the plot, indicating high variability in the structure of their communities. The multivariate approach is important for description of heavily stressed communities characterized by high variability in their structure and low number of counted individuals [27]. Caswell and Cohen (1991) hypothesized that disturbance might induce higher spatial variability in assemblages due to community stress [28]. Warwick and Clarke (1993) have also consistently recorded increased variability among replicates from several benthic communities (meio- as well as macrobenthos) exposed to increasing disturbance levels [27].

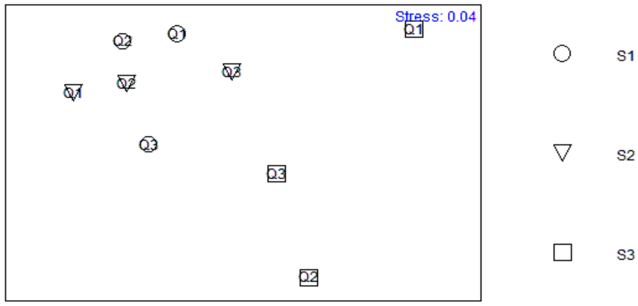

Figure 4: MDS ordination plot based on meiobenthos density at three sampling stations

Values of the nematode/copepod ratio of each station at Wilayah Iskandar development beach are presented in Table 2. The ratio showed a wide variability between stations with highest values were recorded at Station 3 (11.8 to 101.7) and lowest at Station 2 (2.5 to 5.4). The high ratio at Station 3 (>100) could indicate that the area has been polluted. Station 1 and Station 2 recorded lower (<100), than that was proposed by Raffaeli and Mason (1981) for gross polluted situations [9]. Among the two dominant groups of meiobenthos, copepods are more sensitive to environmental stress than nematodes, so that high nematode/copepod ratios might be indicative of pollution situations with higher nematodes density. The ratio increases with organic pollution [29].

The overall ratio which is larger than 100 clearly suggest that the beaches are considerably polluted. Human activities such as recreational boating contribute to the decline in harpacticoids and meiobenthos abundances. Many studies have reported that marine copepods are known to be sensitive to oil and other pollutants [30,31]. The harpacticoid copepod density may provide a useful indicator that can be used in interpreting the health of the ecosystem. The depletion in their densities may reveal the stress or alteration of the health of their habitat.

Table 2: Values of nematode/copepod ratio and densities of nematodes and harpacticoid copepods (Ind/10cm^2) at three sampling stations

Station	Station 1			Station 2			Station 3		
Q	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
N	91	166	245	264	105	97	54	147	178
C	28	66	7	106	38	24	5	3	2
N:C	3.22	2.51	37.26	2.5	5.4	4.11	11.81	50.72	101.7

The presence of pre-diapause copepods was noted at the three beaches of Wilayah Iskandar development with the mean density ranged from 2.2 to 42.8 ind.10cm^{-2} (Figure 2). The behavioural response of copepods to undergo this pre-diapause stage at sampling stations is suggested to be due to their response towards environmental stress in their habitat. It is an adaptation of copepods to survive or avoid stressful and unfavourable environmental conditions [32]. Stressed benthic environment as a result of low water quality at the beaches might trigger their occurrence. This dormant copepod has the potential to become a useful tool for environmental parameters indicator and their existence may indicate environmental stress condition in ecosystems. Dale *et. al* (1999) reported that dinoflagellate cysts can be useful indicators of the development or presence of eutrophication in recent marine environments [33]. Their surveys can give early warning of the presence of toxic species in a given area [34].

Conclusion

Within meiobenthos, nematodes and harpacticoids are the important group to be used as a tool for environmental monitoring to determine the health status of recreational beaches. The nematode/copepod ratio and the presence of pre-diapause copepod at the sampling stations indicated that the recreational beaches of Wilayah Iskandar could be under exposure of contaminant from human activities.

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