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THE DISTRIBUTION AND VARIATION OF TAR ON BEACHES ALONG THE ANDAMAN SEA COAST OF THAILAND

by

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CONTENTS

ABSTRACT

Heavy deposition of tar generally occurred during the south-west monsoon period. The major type of tar was fresh tar (free from sand) which was washed ashore from an offshore source. Most of the tar deposition was between MLWN-MHWS. Variation in deposition depends upon coastal topography, coastal circulation and distance from shore. Deposition appeared to decline from 1977/78 to 1980/81.

I. INTRODUCTION

Most tar balls are originally derived from oily wastes discharged by sea vessels and oil spilled from tanker collision (Shekel and Ravid 1975). When the oil reaches the sea, its fate depends upon many factors, i.e. evaporation, formation of emulsions, microbial degradation activities, etc. The remainder turns into a very viscous sheet and breaks apart due to winds and wave action (Nelson-Smith, 1973). Eagle *et al.* (1979) found that tar lumps formed repidly within a few days after the oil interacted with sea water. These tar lumps may sink and be deposited on the sea bottom or they may be washed ashore (Nelson-Smith, 1973; Simonov, 1974).

Finally, tar lumps deposited on the shore and exposed to sunlight gradually lose their original properties becoming one of three categories of tar ball. The first type is fresh tar which is soft, sticky and nearly free of sand. It may be newly washed ashore tar. The second type is sand coated tar which is relatively soft and coated with sand. It may contain entrained sand since it has been exposed to and mixed with sand on the beach for some time. The last type is aged tar which is hard and brittle and may contain sand and shell fragments as it has been retained on the beach and exposed to air for a long period of time.

The tar surveys along the Andaman Sea coast of Thailand and studies of the variation in type and quantity of tar deposition on beaches were commenced in 1977-81. The study was divided into 3 parts as below:

1. Comparison of beach tar occurrence at selected sites around Phuket Island.
2. Deposition of beach tar during the south-west and north-east monsoons along the Andaman coast of Thailand.

3. Deposition of beach tar on some major offshore islands in the Andaman Sea of Thailand.

II. MATERIALS AND METHODS

Sampling Locations

Various types of beaches were selected for tar sampling as follows:

1. Beaches around Phuket Island. Their locations are shown in Fig. 1B and Table 1.
   - A. Kalim beach is on the west coast being exposed directly to strong tidal current flows.
   - B. Patong beach is on the west coast. It is the most famous holiday resort in Phuket having busy tourist activities almost throughout the year.

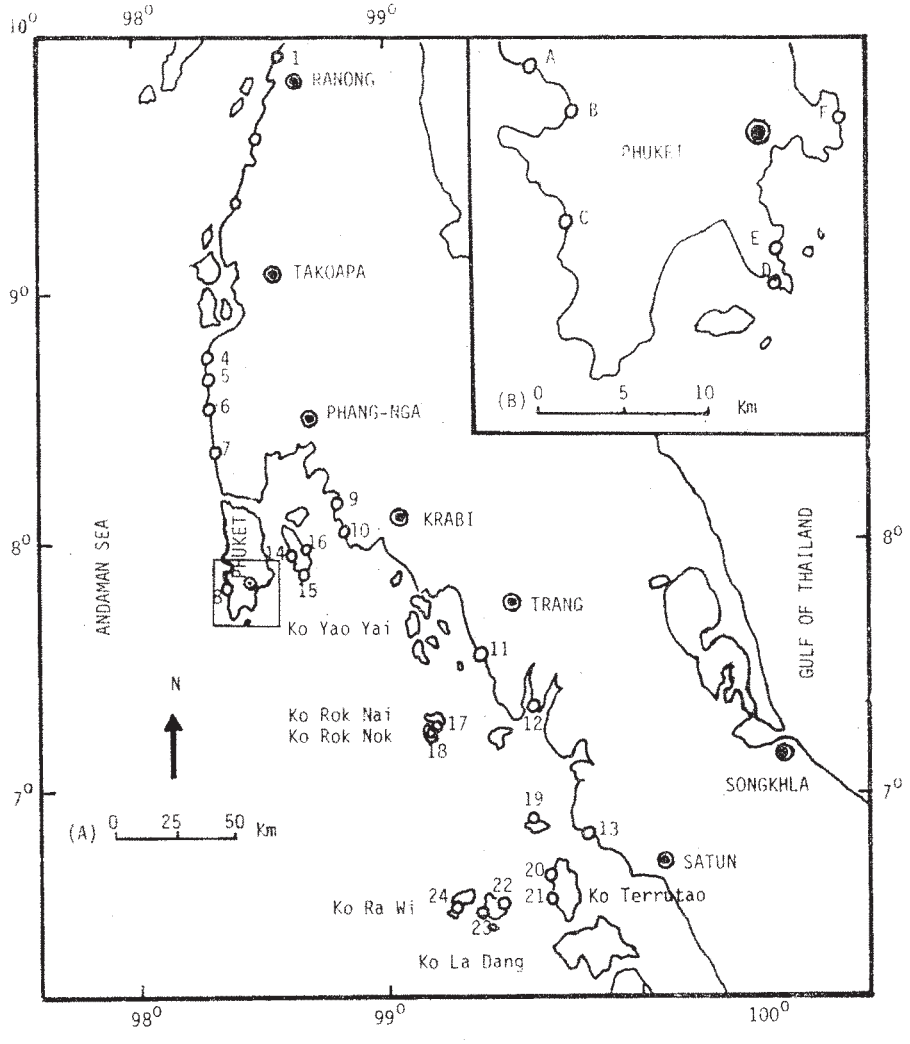

Fig. 1—(A) Map of Andaman Sea coast of Thailand. Sampling sites indicated by circles and numbers. Square box shows southern Phuket area.

(B) Enlarged map of southern Phuket. Sampling sites indicated by circles and letters.

Table 1. Locations of tar sampling beaches around Phuket Island.

Site No	Beach	Lat.	Long.
A	Kalim	7°54′40″	98°17′00″
B	Patong	7°54′00″	98°18′15″
C	Karon	7°50′12″	98°18′00″
D	Laem Pan Wa	7°48′12″	98°24′30″
E	Ao Makarm	7°49′55″	98°24′16″
F	Ko Sire	7°52′45″	98°26′05″

Table 2. Locations of tar sampling bearches along the Andaman Sea Coast of Thailand (Ranong to Satun Provinces)

Site No	Beach	Lat	Long.	Province
1	Paknam Ranong	9°58′36″	98°35′48″	Ranong
2	Bang Bane	9°36′24″	98°28′36″	Ranong
3	Prapars	9°19′36″	98°23′12″	Ranong
4	Bangsak	8°47′12″	98°16′00″	Phang-nga
5	Kuek Kuk	8°41′24″	98°14′18″	Phang-nga
6	Kao Luk	8°36′24″	98°14′36″	Phang-nga
7	Tai Mueng	8°23′24″	98°15′36″	Phang-nga
8	Karon	7°50′12″	98°17′48″	Phuket
9	Noparathara	8°10′48″	98°45′12″	Krabi
10	Klong Muang	8°02′36″	98°47′24″	Krabi
11	Pak Meng	7°24′24″	99°24′36″	Trang
12	Kan Tang	7°28′00″	99°30′48″	Trang
13	Pak Bara	6°50′36″	99°44′36″	Satun

C. Karon beach is on the west coast. It is opened directly to the Andaman Sea and is therefore exposed to strong winds and wave action.

D. Laem Pan Wa beach is in front of Phuket Marine Biological Center (PM BC) on the south-east coast. There are a few islands nearby providing shelter from offshore winds and wave action.

E. Ao Makarm beach is on the east coast being opposite to two big islands. This beach is thus well protected from offshore winds and wave action. A relatively large petrol storage tank farm is situated about 1 km north-east of Ao Makarm.

F. Ko Sire beach is on the east coast being relatively sheltered from winds and wave action due to the protection of some small islands nearby. A fish landing habour is accommodated on this beach.

2. Beaches along the Andaman Sea coast of Thailand from Ranong to Satun provinces are shown in Fig. 1A and Table 2.

3. Beaches on some major offshore islands in the Andaman Sea of Thailand from Ko Yao Yai to Ko Terutao are shown in Fig. 1A and Table 3.

Table 3. Locations of tar sampling beaches on some major offshore islands in the Andaman Sea (from Ko Yao Yai to Ko Terutao).

Site No	Beach	Lat.	Long.	Province
14	West Ko Yao Yai	80°0′24″	98°35′24″	Phang-nga
15	South Ko Yao Yai	7°54′24″	98°35′00″	Phang-nga
16	East Ko Yao Yai	7°57′36″	98°37′00″	Phang-nga
17	Ko Rok Nai	7°13′36″	99°04′48	Trang
18	Ko Rok Nok	7°12′00″	99°04′00″	Trang
19	Ko Bu Lon Le	6°49′50″	99°32′24″	Satun
20	North-west Ko Terutao	6°40′48″	99°38′36″	Satun
21	South-west Ko Terutao	6°33′36″	99°37′36″	Satun
22	East Ko La Dang	6°32′00″	99°101′36″	Satun
23	South Ko La Dang	6°30′24″	99°17′24″	Satun
24	Ko Ra Wi	6°34′30″	99°13′24″	Satun

Collection of Tar balls

Tar balls were collected within one meter quadrats along a beach transect from high water mark down to water level during low tide periods (UNESCO, 1976). On beaches where tar balls were uniformly distributed, two sampling locations were taken. On beaches where tar balls were not distributed uniformly, ten sampling locations were taken to obtain the average quantity of tar on each beach. Tar samples were brought to the laboratory prior to sand separation through 3 mm mesh size seives. Tar balls were weighed to two decimal points. The weight of tar containing entrained sand was calculated by multiplying its volume (substitution in water) times a constant of 0.85 to obtain the estimation of true weight of tar (UNESCO, 1976).

The type of tar was separated by its physical properties i.e. fresh tar is soft and almost free of sand, sand coated tar is soft and coated or contained with sand and aged tar is hard and mixed with sand. The tar component was analysed in the U.K. Vertical distribution of tar balls was calculated by measuring beach slope and sea level at the time of sampling with respect to the mean tidal levels (average values of 5 years sea levels at each location taken from the tide tables).

III. RESULTS

1. Comparison of beach tar occurrence at selected sites around Phuket Island are presented in Figs. 2-4.

A. KALIM BEACH

Heavy tar deposition was recorded between April 1980 and June 1981 with a maximum value of 1946 g/m in January (Table 4A). Fresh tar predominated during May to July but sand coated tar appeared prodominantly during December and April 1981. Tar deposition was mainly confined to between MSL and MHWS (Fig. 2).

B. PATONG BEACH

Very low tar deposition was recorded during April 1980 to June 1981 and small amount of fresh tar was observed occasionally to be less than 5 g/m (Table 4B).

C. KARON BEACH

Heavy deposition of tar balls was recorded during August 1977 and February 1978. A twelve month average of 222 g/m/month with a maximum

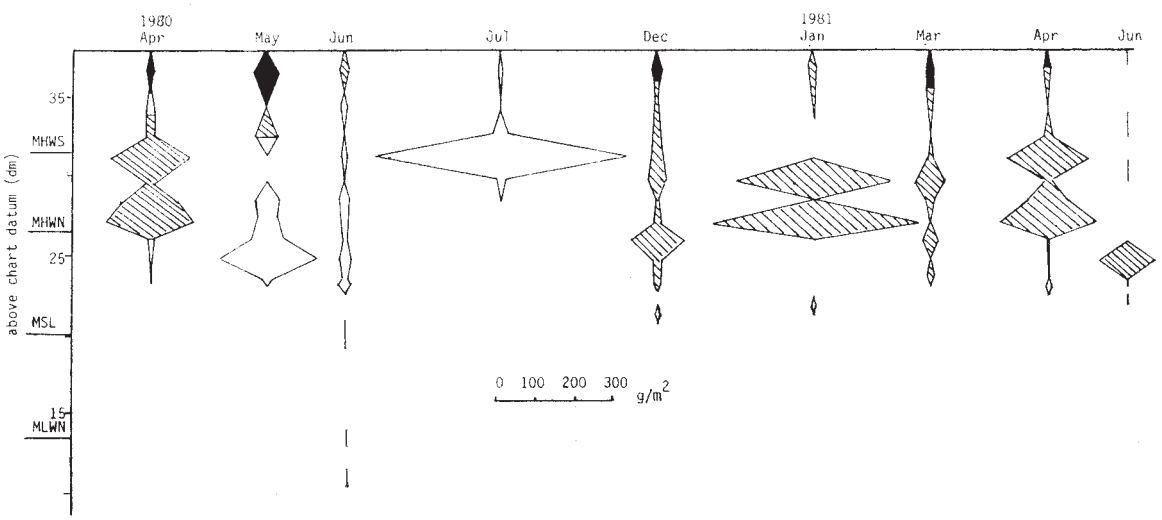

Fig. 2. Vertical distribution of fresh (□), sand coated (▨) and aged tar (■) with respect to tidal level on Kalim beach.

value of 680 g/m in October 1977 were recorded (Table 4C). Fresh tar was found abundantly between MHWN and MHWS (Fig. 3A).

Tar ball deposition during February 1980 to January 1981 was relatively low. A monthly average of 22 g/m/month with a maximum value of only 45 g/m in August 1980 were also recorded. Aged tar was found abundantly (Fig. 3B).

However, aged and sand coated tar deposited on a very gentle slope locality predominated during August 1980 to February 1981 (Fig. 3C).

D. LAEM PAN WA BEACH

Tar ball deposition in 1977-78 was relatively low. A monthly average of 7.9 g/m/month with a maximum value of 23 g/m in December 1977 were recorded (Table 4D). Fresh tar predominated between November 1977 and January 1978. During the rest of the year, sand coated together with aged tar appeared predominantly (Fig. 4A).

Tar ball deposition increased in 1980-81. A twelve month average of 23 g/m/month with a maximum value of 53 g/m in April 1980 were recorded (Table 4D). Sand coated and aged tar appeared predominantly throughout the year between MSL and above MHWS. (Fig. 4B).

E. AND F. AO MAKARM AND SIRE BEACHES

Tar depositions on these two beaches were regarded to be insignificant during 1977 to 1981, although a very small amount of tar was found occasionally (Table 4 E-F).

2. Deposition of beach tar along the Andaman Sea coast of Thailand.

Fresh tar balls were found predominantly on most beaches between June and July 1979 during the south-west monsoon period (Fig. 5A). Heavy deposition was recorded on Kuek Kuk and Kao Luk beaches of Phung-nga province, Karon beach of Phuket province and Pak Meng beach of Trang province to be 791, 244, 734 and 384 g/m respectively (Table 5). During the same monsoon of the following year (September 1980), relatively low amount of tar deposition was recorded to be 22, 42, 42 and 2 g/m respectively of which the main type being sand coated tar (Fig. 5B). Whilst during April 1980 in the north-east monsoon period, a very small amount of tar was recorded

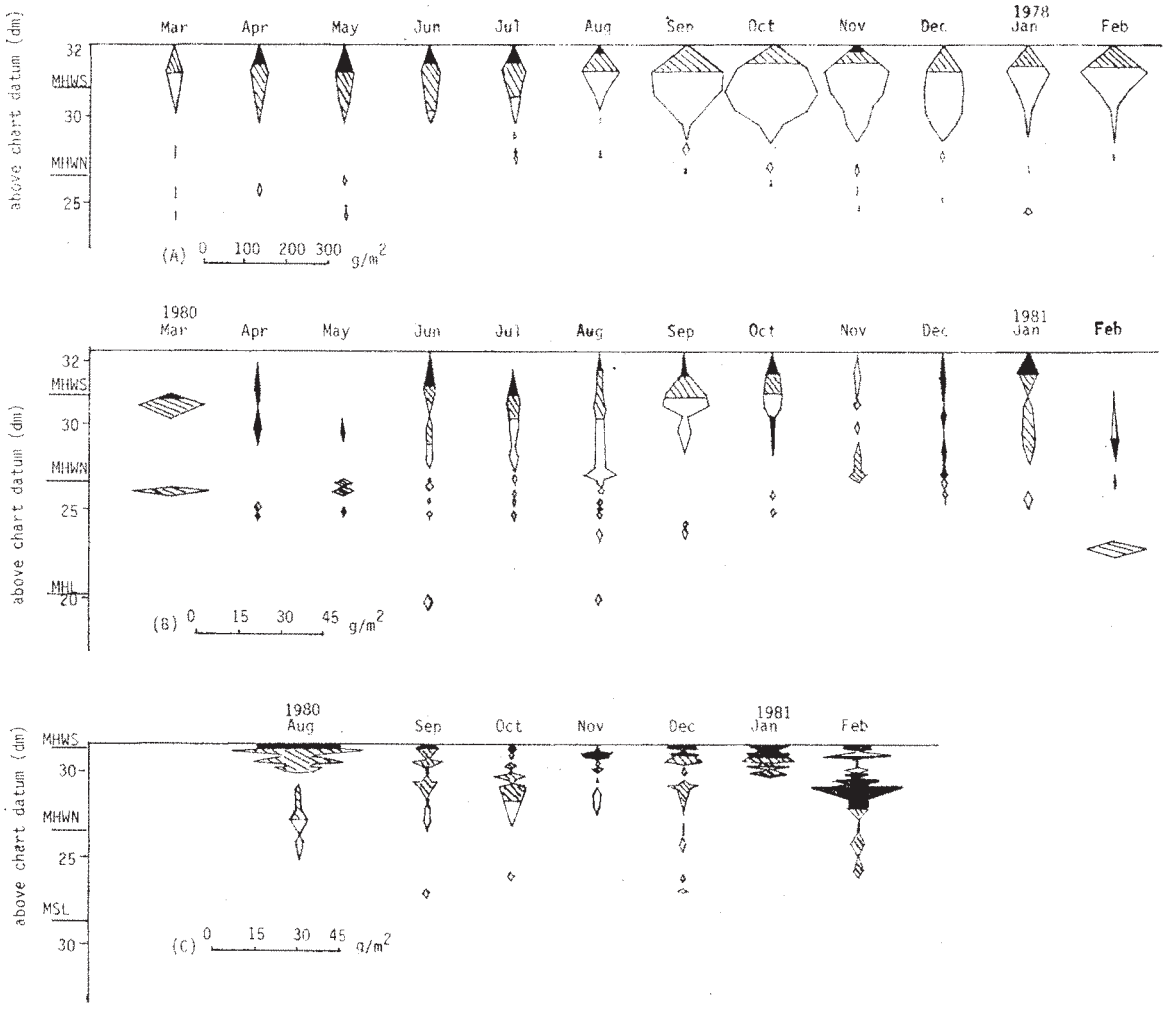

Fig. 3. Vertical distribution of fresh (□), sand coated (▨) and aged tar (■) with respect to tidal level on Karon beach. (A): during 1977/78, (B): during 1980/81, (C): tar deposition on a very gentle slope locality.

to be less than 5 g/m maximum of which sand coated and aged tar predominated along the coast (Fig. 5C). The deposition of tar balls was mainly confined to a zone between MHWN and MHWS on most beaches.

3. Beach tar deposition on beaches of some major offshore islands in the Andaman Sea, Thailand.

Tar deposition in 1978 on offshore beaches was generally low on the leeside where tar balls were collected. The maximum value of 123 g/m was recorded on the beach north-west of Ko Terutao (Table 6). The sand coated tar was predominated between the MHWN and MHWS whilst aged tar was deposited above the MHWS level (Fig. 6).

4. The tar component analysis was reported to be bunker oil which consisted of more than thirty carbon atoms in the hydrocarbon molecule.

Table 4. A. The amount of tar (g/m) deposited on Kalim beach.

Month	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Year 1980-1981										
Amount	1172	1224	276	-	-	-	1449	-	562	1946

B. The amount of tar (g/m) deposited on Patong beach

Year 1980-1981										
Amount	2	5	9	-	-	-	8	6	5	5

C. The amount of tar (g/m) deposited on Karon beach

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Year 1977-1978												
Amount	60	54	83	79	99	102	275	680	475	287	140	327
Year 1980-1981												
Amount	42	2	18	27	25	45	35	16	17	15	11	14
On a very gentle beach slope locality												
Year 1980-1981												
Amount	-	-	-	-	-	67	62	38	32	73	123	297

D. The amount of tar (g/m) deposited on Laem Pan Wa beach.

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Year 1977-1978												
Amount	4	2	2	4	5	7	16	9	15	23	4	4
Year 1980-1981												
Amount	19	53	33	31	25	11	25	11	24	7	18	19

E. The amount of tar (g/m) deposited on Ao Makarm beach.

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Year 1977-1978												
Amount	0	1	0	0	0	0	0	0	1	0	5	0
Year 1980-1981												
Amount	2	0	0	0	0	0	0	1	1	0	0	0

F. The amount of tar (g/m) deposited on Ko Sire beach.

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Year 1977-1978												
Amount	0	0	1	0	0	0	0	0	0	0	0	1
Year 1980-1981												
Amount	0	0	0	0	1	0	0	0	0	1	0	0

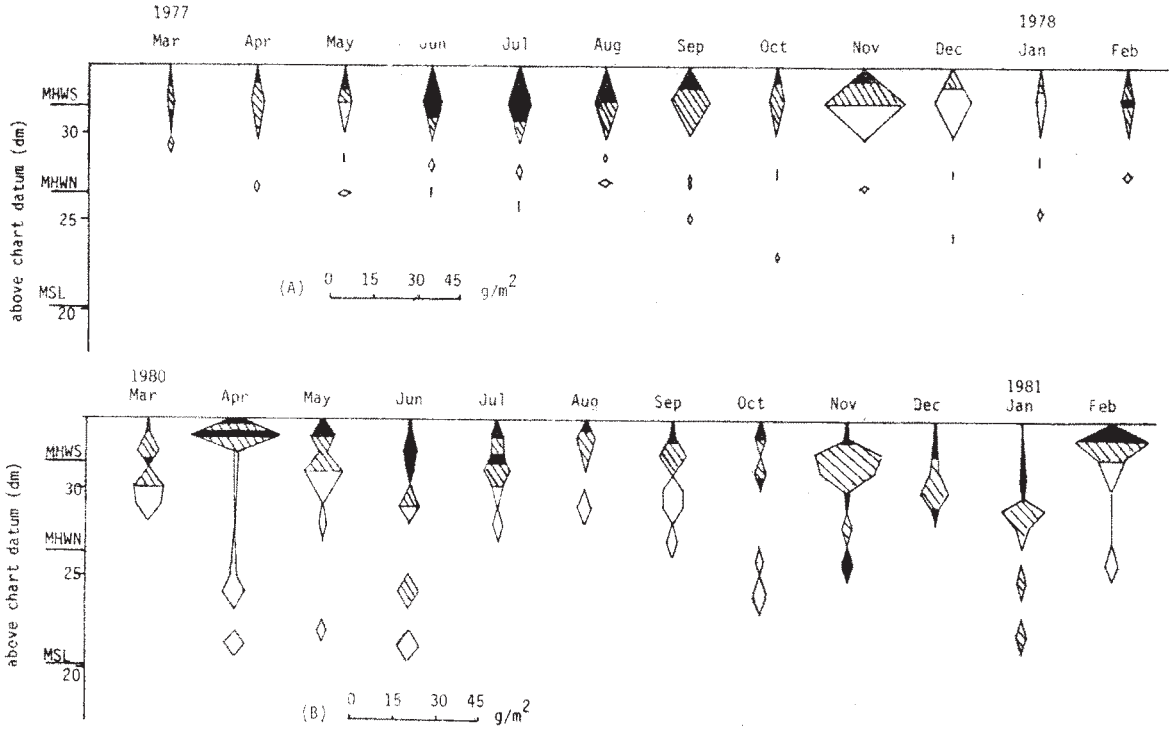

Fig. 4. Vertical distribution of fresh (□), sand coated (▥) and aged tar (■) with respect to tidal level on Laem Pan Wa beach. (A): during 1977/78, (B): during 1980/81.

Table 5. The amount of tar (g/m) deposited on beaches along the Andaman sea coost of Thailand.

Site	1	2	3	4	5	6	7	8	9	10	11	12	13
Year July 1979													
Amount	1	1	2	8	791	244	9	734	1	1	384	1	12
Year April 1980													
Amount	1	1	1	1	4	4	4	3	1	2	2	2	2
Year September 1980													
Amount	1	2	4	2	22	40	25	41	1	1	1	2	4

Table 6. The amount of tar (g/m) deposited on beaches of some major offshore islands in the Andaman Sea, Thailand.

Site	14	15	16	17	18	19	20	21	22	23	24
Year January 1978											
Amount	6	1	1	10	17	21	123	61	3	18	15

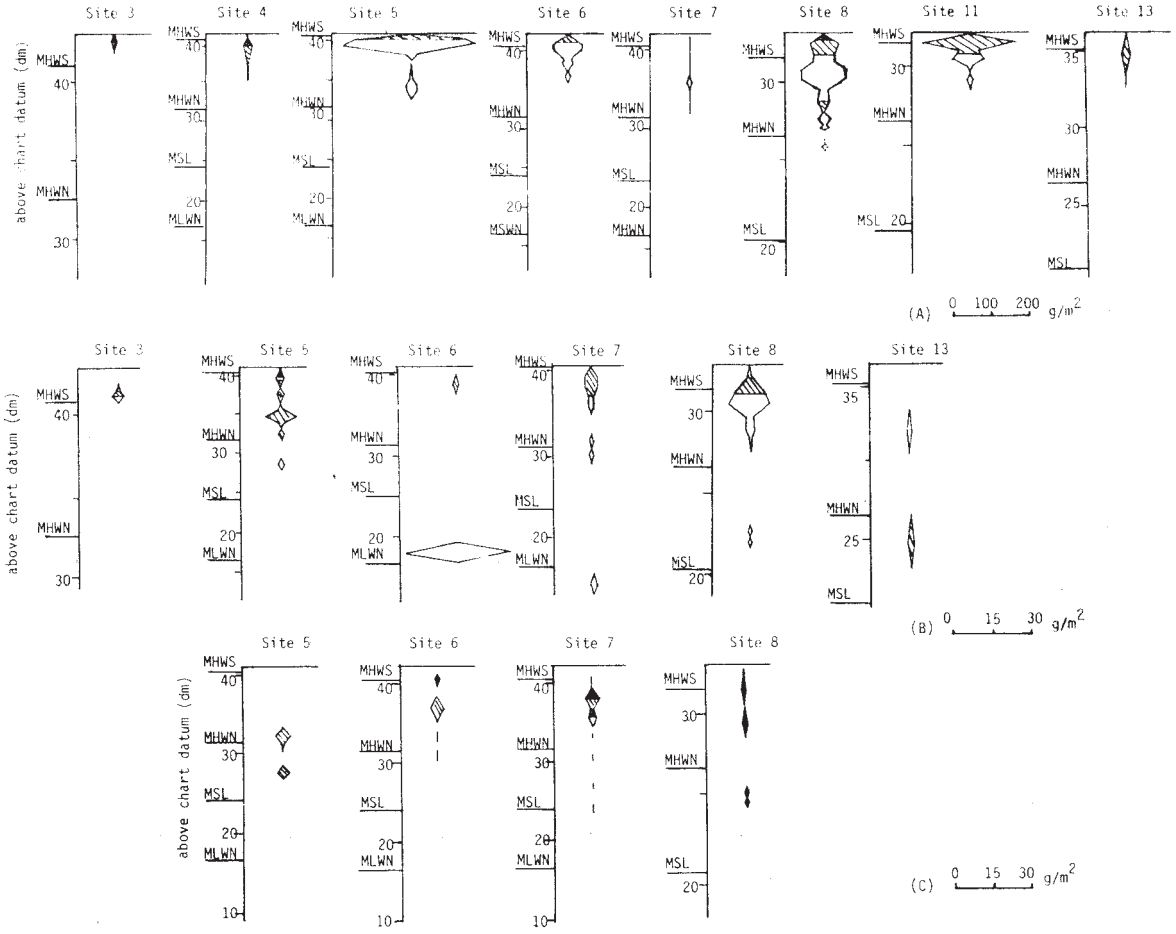

Fig. 5. Vertical distribution of fresh (□), sand coated (▨) and aged tar (■) with respect to tidal level on beaches along the Andaman Sea coast of Thailand. (A): in June/July 1979, (B): in September 1980, (C): in April 1980.

IV. DISCUSSION

Tar ball deposition on the exposed beach of Karon in Phuket Province was relatively high during 1977-1978. The heavy deposition during the south-west monsoon period was probably due to the south-west monsoon blowing ashore and carrying the offshore tar into the coastal circulation, finally became deposited on the beaches. It is speculated that during high water, part of the heavier tar was rewashed back into the sea water, some settled down on the sea bottom, some washed into the coastal circulation while the remainder would be deposited elsewhere.

The quantities of tar on Karon beach decreased by about 90% in 1980-81 as compared to 1977-78. In the first month of south-west monsoon, most of the deposited tar was coated with sand, whilst in the second month the deposited tar was consisted of 83% fresh tar, 16% sand coated tar and 1% aged tar. Most of the aged tar was deposited and spread over the supratidal level (above MHWS). This indicated that the onshore

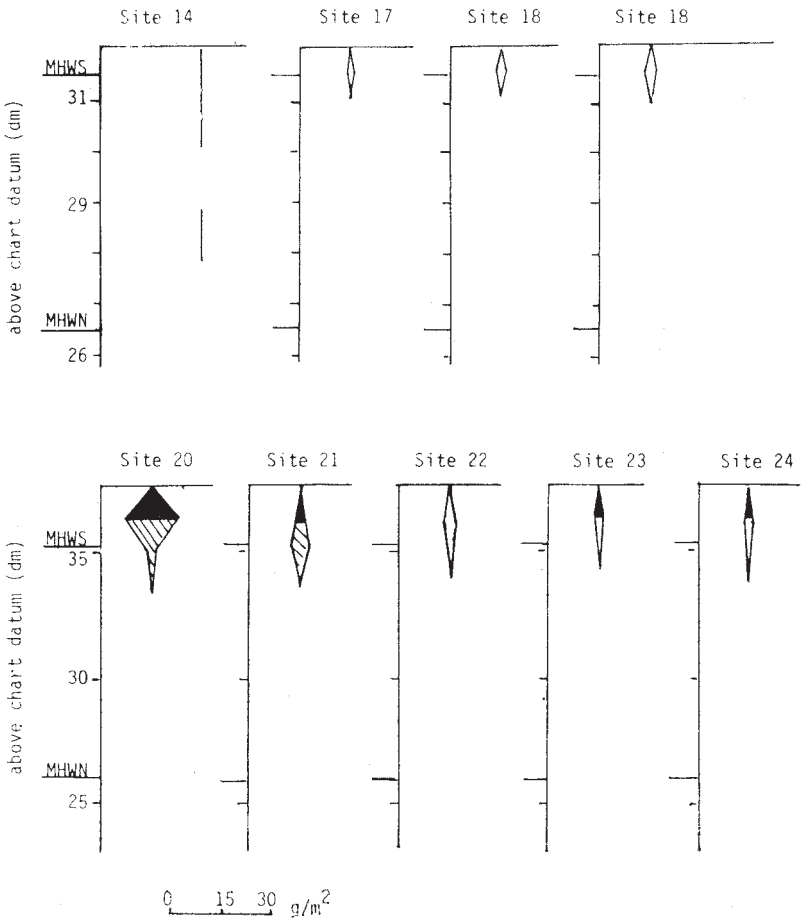

Fig. 6. Vertical distribution of fresh (□), sand coated (⊠) and aged tar (■) in 1978 with respect to tidal level on beaches of some major offshore islands in the Andaman Sea of Thailand.

prevailing wind washed sand coated tar ashore before the arrival of fresh tar. During the north-east monsoon period no fresh tar was found and the type of tar observed was 94% sand coated tar and 6% aged tar. This was in good agreement with the results reported by Eagle *et al.* (1979). They studied the tar ball concentration around the Cape of Good Hope and concluded that tar balls spent a few months drifting in the sea before becoming deposited on beaches. White (1974) reported that variations in the amount of tar were due to the current pattern together with the distance from shore, coastal circulation, beach gradient and the topography of the coast.

Because Laem Pan Wa beach is a sheltered area, and hence relatively small quantity of deposited tar was recorded in 1977-78. The results showed that on this beach the deposition of the fresh tar fraction generally decreased while sand coated and aged tar increased over time. This variation was probably due to the coastal circulation, particularly with a sheltered locality.

On the southern coast of Ao Makarm and the eastern coast of Ko Sire beaches where petrol transportation and deep sea shipping activities

are very intense, a very insignificant amount of tar deposition was recorded on these two beaches. This is because these two beaches are not exposed directly to the south-west monsoon prevailing wind and thus the results suggest that tar balls deposited on these Phuket beaches were entirely derived from the offshore tar.

Along the Andaman Sea coast of Thailand, the heavy deposition of tar was also recorded during the south-west monsoon (1979). Over 80% of the deposited tar was fresh tar. During the north-east monsoon, the low deposited tar consisted of 5% fresh tar, 65% sand coated tar and 30% aged tar. During the south-west monsoon of the following year (1980), the deposited tar consisted of 60% fresh tar, 39% sand coated tar and 1% aged tar. The results showed that fresh tar deposition was generally lower in 1980 as compared to the deposition in 1979 during the same monsoon period. Eagle *et al.* (1979) showed that prevailing monsoon winds together with currents facilitated the distribution and transportation of tar balls in the sea. In the present study, tar component analysis showed that tar found along the Andaman Sea coast of Thailand was bunker oil which was, consisted of more than thirty carbon atoms in the hydrocarbon molecule, discharged by tankers or other cargo vessels in the open ocean.

Dwivedi and Parulekar (1974) and Qasim (1975) studied the distribution of tar balls on Indian beaches particularly on the eastern and western coasts which are under the influence of monsoons similar to the Andaman Sea coast of Thailand. They showed that heavy deposition of tar balls (upto 4480 g/m^2) was seen in the south-west monsoon on the western coast. On the Andaman sea coast of Thailand, the heaviest deposition of fresh tar balls (upto 1980 g/m^2) was recorded in the same monsoon. Swinnerton and Lamontagne (1974) reported that tar balls were also observed in the offshore water of the western coast of India during the north-east monsoon period. Such reports suggest that tar balls were accumulated in the coastal circulation even during the offshore prevailing wind period. However, there was no report on the type of tar found. The present results showed that tar deposition has decreased during the past years. This may be mainly due to the new designed tanker which is equipped with the Load On Top System and used in crude oil transportation operation. By means of this system, the oily waste water from washing and cleaning tanks is transferred to slop tanks to separate the oil residues from water. This process is repeated in the main ballast water tanks until clean water is separated underneath and discharged back to the sea; the oily residues being stored in the tank provided. Such a new design is now used in over 75% of tanker shipping (Nelson-Smith, 1973).

There were relatively low amount of tar balls deposited on beaches of offshore islands because the beaches are on the leesides of these islands and the exposed sites are rocky shores and cliffs. The present survey could be carried out only during the north-east monsoon while the sea was calm but in the south-west monsoon, even though tar balls were washing ahore, the sea was too rough for the Center's research vessel to cruise and hence the results presented would be lower estimated.

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