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Petroleum Hydrocarbon along the Coastal Areas of Port Dickson

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ABSTRAK

Kandungan hidrokarbon petroleum di dalam air dan pasir di sepanjang pantai Port Dickson telah dikaji di antara bulan Disember 1984 dan bulan November 1985. Min dan julat kepekatan hidrokarbon petroleum di dalam air masing-masing adalah 32.24 ppb dan 2.52-73.34 ppb. Manakala julat kandungan hidrokarbon petroleum di dalam pasir adalah di antara 2.1 dan 70.4 mg/kg pasir kering. Didapati bahawa turun naik kepekatan hidrokarbon petroleum yang ketara didapati di setiap stesen antara tarikh pensampelan dalam tempoh kajian ini diadakan. Kajian ini menunjukkan bahawa kawasan pantai Port Dickson telah dicemari oleh hidrokarbon petroleum tetapi peringkatnya masih agak rendah.

ABSTRACT

The petroleum hydrocarbon content in water and sand along the coast of Port Dickson was studied between December 1984 and November 1985. The mean and range of petroleum hydrocarbon in water were 32.24 ppb and 2.52-73.34 ppb respectively, while for the sand, the range was between 2.1 and 70.4 mg/kg dry sand. A pronounced fluctuation of hydrocarbon level in water with sampling date was detected at the sampling stations during the sampling period. The results indicated that the coastal area of Port Dickson carried some degree of hydrocarbon pollution.

INTRODUCTION

Port Dickson is a well known recreational beach situated in western Peninsular Malaysia. It faces the Straight of Malacca, one of the busiest routes for oil tankers in the world. It has been estimated that 4000 oil tankers carrying about 200 million metric tons of crude oil pass through this straits anually (Ridzwan *et al.* 1983). Tanker accidents and release of oily bilge water in the straits have created a potential risk of oil pollution in this area. Additionally, there are two oil refineries located in Port Dickson. These will make the coastal area of Port Dickson more prone to oil pollution. In the Straits of Malacca, except for a study of oil pollution which was carried out from January, 1979 to June 1980, under an IOC/WMO Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP) in the Indian Region (Sen Grupta 1980), no other studies of hydrocarbon distribution have been conducted. The objective of the present study was to assess the level of oil in the coastal waters and in the sand along the beach of Port Dickson.

MATERIALS AND METHODS

Study Area

A total of 5 sampling stations were established along the shoreline of Port Dickson (*Fig. 1*). The stations were visited 10 times between December 1984 and November 1985.

Sample Collection

Water samples were collected at half a metre depth with a 3-litre glass round bottom flask. Sand samples along the beach at each station were collected randomly by using a 30 cm × 30 cm quadrat. The top 1 cm of the sand was scooped out with a stainless steel spatula. Four

subsamples were taken, and wrapped in aluminium foil. The samples were kept cool and brought back to the laboratory. They were kept at –20°C until analysis.

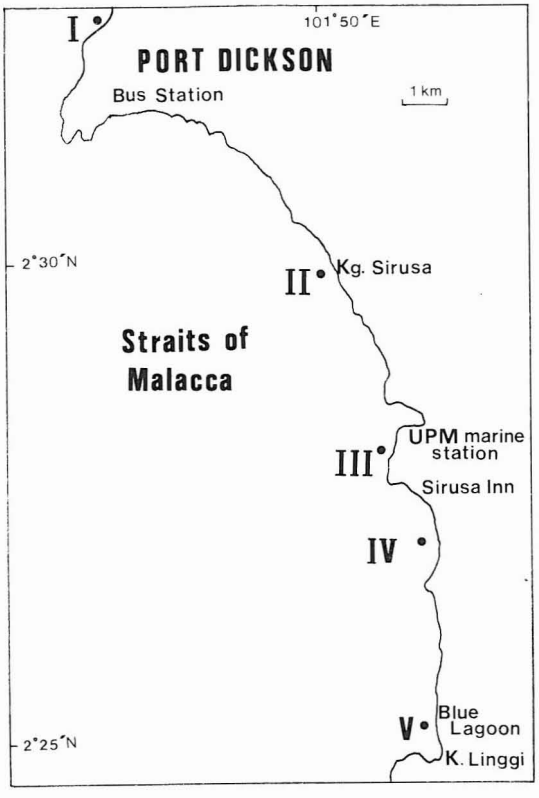

Fig. 1 Map showing the sampling stations(°)

Hydrocarbon Analysis.

Water. Immediately after taking a water sample, 2 liters of it were extracted thrice with dichloromethane (40 ml:40 ml:20 ml). The combined dichloromethane extract was freed from the residual water by treatment with 10 g anhydrous sodium sulfate and the polar organic substances were removed with 3 g silica gel (60-120 mesh). It was then evaporated to dryness in a rotary evaporator. The fluorescence of the residues, dissolved in 10 ml n-hexane, was measured with a Kontron fluorometer (SFM - 23) with 1-cm quartz cell. The fluorescent intensity was measured at 374 nm with excitation at 310 nm (Parsons *et al.* 1984). Esso Tapis A crude oil was used for the calibration. The detection limit of hydrocarbon in water was 0.5 ppb. Triplicate experiments were conducted on each sample. a 93% recovery was achieved from synthetic sea water containing 10 ppb of ESSO Tapis A crude oil. The standard deviation for the recovery test was ± 0.6 ppb.

Sand. Ten grams of the sand sample was weighed and transferred into a 500 ml glass separating funnel. 100 ml of distilled water was added then followed with 50 ml of n-hexane. The mixture was shaken for 5 minutes and the hexane extract was separated. The sand-water mixture that was left behind was extracted twice with 25 ml n-hexane. The combined hexane extract was dehydrated with anhydrous Sodium Sulfate and freed from polar organic substances with silica gel. The hydrocarbon content in the combined hexane was determined by fluorescence method. The recovery of Esso Tapis A crude oil, 10 µg, in oil free marine sediment was 85%.

Gas-liquid Chromatographic Analysis. After determination of hydrocarbon contents in water and sand by the flourescence method, the samples of each station (taken between 6.12.84 and 26.1.85) were pooled and the volume was reduced to 0.1 ml by using pure nitrogen gas at room temperature. Fractional analysis of the hydrocarbon residues in the cencentrated sample was performed with a Hewlet-Packard 5840A gas chromatography equipped with a flame ionization detector. ESSO Tapis A crude oil (20 mg/ml) was used as the reference. The conditons of the chromatography were the same as described previously (Law 1984). The attenuation setting for the analysis was at 2. The results of the oil residues fraction analysis in water and sand are presented in *Figure 2.*

RESULTS

Table 1 shows the petroleum levels in water and in sand collected along the shoreline of Port Dickson. The mean and range of hydrocarbon in water at stations 1, 2, 3, 4, and 5 were 19.2 ppb (8.53 – 31.72 ppb), 28.51 ppb (9.91 – 54.59 ppb), 28.29 ppb (2.52 – 62.77 ppb), 38.05 ppb (9.59 – 73.34 ppb), and 47.15 ppb (13.79 – 61.97 ppb) respectively. The mean and range of hydrocarbon content in sand at stations 1, 2, 4, and 5 were 17.72 mg/kg dry sand (2.28 – 29.33 mg/kg dry sand). 34.92 mg/

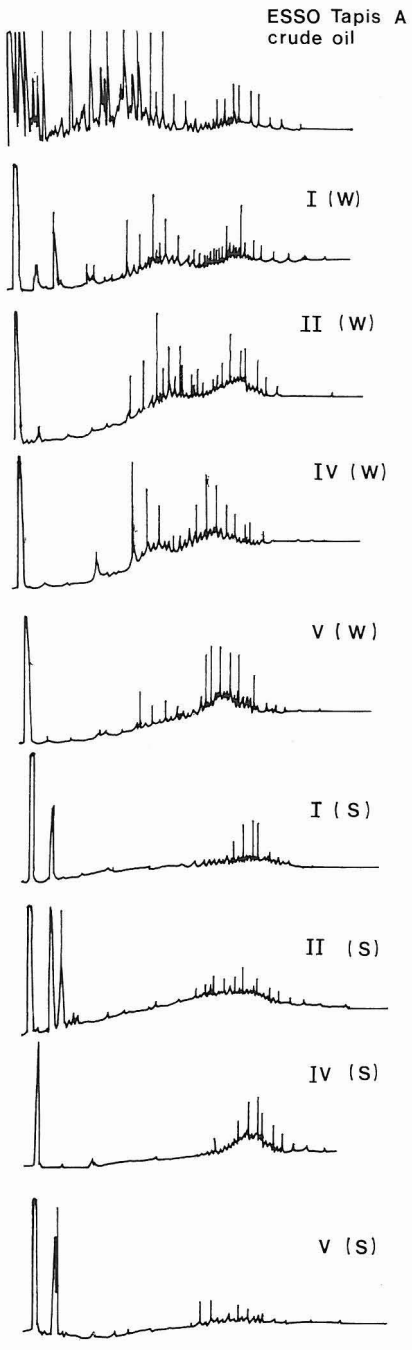

Fig. 2 Gas chromatograpic spectra of oil residues in water (W) and in sand (S) of the sampling stations.

kg dry sand (4.23 – 67.19 mg/kg dry sand), 36.20 mg/kg dry sand (1.79 – 70.36 mg/kg dry sand), and 23.14 mg/kg dry sand (5.28 – 50.46 mg/kg dry sand) respectively.

DISCUSSION

The overall mean and range of the hydrocarbon levels in water of the present study are 32.24 ppb and 2.52 – 73.34 ppb respectively. A comparison of the hydrocarbon levels in water from the present study with values reported in other parts of the world are presented in Table 2. The results indicate that the hydrocarbon level in Port Dickson coastal waters was lower than that found in the Sarawak and Kuantan coastal waters (Mohamed *et al.* 1988 ; Law and Zulkifli 1987), and much lower than that detected in the coastal waters off Kuala Terengganu (Law and Rahimi 1986). The level was also lower than that found in the Egyptian Rea Sea, 36.8 ppb (Hanna 1983), the Southern Baltic Sea, 55.3 ppb (Law and Andrulewicz 1983), and about 10 times lower than that of the Boston Harbour waters. 292 ppb (Ahmad *et al.* 1974). However, the level was about two thousand times higher than that detected in the Pacific Ocean (Cretney and Wong 1971). The results indicate that the coastal waters off Port Dickson carry some degree of petroleum hydrocarbon pollution.

A pronounced fluctuation of hydrocarbon level in water with sampling date was observed at all the sampling stations (Table 1). There was an approximate tenfold difference in level in which a maximum was detected on 26th June 1985 and a minimum on 19th December 1984. The results indicate that during the Southwest monsoon (data obtained between June and September), a higher level of petroleum hydrocarbon is found compared to the level detected during the Northeast monsoon (data obtained between November and January). This may be obviated by the strong wind action across the Straits of Malacca which drives the surface film of oil towards the Malaysian coastal waters. Further studies are being conducted to elucidate this expectation.

No significant difference of hydrocarbon levels in water was detected among the stations at the same date of sampling of the following dates 28/12/84, 6/6/85, 28/8/85 and 19/9/

TABLE 1
Petroleum Hydrocarbon contents in water and sand along the coast of Port Dickson (in ESSO Tapis A Crude Oil equivalents).

Station / Sampling Date	I		II		III		IV		V	
	Water[1]	Sand[2]	Water	Sand	Water	Sand	Water	Sand	Water	Sand
6.12.83	31.72 ± 1.64 (HT)[4]	29.33 ± 21.04	22.67 ± 1.79 (HT)	67.19 ± 78.89	–[3]	–	15.11 ± 3.00 (LT)[5]	70.36 ± 39.57	38.59 ± 2.53 (LT)	50.46 ± 37.54
19.12.84	8.53 ± 1.95 (HT)	10.89 ± 5.27	3.25 ± 0.11 (HT)	58.39 ± 48.0	–	–	2.52 ± 0.92 (HT)	35.02 ± 34.04	10.81 ± 3.68 (LT)	23.40 ± 16.66
28.12.84	12.92 ± 1.20 (LT)	2.28 ± 0.61	9.91 ± 0.40 (LT)	4.23 ± 2.58	–	–	10.24 ± 0.80 (LT)	1.79 ± 1.44	9.59 ± 4.36 (HT)	5.28 ± 0.57
26.1.85	23.60 ± 0.17 (LT)	28.36 ± 17.06	20.64 ± 3.45 (LT)	8.86 ± 7.46	–	–	21.94 ± 0.58 (LT)	37.62 ± 34.13	14.87 ± 0.98 (HT)	13.42 ± 4.88
26.6.85	–	–	54.59 ± 8.37 (HT)	–	–	–	62.77 ± 10.88 (HT)	–	73.34 ± 6.30 (HT)	–
28.8.85	–	–	19.10 ± 9.51 (LT)	–	13.79 ± 5.35 (LT)	–	11.30 ± 1.18 (LT)		12.73 ± 1.51 (LT)	–
19.9.85	–	–	51.21 ± 2.10 (HT)	–	52.81 ± 15.78 (HT)	–	56.63 ± 1.44 (HT)	–	62.72 ± 6.52 (HT)	–
5.10.85	–	–	–	–	49.57 ± 5.45 (HT)	–	–	–	–	–
30.10.85	–	–	–	–	60.02 ± 3.08 (HT)	–	36.03 ± 2.87 (HT)	–	60.92 ± 14.66 (HT)	–
20.11.85	–	–	46.71 ± 4.24 (LT)	–	61.97 ± 18.62 (LT)	–	38.07 ± 3.92 (HT)	–	58.91 ± 10.68 (HT)	–
Mean	19.20	17.72	28.51	34.92	47.15	–	28.29	36.20	38.05	23.14
(Range)	8.53 – 31.72	2.28 – 29.33	3.25 – 54.59	4.23 – 67.19	13.79 – 61.97		2.52 – 62.77	1.79 – 70.36	9.59 – 73.34	5.28 – 50.46

[1] ppb: mean ± S.D.
[2] mg/kg dry sand
[3] not determined
[4] High tide during sampling
[5] Low tide during sampling

85 (P>0.01), while significant differences were found for the rest of the sampling dates. Furthermore, there was no correlation between the hydrocarbon level and the tidal condition at the sampling stations throughout the study period. At present, the results do not suggest whether the main source of oil pollution in Port Dickson coastal areas come from the Straits of Malacca or from land runoff from Port Dickson itself. Further studies are required to identify the source of oil pollution in the Port Dickson coastal areas. Hydrocarbon contents in sediment and sand is a better indicator for oil pollution in an area than the assessment of the hydrocarbon level in water. Sediment(dry) containing more than 100 mg hydrocarbon per kilogram of sediment is considered an indication of oil pollution in

TABLE 2
Comparison of petroleum hydrocarbon level in Port Dickson coastal waters with levels reported in other parts of the world. (all in ppb)

Location	Level(range)	References
Boston Harbour, USA	292	Ahmad *et al.* 1974
Southern Baltic Sea	55.3(2.0 – 13.0)	Law and Andrulewicz 1983
Egyptian Red Sea	36.8(10 – 105)	Hanna, 1983
Goa coastal waters	30.9(22.9 – 40.0)	Fondekar *et al.* 1980
English Channel & North Sea	10.3(1.4 – 61.5)	Marchand and Caprais 1985
Eastern Mediterranean Sea	5.8(0.3 – 40.0)	Ravid *et al.* 1985
Northwestern Arabian Gulf	3.5(1.2 – 7.8)	EL Samra *et al.* 1986
Hong Kong Harbour	8.56(3.67 – 11.98)	Cheung *et al.* 1979
Pacific Ocean	0.016	Cretney and Wong; 1971
South China Sea, Terengganu coastal waters	980(10 – 1750)	Law and Rahimi 1986
South China Sea, Kuantan coastal waters	36.9(9.49 – 65.56)	Law and Zulkifli 1987
South China Sea, Sarawak coastal waters	133.96	Mohamed *et al.* 1988
Present study Port Dickson, Straits of Malacca	32.24(2.52 – 73.34)	

the area (Marchand *et al.* 1982). The chemistry of hydrocarbon in sand is probably more complex than that in the sediment. The adsorptivity of hydrocarbon on sand,tidal condition, precipitation and evaporation, photochemical oxidation and microbial biodegradation will have great influence on the level and composition of hydrocarbon in sand. A significant amount of petroleum hydrocarbon was detected in the sand at all the sampling stations. The ranges of hydrocarbon content in sand along the shoreline of Port Dickson were between 2.1 to 70.4 mg/kg dry sand. The gas liquid chromatography analysis of hydrocarbon residues in sand and in water of the present study are shown in *Figure 2.* The results indicate that hydrocarbon in sand mainly comprised heavy oil fraction. The difference between the hydrocarbon components in sand and water indicated the rapid processes of hydrocarbon weathering in sand in this area. Further studies are required to investigate the rate of hydrocarbon weathering in sand especially in the tropics.

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REFERENCES

AHMAD, A.H., M.D. BEASLEY, A.C. EFROMSON and R.A. HITES. 1974. Marine Pollution Monitoring (petroleum). Proceedings of a symposium and workshop held at NBS Gaithersburg, Maryland, 13-17 May, 1974. NBS spec. publ. (409), p 109.

CHEUNG, M.T., T.Y. CHENG, S.W. LEUNG, C.C LO, and L.M. MAK. 1979. Oil Pollution along Coastal Areas of Hong Kong. *Mar. Pollut. Bull.* **10:** 228-231.

CRETNEY, W.J. and C.S. WONG. 1974. Marine Pollution Monitoring (Petroleum). Preceedings of a symposium and workshop held at NBS, Gaithersburg, Maryland, 13-17 May, 1974. NBS spec. publ. (409), p 113.

EL SAMRA, M.I., H.I. EMARA and F. SHUNBO. 1986. Dissolved Petroleum Hydrocarbon in the Northwestern Arabian Gulf. *Mar. Pollut. Bull.* **17:** 65-68.

FONDEKAR, S.P., R.S. TOPGI, and R.J. NORONHA. 1980. Distribution of Petroleum Hydrocarbon in Goa Coastal Waters. *Indian J. Mar. Sci.* **9:** 286-288.

HANNA, R.G.M. 1983. Oil pollution on the Egyptian Red Sea Coast. *Mar. Pollut. Bull.* **14:** 268-271.

LAW, A.T. 1984. Population and Activity of Hydrocarbon-degrading Microorganisms in the Coastal waters of Peninsular Malaysia. *Pertanika* **7(1):** 19-26.

LAW , A.T., and RAHIMI B. YUSOF. 1986. Hydrocarbon Distribution in the South China Sea. Ekspedisi Matahari '85. A Study on the Offshore Waters of the Malaysian EEZ. Mohsin, A.K.M., Mohd. Ibrahim Hj. Mohamed and Mohd. Azmi Ambak (eds.). Faculty of Fisheries and Marine Science, Universiti Pertanian Malaysia, Occasional Publication **(3):** 93-100.

LAW, A.T., and ZULKIFLI B. MAHMOOD. 1987. Distribution of Petroleum Hydrocarbon in the South-Western Portion of the South China Sea. Ekspedisi Matahari '86: A Study on the Offshore Waters of the Malaysian EEZ. A.K.M. Mohsin, Ridzwan Abd. Rahman and M.A. Ambak (eds.). Faculty of Fisheries and Marine Science, Universiti Pertanian Malaysia. Occasional Publication **(4):** 53-60.

LAW, R., and E. ANDRULEWICZ. 1983. Hydrocarbon in Water, Sediment and Mussles from the Southern Baltic Sea. *Mar. Pollut. Bull.* **14:** 289-293.

MARCHAND, M., G. BODENNEC, J.-C. CAPRAIS, and P. PIGNET. 1982. The AMOCO CADIZ Oil Spill, Distribution and Evolution of Oil Pollution in Marine Sediments, Ecology Study of the AMOCO CADIZ Oil Spill. Report of the NOAA-CNEXO Joint Scientific Commission. pp. 143-157.

MARCHAND, M., and J.-C. CAPRAIS. 1985. Hydrocarbons and Halogenated Hydrocarbons in Coastal Waters of the English Channel and the North Sea. *Mar. Pollut. Bull.* **16:** 78-81.

MOHAMED, M.I.H., A.T. LAW, A.K.M. MOHSIN and M.Z.M. SAID. 1988. Findings of the Offshore waters of the Malaysian EEZ. Paper presented at the seminar on *The Marine Environment: Challenges and Opportunities*, 31 March – 2 April, 1988, ISIS. Kuala Lumpur, Malaysia (Mimeo).

PARSONS, T.R., Y. MAITA and C.M. LALLI. 1984. *A Manual of Chemical and Biological Methods for Sea Water Analysis.* Frankfurt: Pergamon Press 173 pp.

RAVID, R., O.H. OREN, J. BEN-YOSEF, and H. HORNUNG. 1985. Oil Pollution in the Eastern Mediterranean. *Mar. Pollut. Bull.* **16:** 81-84.

RIDZWAN ABDUL RAHMAN, M.W.R.N. DE SILVA and LAW AH THEEM. 1983. Role of Marine Science Research in National Development *Pertanika*, **6:** 37-53.

SEN GUPTA R. 1980. Status Report on IOC/WMO Marine Pollution (Petroleum) Monitoring Pilot Project under the framework of Integrated Global Ocean Station System (IGOSS) for the Indian Ocean Region. Tech Rep. No. 04/80, National Inst. Oceanogr., Dona Paula, Goa. 16 pp.

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