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Coastal water quality of Tioman Island: effects of human activity and the distance from shoreline

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ABSTRACT

A study was conducted to know the (i) effect of anthropogenic activity and (ii) effects of distance from shoreline on the coastal water quality of Tioman Island, Malaysia. This study was a part of marine expedition conducted on 4 July 2012 to understand coral diversity and distribution around coastal water of Tioman Island. A series of physicochemical parameters namely temperature, dissolved oxygen (DO), pH, salinity, transparency, total suspended solids, nitrate, ammonia, phosphate phosphorus, and silicate were determined in this study. A total of 16 different study sites (stations 1–16) were selected in the coastal water around the Tioman Island. Half of the study sites was located within 1 km from the shoreline and other half was located approximately 6 km away from the shoreline. Some study sites are characterized by no human activity, while some sites are characterized by diving activities. A few study sites are characterized with both diving activity and near residential area. The overall mean values of different water quality parameters recorded in the all sampling stations were temperature 27.98 ± 0.40 °C, pH 8.34 ± 0.02, DO 6.92 ± 0.43 (mg l^{-1}), salinity 33.54 ± 0.11 pss, TSS 0.39 ± 0.03 g l^{-1}, nitrate 0.85 ± 0.55 μM, ammonia 1.89 ± 0.56 μM, phosphate 0.16 ± 0.09 μM, and silicate 2.62 ± 0.76 μM. Temperature, DO, transparency, salinity, and ammonia were significantly affected by anthropogenic activity, while anthropogenic activity had no significant effect on pH, total suspended solids, nitrate, and phosphate. No significant difference was observed between the water quality of 1 km from shoreline and 6 km away from shoreline. Good and careful management by the authorities of this island may save the biodiversity and beauty of the coastal water of Tioman Island. Therefore, a balance between human activity and conservation of biodiversity on the coastal water of Tioman Island is needed.

Keywords: Salinity; Dissolved oxygen; Ammonia; Transparency; Malaysia

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1. Introduction

Besides natural geological and oceanographic processes, coastal water quality is greatly influenced by anthropogenic activities. The anthropogenic impacts to coastal water quality mainly come from land, shoreline, and marine activities. However, coastal water quality has been dramatically changing in the last decades due to intensification of many different anthropogenic activities including aquaculture, fishing, and urbanization along coastal areas [1,2]. Aquaculture discharges majority of fish feed nutrients (65–89% nitrogen and 64–87% phosphorous) in the surrounding environment [3–6]. The amount of waste in the form of nitrogen more than doubled in the coastal water of the world from 1960 to 1990 [7]. This has led to rapid deterioration of water quality in many coastal water of the world [1,8,9]. However, deteriorating water quality can have many ecological, social, and economic effects. These include the loss of marine plant and animal, and restriction of recreational use [10].

Tioman Island is the largest island on the east coast of Peninsular Malaysia. This island is a popular tourist destination in Malaysia. It is surrounded with beautiful beaches that brimming with beautiful fishes, corals, and many other marine life [11]. The rare giant clam and several types of corals are also observed around the Tioman Island. In addition to these, the island is also very important for its unique marine ecosystems [11]. Therefore, the marine area around the Tioman Island has been gazetted as marine reserves and marine parks under the Malaysian Fisheries Act 1985. This marine reserve area is confined to an area at the lowest tide two nautical miles toward the ocean. Presently, many people think that fishing and other human activities are destroying marine fauna and flora such as fishes, coral reefs, and aquatic floras of marine reserve area in Tioman Island. It is assumed that the overall quality of Tioman Island's coastal waters must be good due to very light residential development, although some people think that currently, the coastal water of Tioman Island has been under pressure those from residential sewerage. Currently, nothing is known about the water quality of the marine area around the Tioman Island. However, understanding the quality of Tioman coastal water is important for its proper management. Rules and legislation can be applied to ensure good water quality to protect coastal ecosystem of Tioman Island. Therefore, a study was conducted to know the status of water quality on the coastal water of Tioman Island. The main objectives of this study were to know the (i) effects of anthropogenic activity and (ii) effects of distance from shoreline on the water quality of the coastal water around the island.

2. Materials and methods

This study was conducted in coastal water of Tioman Island, which is located at the 2˝35˝N and 104˝15˝E in the South China Sea (32 km from Mersing, Johor and 80 km from Kuala Rompin, Pahang). This study is a part of marine expedition on coral diversity and distribution around coastal water of Tioman Island. A series of physicochemical parameters (temperature, dissolved oxygen (DO), pH, salinity, transparency, total suspended solids (TSS), nitrate, ammonia, phosphate phosphorus and silicate) were determined in this study. For this study, a total of 16 different study sites (stations 1–16) were selected in the coastal water around the Tioman Island (Fig. 1). Stations St 1, St 3, St 5, St 7, St 9, St 11, St 13, and St 15 were the near-shore stations, which were located within 1 km from shoreline. Stations St 2, St 4, St 6, St 8, St 10, St 12, St 14, and St 16 were located approximately 6 km away from shoreline. There is no human activity (NA) in stations St 1–St 6, while diving activities are observed in stations St 7, St 8, St 15, and St 16. Stations St 9–St 14 were characterized with both diving activity and near residential area.

All water samples for physical and chemical parameters determination were collected on 4 July 2012. Temperature, DO, pH, and salinity were recorded directly in the field at each sampling station using a portable Hydrolab equipment (Hydrolab Minisonde® water quality multiprobes). Water transparency was determined using a Secchi disk. Water samples were taken from 0 to 5 m depth for determining TSS, nitrate, ammonia, phosphate, and silicate. They were determined according to Persons et al. [12].

3. Results and discussion

This is first extensive study that determined the quality of Tioman coastal water. The overall mean values of different water quality parameters recorded in all sampling stations were temperature 27.98 ± 0.40 ˚C, pH 8.34 ± 0.02, DO 6.92 ± 0.43 (mg l^{-1}), salinity 33.54 ± 0.11 pss, TSS 0.39 ± 0.03 g l^{-1}, nitrate 0.85 ± 0.55 μM, ammonia 1.89 ± 0.56 μM, phosphate 0.16 ± 0.09 μM, and silicate 2.62 ± 0.76 μM. The water temperature of Tioman coastal water varied from 27.2 ˚C (St 9) to 28.5 ˚C (St 5), which was more or less constant. In this study, it was observed that different anthropogenic activity significantly affected some water quality parameters (Table 1). Temperature, DO,

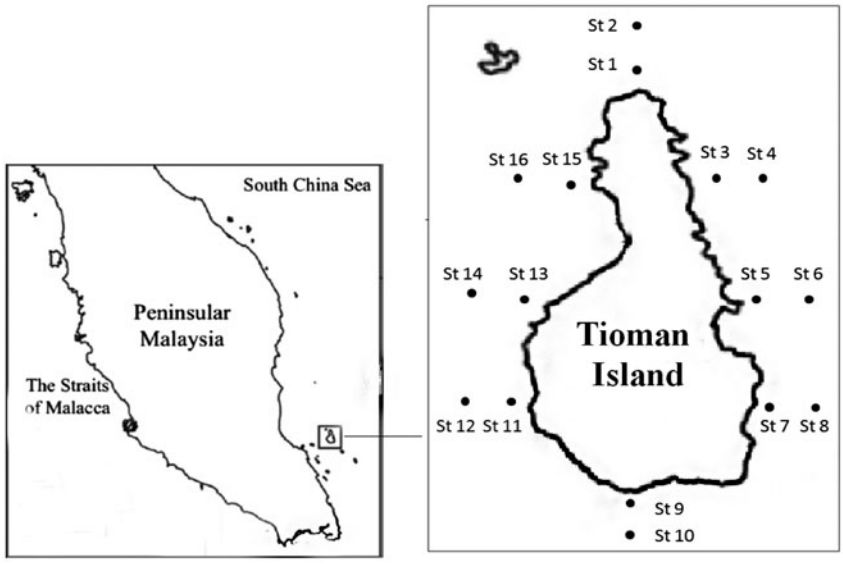

Fig. 1. Map of Tioman Island showing all sampling stations.

Table 1
Effects of anthropogenic activity on the water quality in the coastal water of Tioman Island, Malaysia

Parameters	Significant (p value)	Tukey test		
		NA	SNA	RAOA
Temperature (℃)	*	28.28 ± 0.22^{a}	27.95 ± 0.14^{ab}	27.67 ± 0.45^{b}
DO (mg l^{-1})	**	6.48 ± 0.14^{c}	7.41 ± 0.31^{a}	7.03 ± 0.16^{b}
pH	ns	8.29 ± 0.06	8.21 ± 0.12	8.25 ± 0.15
Salinity (pss)	*	33.46 ± 0.13^{b}	33.53 ± 0.09^{ab}	33.62 ± 0.03^{a}
Transparency (m)	*	14.25 ± 4.96^{a}	8.75 ± 2.63^{ab}	7.50 ± 1.87^{b}
TSS (g l^{-1})	ns	0.37 ± 0.02	0.40 ± 0.04	0.40 ± 0.04
Nitrate (μM)	ns	0.59 ± 0.41	0.74 ± 0.30	1.20 ± 0.68
Ammonia (μM)	**	2.31 ± 0.14^{a}	2.25 ± 0.32^{a}	1.23 ± 0.06^{b}
Phosphate (μM)	ns	0.152 ± 0.044	0.134 ± 0.032	0.189 ± 0.146
Silicate (μM)	ns	2.36 ± 0.76	2.88 ± 0.76	2.71 ± 0.81

Notes: NA refers the stations, which are characterized by no activity; SNA refers the stations, which are characterized by SNA; RAOA refers the stations, which are located near residential area. Data are mean ± standard deviation. Mean values in the same row with no superscript in common differ significantly ($p < 0.05$). If the effects are significant, ANOVA was followed by Tukey test. *$p < 0.05$; **$p < 0.01$; ns, not significant.

transparency, salinity, and ammonia were significantly ($p < 0.05$) affected by anthropogenic activity, while anthropogenic activity had no significant effects ($p > 0.05$) on pH, TSS, nitrate, and phosphate.

Water temperature was lower in the stations, which are located near residential area (RAOA) than the stations, which are characterized only by snorkeling activity (SNA) and followed by the stations with NA (Table 1). The possible reason of lower water temperature in the stations near residential area might be due to more agitation of water by human activity (both residential and snorkeling activities). Agitation helps mixing of surface and bottom water that resulted lower temperature in the stations located near residential area than the stations characterized by only SNA and no activity [13,14]. Mixing of surface and bottom water through human activity can also explain why oxygen concentration was higher and water transparency was lower in stations near residential area than other stations. Nitrate and phosphate were higher in stations RAOA than the stations SNA and following by the stations NA. The possible reason of highest nitrate and phosphate in the stations near residential area might be due to organic and inorganic

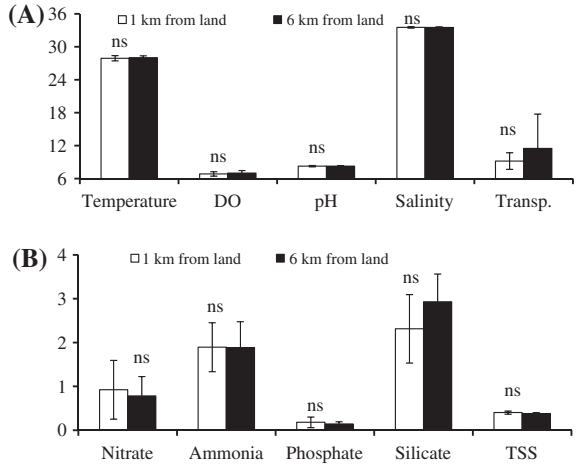

Fig. 2. Effects of distance from shoreline on temperature (°C), DO (mg l^{-1}), pH, salinity (pss), and transparency (m) (A); and nitrate (μM), ammonia (μM), phosphate (μM), silicate (μM), and TSS (g l^{-1}) (B) in the coastal water of Tioman Island. Data are mean ± standard deviation.

wastes, which are normally discharged from residential area. The organic and inorganic wastes are normally very rich in nitrogen and phosphorous and increase nitrate and phosphate concentration of water after bacterial decomposition [15–18]. There is no previous study comparing the effects of human activities on the quality of Tioman coastal water. However, the result of the present study clearly indicated that the quality of Tioman coastal water is influenced by human activities.

In the present study, the water quality of 1 km from shoreline and 6 km away from shoreline was compared (Fig. 2). However, no significant different was observed between the water quality of 1 km from shoreline and 6 km away from shoreline. The possible reason of no significant different might be due to water current and tidal activities. High water current and tidal activities distributed heat and nutrients rapidly between water of 1 km away from shoreline and 6 km away from shoreline [19,20].

4. Conclusion

Coastal water around the Tioman Island is significantly influencing by human activities. Good and careful management by the authorities of this island may help in maintaining water quality in a suitable range, which can save the biodiversity and beauty of the coastal water of Tioman Island. Therefore, a balance between human activity and conservation of biodiversity on the coastal water of Tioman Island is needed. The results of this study are based on 1 d observation. A long-term research is needed to know more about the coastal water quality of Tioman Island.

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