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N-Alkane Distribution in Surficial Sediments from the Aden City Coast, Yemen

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ABSTRACT

The paper presents the *N*-alkanes distribution in recent sediments of Aden city coast. The results are the first of their kind for the region and should serve as baseline for future studies. The concentration of *N*-alkanes in sediment samples ranged from 3 to 1805 ng/g dry weight, expressed as Kuwait crude oil equivalent. It is evident that all the sites are contaminated to some extent with *N*-alkanes. *N*-alkanes generally constitute the major fraction of saturated hydrocarbons, and their distribution patterns are characterized by carbon-number ranges and predominance, depending on the nature of the source material and its microbial or geochemical alteration. In this respect it has been recognized that distributions exhibiting odd carbon-number predominance in the C_{15}-C_{21} and C_{25}-C_{31} ranges are characteristic of autochthonous and allochthonous natural inputs respectively, whereas slight even carbon-number predominance or smooth distribution in the C_{20}-C_{30} range have been invoked for reduction or bacterial diagentic processes. Finally, fossil (petroleum) *N*-alkanes are characterized by a low carbon preference distribution generally concurrent with an unresolved complex mixture of branched and cyclic saturated hydrocarbons.

INTRODUCTION

The Gulf of Aden is among the busiest tanker routs. The local marine environment of Aden city is exposed to a relatively high chronic input of petroleum hydrocarbons from industrial effluents, sewage and oil spills. The impacts are from tanker and ship traffic (Linden et al. 1990). The most extensive studies of habitat fauna other than coral are the of Fishelson (1971) who detailed communities within the shallow benthic habitats.

Hydrocarbons found in recent aquatic sediments reflect natural and anthropogenic inputs from the water column by transport and sedimentation, as well as the digenetic processes taking place within the sediment (Grimalt & Albaiges 1985). Marine pollution of the Gulf of Aden had recently drawn the attention of national and international agencies as well as public awareness of the enormous increment of pollutants particularly oil and trace metals (Hassan et al. 2003).

There are different forms of impacts on the coastal and marine environment of Yemen caused mainly by human and developmental activities (Haskoning 1991, Rushdi et al. 1994). These activities introduce pollutants to the marine environments and cause the detraction of some special habitats of the region. The most widely recognized issue is the oil-related pollution, where considerable attention has been focused (Dick 1987, Rushdi et al. 1994, DouAbul et al. 1997, DouAbul & Al-Shiwafi 1998).

The general aims of the present work were to estimate the impact of chronic petroleum discharges on local environments and to devise analytical methods and monitoring strategies for the long-term assessment of environmental quality. In Yemen, previous data concerning petroleum hydrocarbons in coastal waters are not available.

MATERIALS AND METHODS

Sample collection: Nine sample sites were selected to represent different habitats of the coast of Aden city of Yemen. The sediment samples were drained-off water, placed in screw capped glass jars and stored frozen in the Department of Earth and Environmental Science till time of analysis. Sub-tidal sediment samples were collected as represented in Table 1 and Fig. 1.

Table 1: Sampling locations.

Station Number	Nearest City
I	Al- omal Island
II	Abyan Coast (1)
III	Abyan Coast (2)
RS,IV	Syra'a
V	Free Area
VI	Algader Area
VII	Infront of Refinery
VIII	Steam Station
IX	Gold Moor

RS= Reference station.

Sample treatment and analysis: Sediment samples from the same nine sites were also collected on 16-21 April, 2006 using stainless steel Ekman's grab. Just before analysis, sediment samples were thawed, dried in an oven at 40°C over night and ground by an agate motor. Because of the non-homogenous nature of these sediments, they were sieved through a 63µ sieve (silt and clay fraction).

Extraction and analysis: The extraction method is that of Wade et al. (1988). A total of 10 g dried sediment was Soxhlet-extracted with methylene chloride and concentrated in Kudema-Danish tubes. The extracts were fractionated by alumina : silica gel (80-100) mesh chromatography. The extracts were sequentially eluted from the column with 50 mL of hexane (*N*-alkanes fraction) and analysed by capillary gas chromatography (GC) and gas chromatography-mass spectrometry (GC/MS).

RESULTS AND DISCUSSION

In order to gain some information on the present status and source/s of oil pollution in the region, sediment samples from coast of Aden city were taken and analysed for *N*-alkanes. The concentration

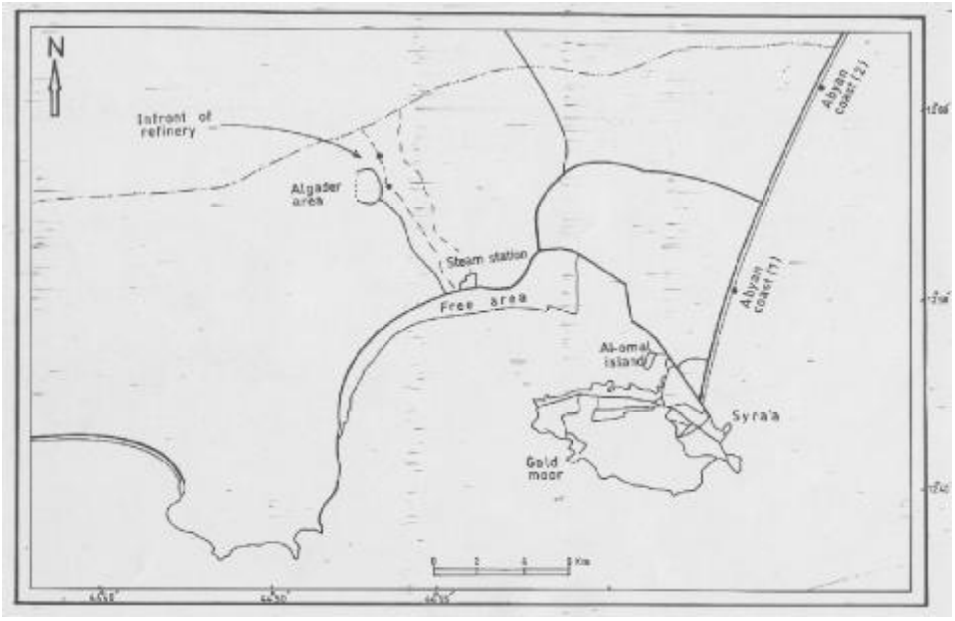

Fig. 1: Study area.

of *N*-alkanes in sediment samples is given in Table 2 and ranged from 3 ng/g at station IV to 1805 ng/g at station VII in dry weight expressed as Kuwait crude oil equivalent. Total concentration of *N*-alkanes was found to range between 4209 ng/g and 10264 ng/g dry weight sediment.

N-alkanes generally constitute the major fraction of saturated hydrocarbons, and their distribution patterns are characterized by carbon-number ranges and predominance depending on the nature of the source material and its microbial or geochemical alteration. In this respect it has been recognized that the distributions exhibiting odd carbon-number predominance in the C15-C21 and C25-C31 ranges are characteristic of autochthonous and allochthonous natural inputs, respectively (Tissot et al. 1975), whereas slight even carbon-number predominance or smooth distributions in the C20-C30 range have been invoked for reduction or bacterial diagentic processes. Finally, fossil (petroleum) *N*-alkanes are characterized by a low carbon preference distribution generally concurrent with an unresolved complex mixture of branched and cyclic saturated hydrocarbons (Farrington & Meyer 1975). Artificial (domestic, urban-industrial and agricultural wastes) sources (DouAbul et al. 1984), Most of oil produced in this region is exported via sea and pipeline, while local refineries and consumption facilities are located in coastal area. The wide spread of oil contamination in the Gulf of Aden is not surprising (Heba et al. 2000, DouAbul & Heba 1996).

Table 2: Total alkanes (ng/g dry weight) of *N*-alkanes in coastal sediments from coast of Aden city, Yemen.

Analyte	Sampling Locations								
Alkanes & Isoprenids	I	II	III	IV	V	VI	VII	VIII	IX
C10	20	37	42	30	35	40	45	41	33
C11	18	40	45	33	27	33	43	35	30
C12	48	75	44	73	80	85	90	83	73
C13	31	65	63	40	43	55	67	63	52
C14	150	202	180	160	180	175	192	185	170
C15	53	71	35	20	110	108	115	110	98
C16	30	63	53	43	35	38	50	44	30
C17	130	200	93	110	40	90	98	91	80
Pristane	5	30	35	14	18	35	42	42	12
C18	170	273	153	110	135	233	265	199	83
Phytane	10	30	43	23	30	25	33	27	18
C19	205	373	402	203	307	280	350	290	195
C20	600	830	811	290	650	703	850	793	350
C21	700	1100	630	600	830	698	1080	903	705
C22	870	1535	833	173	911	703	1500	1171	395
C23	935	1030	1700	705	1505	1630	1805	1800	780
C24	995	1200	1250	600	935	1110	1250	1100	870
C25	470	750	600	473	580	583	750	700	350
C26	370	420	410	250	370	388	415	413	250
C27	200	283	193	130	207	190	290	193	93
C28	70	173	193	50	88	93	190	173	83
C29	80	170	53	23	70	135	180	189	58
C30	30	73	88	12	23	63	80	69	53
C31	78	153	88	30	80	133	160	120	67
C32	83	120	120	4	12	15	118	98	73
C33	50	103	114	3	17	110	120	93	57
C34	18	83	70	7	63	53	86	77	13
Total Alkanes	6427	9484	8341	4209	7381	7804	10264	9102	5071

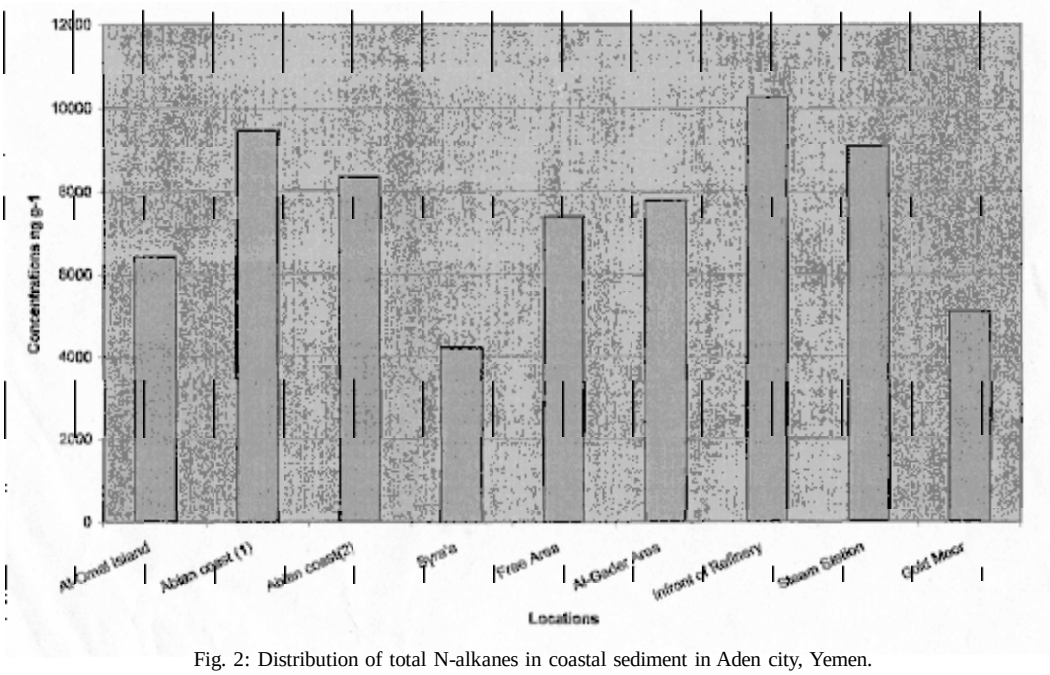

Fig. 2: Distribution of total N-alkanes in coastal sediment in Aden city, Yemen.

The usually common pollutants in the coastal line of Aden originate from discharges from desalination power generation, sewage and wastewater treatment plants in addition to hydrocarbon compounds. From the results presented here, it is evident that all the sites are contaminated to some extent with *N*-alkanes. Goldberg (1975) has reported that the unpolluted open ocean sediments contain 1-4 µg/g dry weight hydrocarbons, less than 100 µg/g in coastal sediments, and up to 12,000 µg/g in highly polluted areas. However, it should be borne in mind that the efficiency of hydrocarbon adsorbance onto sediment particles are governed mainly by its grain size and total organic matter (Abubaker et al. 2002). Sediment samples collected from the coast of Aden city revealed an *N*-alkanes pattern distribution of a mixture of both natural biogenic and petroleum origin (Fig. 2).

CONCLUSION AND RECOMMENDATIONS

The main conclusion of the present study is that this pollution is a consequence of oil operations and heavy ship traffic crossing the Gulf of Aden and Red Sea. The following recommendations are made to contain the pollution.

1. The importance of these data can be comprehended by the fact that they establish for the first time background and patterns of *N*-alkanes in the coast of Aden city.
2. These data are the first of their kind for the region.
3. The present study recommended that a continuous monitoring programme for the coast of Aden city.
4. Since oil is the major source of pollution to the Red Sea and Gulf of Aden, measures should be taken by EPC to enforce the enacting Law No. (16) of 2004 regarding the protection of marine environment from pollution in particular Article (12). Yemeni Government is kindly requested to implement International Convention (MARPOL) concerning the protection of the marine environment from pollution in general and oil pollution in particular.

5. Evaluation of possible risks imposed on different population segments in Yemen and/or the rest of the and Gulf of Aden Red Sea region due to prolonged seafood consumption requires further investigations involving seasonal analysis of edible tissues of different species/size/age categories of locally consumed fish in addition to conducting seafood consumption surveys.

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