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PETROLEUM HYDROCARBON IN SURFACE SEDIMENT FROM COASTAL AREA OF PUTATAN AND PAPAR, SABAH

(Petroleum Hidrokarbon di Dalam Sedimen Permukaan daripada Pesisiran Pantai Putatan dan Papar, Sabah)

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Abstract

Total petroleum hydrocarbons (TPH) and percent total organic carbon (TOC) were investigated in surface sediments from coastal area of Papar and Putatan, Sabah. Samples were collected in five different stations in each area by using Ponar grab sampler. Samples were extracted with Soxhlet, concentrated and analyzed by using UV/VIS spectrophotometer. The overall mean and range of TPH concentrations in the sediments from coastal area of Papar and Putatan were 1.95 (0.53 – 4.59 mg/kg dw Miri crude oil equivalents) and 0.85 (0.26 – 1.64 mg/kg dw Miri crude oil equivalents) respectively. Meanwhile, the TOC ranged from 0.81 – 2.32% and 0.35 – 0.81% respectively. Statistical analysis using Pearson correlation showed no significant differences between TPH and TOC ($p < 0.05$) in both areas.

Keywords: Total petroleum hydrocarbons, surface sediment

Abstrak

Jumlah petroleum hidrokarbon (TPH) dan peratus jumlah karbon organik (TOC) telah dikaji dalam sedimen permukaan dari kawasan pesisiran pantai Papar dan Putatan, Sabah. Sampel dikumpul dari lima stesen yang berbeza di setiap kawasan dengan menggunakan *Ponar grab sampler*. Sampel telah diekstrak menggunakan Soxhlet, dipekatkan dan dianalisis menggunakan UV / VIS spektrofotometer. Nilai min dan julat keseluruhan kepekatan TPH dalam sedimen dari kawasan persisiran pantai Papar dan Putatan adalah 1.95 (0.53 – 4.59 mg/kg bk, setara dengan minyak mentah Miri) dan 0.85 (0.26 - 1,64 mg/kg bk, setara dengan minyak mentah Miri) masing-masing. Sementara itu, julat TOC adalah di antara 0.81 – 2.32% dan 0.35 – 0.81% masing-masing. Analisis statistik menggunakan korelasi Pearson menunjukkan tiada perbezaan yang signifikan di antara TPH dan TOC ($p <0.05$) di kedua-dua kawasan.

Kata kunci: jumlah petroleum hidrokarbon, sedimen permukaan

Introduction

Hydrocarbons are ubiquitous constituents in aquatic sediments, relatively stable in the marine environment and often accumulate in biological communities and ecosystems, thus representing a human health hazard [1, 2]. Their sources can be either natural or anthropogenic. Hydrocarbons generated by biological or diagenetic processes naturally occur at low content in sediments, and are part of the natural hydrocarbon baseline of an ecosystem [3]. Aliphatic hydrocarbons derive from a variety of natural sources including terrestrial plants and marine algae [4] but they are also major components of petroleum. In marine sediments, especially in coastal areas, human activities are believed to be an important influence on hydrocarbons. Those activities include oil transportation and spill, shipping, and industrial, storm water and domestic discharge.

The subject of the research is sediment because sediment and sand is a good indicator for oil pollution in an area than the assessment of hydrocarbon in the water [5]. Bottom sediments of most aquatic systems are known to act as a reservoir or sink for petroleum hydrocarbons, trace metals, and some other pollutants [6]. Moreover, sediments are composite materials, which consist of inorganic components, mineral particulates and organic matter in various stages of decomposition, and are well known for their sensitive indicators between natural and anthropogenic variables [7]. The organic matter content of sediments, quantified by the concentration of total organic carbon (TOC), is thought to play an important role in the accumulation and release of different micro pollutants [8]. The input of organic matter to coastal systems is indeed the triggering mechanism leading to ecological concern [9]. TOC measurement provides information on all organic substance content in water or sediments [10, 11]. These substances either from natural sources, such as humic acids, mineral oils, solvents, pesticides, poly aromatic hydrocarbons or chlorinated organic compounds [12]. However, the quantity of TOC in the sediments/soils depends on the amount of organic matter added, sediment texture such as clay content, and climatic conditions [13].

Due to the lack of information regarding the concentration of petroleum hydrocarbons in the sediments of the coastlines of Sabah, this study was designed to determine the total hydrocarbon concentration (TPH) and total organic carbon (TOC) in the surface sediment of Papar and Putatan, Sabah (Table 1). Correlations with surface sediment TPH and TOC from sampling stations are discussed.

Table 1. Description of station in Papar and Putatan, Sabah.

Area	Station	Coordinate
Papar	A1	N 05°44.016’, E 115°53.387’
	A2	N 05°44.925’, E 115°53.672’
	A3	N 05°45.744’, E 115°54.323’
	A4	N 05°45.823’, E 115°55.594’
	A5	N 05°46.412’, E 115°56.731’
Putatan	B1	N 05°51.518’, E 116°02.043’
	B2	N 05°51.854’, E 116°02.168’
	B3	N 05°52.235’, E116°02.331’
	B4	N 05°52.715’, E116°02.514’
	B5	N 05°53.079’, E116°02.250’

Experimental

This study was conducted in January 2011. Surface sediment samples (0-1 cm) were collected using Ponar grab sampler from 5 stations in each area as shown in Table 1. Analysis of the top (1-2 cm) surface layer provides baseline data for present-day pollution [8, 14, 15, 16]. 10 g of sediments was dried in the oven at 105 °C for 2 hours for the moisture content analysis. The procedure used for TPH analysis was standard method sediment/sludge APHA 5520E [17]. 10 g of sediment was extracted with saturated hydrochloric acid (HCl) and 15 g magnesium sulphate ($MgSO_4$). After mashing the whole sediment sample, the sample was extracted with Soxhlet for 4 hours with 250 ml petroleum ether. The extracts were saturated using rotary evaporator and cleaned-up on silica gel columns. The eluate from the columns was concentrated with pure nitrogen and the TPH were analysed by using UV/VIS spectrophotometer Lambda 25 Perkin Elmer (excitation was at 239 nm and emission at 259 nm). A calibration curve was generated using Miri crude oil as arbitrary standard. Percentage of TOC was measured based on United Nations Environment Programme (UNEP)/MAP Athens (2006) method [18].

Results and Discussion

Table 2 shows the concentration of TPH and percentage of TOC in sediment collected along the coastal area of Papar and Putatan, Sabah. The overall range and mean of the TPH concentrations in both areas were 0.26 - 4.59 and 1.40 mg/kg dw Miri crude oil equivalents respectively, while TOC were 0.35 - 2.32% and 1.15% respectively.

Table 2. The TPH concentrations and TOC in sediment from Papar and Putatan, Sabah.

Area	Station	TPH (mg/kg) dw	TOC (%)
Papar	A1	2.82	0.81
	A2	4.59	1.91
	A3	0.79	2.09
	A4	1.05	2.32
	A5	0.53	1.04
	Mean	**1.95**	**1.63**
Putatan	B1	0.26	0.64
	B2	1.64	0.75
	B3	1.44	0.35
	B4	0.39	0.81
	B5	0.54	0.81
	Mean	**0.85**	**0.67**

The result shows that the higher TPH concentrations are found at station A2 which is Papar area. The range of TPH concentration at Papar area is 0.53 – 4.59 mg/kg dw and the mean is 1.95 mg/kg dw Miri crude oil equivalents. Meanwhile, the lower TPH concentrations are found at station B1 which is Putatan area. The range of TPH concentration at Putatan area is 0.26 – 1.64 mg/kg dw and the mean is 0.85 mg/kg dw Miri crude oil equivalents. The ranged of the TOC percentage in Papar and Putatan are 0.81 – 2.32% and 0.35 – 0.81% respectively. The highest level of TOC was recorded at station A4 (2.32%), meanwhile the lowest level was recorded at station B3 (0.35%). The mean of TOC at Papar area (1.6%) was twice the amount of TOC at Putatan area (0.67%).

The mean TPH concentration at Papar area was found to be twice higher than the mean at Putatan area. This is due to the main activity of fishing by boat. Papar area is well-known as a place which produces dried anchovy and dried salted fish. Boat is used as the main transportation to travel from land to reach the *bagang* (the traditional house made by wood at the ocean to catch anchovy). In addition, the water flushing out from the Papar River may contribute to the sources of hydrocarbon from land activities and vehicles which is close to the station A2. According to Tahir *et al*. [19], the variation between estuarine and coastal area may attribute to an insignificant input from inland hydrocarbon sources or due to efficient mixing in the estuarine zone. Alfred *et al.* [20] stated that the migration of hydrocarbon in sediment associate mainly with hydrothermal minerals and deep ground waters. So, the difference TPH concentrations in Papar and Putatan area may due to the differences in physical and biological characteristic of coastal area such as the sediment size, the composition of sediment and the species of organism present.

A comparison of the TPH from the present study with values reported in other parts in Malaysia is presented in Table 3. The results indicate that the TPH levels in Papar and Putatan is much lower than that found in Peninsular Malaysia [19, 21, 22, 23, 24]. The main contribution to the hydrocarbon pollution in Peninsular Malaysia was by shipping activities, illegal discharge of oily waste water by vessels and through the routine handling of crude oil at the terminals of refineries [22, 23, 24]. Tahir *et al*. [19] conducted a survey in coastal water and sediment of east coast Peninsular Malaysia and their study showed significant differences in the levels of TPH could be directly attributed to much higher maritime activities and major oil production companies along the east coast of Peninsular Malaysia. Abdullah [21] stated that the hydrocarbon concentrations are related not only due to possible sources of hydrocarbon but also the physical characteristic of the sediment samples. Clayey sediment contains more hydrocarbons compared to sandy sediment.

The sources and transportation of sedimentary organic matter composition can be used as physical indicator to the hydrocarbon concentration or organic pollution [25, 26, 27]. However, Simpson *et al.* [28] stated that the relationship between TPH and organic matter of sediment was only significant in a highly contaminated site. Al-Ghadban *et al.* [29] also stated that the efficiency of TOC in indicating TPH level and considered it to be authentic when TPH is present in high concentration. Statistical analysis of the result using Pearson correlation revealed that there is no significant difference between TPH and TOC at both areas ($P < 0.05$). It means that the level of TPH observed in the sediments of the coastlines of Papar and Putatan do not correlate significantly with TOC content in various stations.

According to the Food and Agricultural Organization [30], sediments containing hydrocarbon levels less than 100 mg/kg dry weight can be classified as unpolluted. Based on this classification, it can be stated that the levels of TPH obtained from the present investigation in both Papar and Putatan area are still below the alarming pollution level.

Table 3. Comparison of petroleum hydrocarbon levels in Papar and Putatan sediment with levels reported in other part in Malaysia.

Location	Petroleum Hydrocarbon in Sediment (mg/kg dw)	References
East coast Peninsular Malaysia	0.8 – 20.0	[19]
Straits of Johor	14.259 – 361.371	[22]
Port Dickson	21.73 – 74.50	[23]
Pulau Langkawi, Pulau Ketam, Tanjung Piai, Pulau Tioman and Kemaman.	18.2 – 847.4	[21]
Straits of Malacca	52 - 128	[24]
Papar and Putatan, Sabah	0.26 - 4.59	Present study

Conclusion

TPH and TOC in sediment from coastal area of Papar and Putatan, Sabah were quantified and compared. The mean TPH and TOC in surface sediment from Papar coastal area are 1.95 mg/kg dw Miri crude oil equivalents and 1.63% while at Putatan area are 0.85 mg/kg dw Miri crude oil equivalents and 0.67% respectively. The sediment samples in both areas can be concluded as non-polluted by petroleum hydrocarbon based on with FAO (1982) standard.

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