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A Preliminary Study of Total Petrogenic Hydrocarbon Distribution in Setiu Wetland, Southern South China Sea (Malaysia)

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Abstract The distribution of total petrogenic hydrocarbon was investigated in the subsurface water of Setiu Wetland from July to October 2008. The concentration was quantified by UV-fluorescence spectroscopy and ranged from 4 to 121 μg/L (mean 60 ± 41 μg/L). Higher total petrogenic hydrocarbon concentrations were found in area with high boating activities suggesting that the contribution is likely related to fossil fuel combustion. The present study also revealed that the total petrogenic hydrocarbon values are still lower that those reported in Malaysian coastal waters.

Keywords Total petrogenic hydrocarbon · Subsurface water · Anthropogenic activities · Setiu Wetland · South China Sea (Malaysia)

Total petrogenic hydrocarbon (TPH) contamination has been an issue of concern in water quality study especially in the marine environment. As a result, many studies have been conducted on the distribution of TPH in the water column, sediments and aquatic organisms (Mohd Tahir et al. 1997; Shriadah 2001; Chouksey et al. 2004; Li et al. 2010; Venkatachalapathy et al. 2010). Sources of this contaminant are mainly from anthropogenic activities such as industrial discharge, direct spillage of petroleum products and shipping activities. However, some polycyclic aromatic hydrocarbon compounds, which would contribute to the TPH concentration measurements, can also be from biogenic sources such as diagenetic process of terrestrial organic matters but the contribution from these sources is relatively small. TPH was studied due to its potentially harmful effects on the aquatic organisms and humans as well. The widespread contamination by TPH is of major concern because of its toxicity, persistency and bioaccumulative nature.

The Setiu Wetland is situated at Setiu-Chalok-Bari-Merang River basin, Terengganu, Malaysia. The area covers many ecosystems such as estuary, mangrove, wetland and lagoon (WWF 2008). It is one of the few wetlands in the Peninsular Malaysia and has diverse ecosystems that offer a vast array of biological diversity and many utilizable natural resources. It is connected to the South China Sea through Kuala Setiu Baharu estuary. Freshwater inputs are from Setiu River and from a nearby natural lake (Berambak Lake) which is connected to the wetland via Ular River. Upstream activities, especially at Ular River, are dominated by agricultural activities of mainly palm oil plantations. The main activities within the wetland are aquaculture such as brackish water cage culture, pond culture, pen culture and oyster farming. In addition, surrounding villages within the wetland also produce the well-known Terengganu budu, fish and seafood based delicacies like fish crackers, dried anchovies and shrimp paste. There is also small jetty for boating activities in this area. As a result, many contaminants and associated waste products

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from these activities have found their way into the wetland via runoff and direct inputs (Suratman et al. 2005; Mohd Tahir et al. 2006). Despite the importance of the wetland ecologically and economically, there is lack of previous studies dealing with TPH. Thus, the aim of the study was to determine the TPH distribution along the area for future monitoring strategies in the region. This paper discusses the results for four samplings of a preliminary study.

Materials and Methods

Sampling was performed at approximately monthly intervals between July and October 2008 at stations shown in Fig. 1. Subsurface water samples (0.5 m depth) were collected using a Van Dorn sampler during the high tide. Extreme care was taken to avoid sample contamination with TPH from the sampling boat by collecting the water samples upstream from the engine. Samples were stored in glass bottles, acidified to pH 2–3 with concentrated sulphuric acid and transported back to the laboratory. The detail procedure of the analysis is described in Parson et al. (1984). Briefly, water samples were extracted three times with dichloromethane. Extracts were combined and dried over anhydrous sodium sulphate. It was then evaporated to dryness in a rotary evaporator and the concentrated sample was re-constituted in n-hexane. Extracts were stored in glass vials and stored refrigerated (−4°C) until analysis by spectrofluorometry. The fluorescence of the samples was measured by Varian spectrophotometer model Cary Eclipse using 310 nm for excitation and 374 nm for emission wavelengths. A calibration curve was produced with a crude oil standard. The method detection limit for TPH was 1 μg/L. Method efficiency in recovering TPH from water samples was carried out in the laboratory using artificial seawater. Artificial seawater was spiked with crude oil and extracted with method as detailed above. Recoveries from spiked samples were found to be 89 ± 14%. The data were then tested by two-way analysis of variance (ANOVA) at 95% significance level to show differences between sampling stations and dates.

Results and Discussion

The results are presented in Fig. 2 and show that TPH was present at all stations. Statistical tests showed that the TPH concentrations were significantly different ($p < 0.05$) between sampling stations and date of sampling. During the present study, both the minimum and maximum concentrations of TPH were recorded at station S6 with the values of 4 and 121 μg/L, respectively. The mean concentration of TPH for each station ranged between 33 and 71 μg/L. In general, there were two distribution patterns observed within the study area i.e. relatively lower concentrations were recorded at stations S1, S2 and S3 whereas higher concentrations were found in stations S4 to S10.

The distributions patterns were dependent upon different local inputs. Station S3 was located outside of the wetland, which could served as a baseline station with relatively low levels of TPH in coastal seawater. In addition, stations S2 and S3 were situated at the upstream of the wetland away from the influence of major anthropogenic activities. In

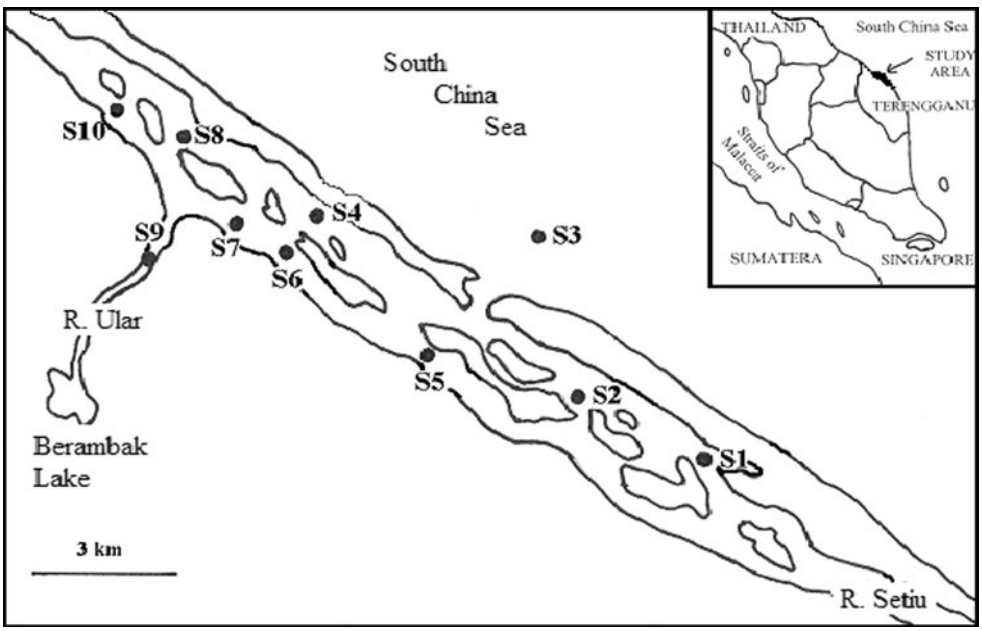

Fig. 1 Locations of sampling sites at Setiu Wetland

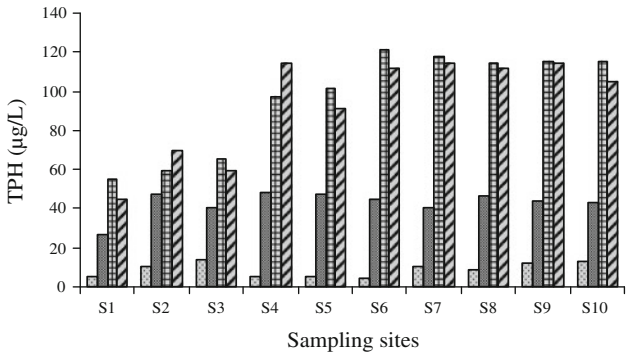

Fig. 2 Total petrogenic hydrocarbon (TPH) concentrations during the present study

contrast, relatively high concentrations were observed for the rest of the stations and were probably due to the presence of boating activities and settlement of people in this area. At these stations, there are aquaculture and activities involving seafood based especially near the stations S6, S7, S8 and S10. It is suggested that the sources of TPH include oil spills from the machinery used for food production and untreated effluents from these local industries flow into the wetland area. In addition, there is also a small jetty for boat landing near station S8. This jetty is used for commercial fishermen and aquaculture activities. High concentrations near the station may be due to operational discharge as well as fuel spills and engine leaks from boating activities. Previous studies also have shown that the major sources of TPH are attributed to the shipping activities, oil production activities and untreated residues from industries (El Samra et al. 1986; Abdullah et al. 1994; Mohd Tahir et al. 1997; Li et al. 2010). However, it is important to note that high concentrations of TPH were recorded at station S9 which received input from the palm oil plantation upstream of Ular River. Anthropogenic input at this station is mainly due to agricultural run-off that would consist primarily as fertilizer. The exact source of TPH at this site is therefore unknown.

TPH concentrations in the present study were compared with those previously reported in the literature (Table 1). However, it is should be noted that owing to the differences in the types of crude oil used as standard to obtain the TPH concentration, this comparison is only relative measure on extent of TPH pollution in the area surveyed. The concentrations of TPH in this study are significantly lower than those reported at Malaysian west coast coastal waters (Abdullah et al. 1994) and Strait of Johor (Abdullah et al. 1996). The authors attributed the high concentrations found at these two study areas were due to busy shipping activities (route and seaport) involving tankers and vessels and contribution from land-based industrial and urban sources. In contrast, lower concentrations of TPH were recorded at east coast Peninsular Malaysia waters (Mohd Tahir et al. 1997). With the exception of the coastal town of Kerteh which has crude oil terminals, there are no major industrial-based activities along the east coast area that could have contributed high significant TPH in the region. Higher concentrations of TPH in Setiu Wetland compared to those recorded by Mohd Tahir et al. (1997) were due to 'closed' nature system of the wetland. There is only a small open estuary for the Setiu Wetland compared to large area of the wetland. In addition, there is no output from the estuary to coastal waters during the low water because the estuary is closed. As a result, the movement of the water to the sea is restricted and may contribute to high TPH concentration in the wetland area.

Table 1 Comparison of total petrogenic hydrocarbon (TPH) with those of selected marine areas

Location	Concentration (µg/L)	References
Setiu Wetland (Present study)	4–121	Present study
Malaysian west coast coastal waters	5–386	Abdullah et al. (1994)
Malaysian east coast coastal waters	1.4–21.8	Mohd Tahir et al. (1997)
Strait of Johor, Peninsular Malaysia	25–2795	Abdullah et al. (1996)
UK Marine Waters	1.1–74	Law (1981)
Northwestern Arabian Gulf	1.2–546.4	El Samra et al. (1986)
Arabian Gulf and Oman Gulf	1.6–13	Shriadah (2000)
Bohai Bay, China	23.7–508	Li et al. (2010)

Comparing the results in the present study with those reported globally shows the TPH concentrations are lower than the northwestern Arabian Gulf (El Samra et al. 1986) and Bohai Bay, China (Li et al. 2010). The high concentrations at these locations were primarily from the heavy maritime transport of crude and refined oil, shipping activities and land-based untreated waste water discharges into the coastal areas. Although there are many industrialized regions in the UK and intense petroleum activity areas at Arabian and Oman Gulfs, these areas recorded lower TPH concentrations (Law 1981; Shriadah 2000). This is probably due to the sampling stations which were located at the offshore compared to our study. Generally, the concentrations of TPH in seawater is higher in near-coastal waters that the open sea (Barbier et al. 1973). Based on the classification by Food and Agricultural Organisation (FAO 1982), if concentrations of hydrocarbon are less than 2.5 µg/L in seawater, they can be considered as unpolluted. On this basis of this criterion, the concentrations found in Setiu Wetland are polluted with respect to TPH. However, the limited nature of this study means that a wider ranging study of TPH is needed and continued monitoring of this important parameter recommended.

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