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TEMPORAL VARIATIONS IN BEACH TAR CONCENTRATION ALONG IBENO COASTLINE, NIGERIA

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ABSTRACT:

The extent of accumulation and distribution of beach tars (weathered crude oil residues) along Ibeno segment of the Nigerian coastline was investigated between 1989 and 1990. The beach tars were monitored at monthly intervals over a distance of 35km per trip and quantified by gravimetry. A seasonal or temporal variation existed in the pattern of tar distribution. While the highest concentration of tar ($5.46gm^{-2}$ $month^{-1}$) was recorded in June 1989, the lowest accumulation ($0.02gm^{-2}$ $month^{-1}$) occurred in November 1989. These observations showed that more tar was deposited in the wet season than the dry season. A pair-wise correlation analysis gave good correlation between beach tar and wind speed ($r = 0.78$, $P < 0.05$), beach tar and total rainfall ($r = 0.55$, $P < 0.05$) thereby identifying wind speed and precipitation as the principal environmental factors influencing the pattern of tar distribution along the coastline. The observed temporal trend and information is a reliable tool when executing environmental management plan for the protection of the beach against shoreline erosion and for beach development for recreation and tourism.

Key words: Beach tars, temporal variation, Nigeria, environmental factors, beach development

INTRODUCTION

Marine pollution by petroleum have been reported worldwide. Several sources and inputs of petroleum in marine environments have also been identified (Wheeler, 1978, GESAMP, 1990). Nigeria has a coastline stretching over 800km. Adjoining the beaches are several oil rigs and producing wells located in the offshore environment .The textural characteristics of Nigerian beaches range from fine sand in the east (Okposo beach) to coarse sandy texture in the west (Badagry beach). The retentive capacity of entrained pollutants are dependent on the textural characteristics of these beaches (Asuquo, 1998).

Ecological impact caused by spilled oil have been reported (Odu, 1972, Ibiebele et al, 1983, Odu and Imevbore, 1985). Considerable efforts have been made also in documenting oil spill incidents (Awobajo, 1981, Nwankwo, 1981). The highest number of spill incidents were attributed to equipment failure which contributed about 58.7% of the net volume of spilled oil during the period ,1976 to 1981 (Nwankwo, 1981). There was no observation of floating oil or oil patches during this study, but previous measurements estimate the mean thickness of 0.01 - 0.1mm for Nigerian oils (Nwankwo, 1981). This is so because Nigerian oils are generally light to medium gravity oils (API gravity 20 to 50, Asuquo et al ,1996).

The terrestrial environment (intertidal/ backshore zone) where the study was carried out consists of the Ibeno beach located at the western end (designated segment A) and Okposo at the eastern end (segment B, Fig. 1). The beaches are found in the tropical rain forest belt of Nigeria and covers a distance of about 35km of the Atlantic coastline. It lies between latitude 4^0 32" and 4^0 36"N and longitude $8^0$00 and $8^0$16"E.

The foreshore is flat and characterised by numerous beach ridges. At the lowest tide, the active beach measures 30 to 150m wide at the Okposo end. The beach is rather hard and dewatered and the sediment is composed of micaceous and calcareous minerals. The topography of the beaches are excellent and their development can be quite rewarding.

Environmental degradation and contamination of soils (Odu 1972, 1981) and beaches (Enyenihi and Antia 1985, Asuquo 1991, Enyenihi et al, 1992) arising from the presence of petroleum in the Nigerian environment have been reported . The reports of tar on beaches highlighted principally the relative level and abundance of the petroleum residues on the shoreline but there is none yet on the spatial and temporal variation of these pollutants along the Nigerian coastline. The aim of this report is to show the temporal trends in beach tar distribution, its relationship with environmental factors and the usefulness of such an information for environmental planning and management programs of the beaches.

MATERIALS AND METHODS:

The methods used in the sampling and preliminary analysis of tar are as described previously (Asuquo, 1991). It involves hand picking of all visible tar on the sandy surface

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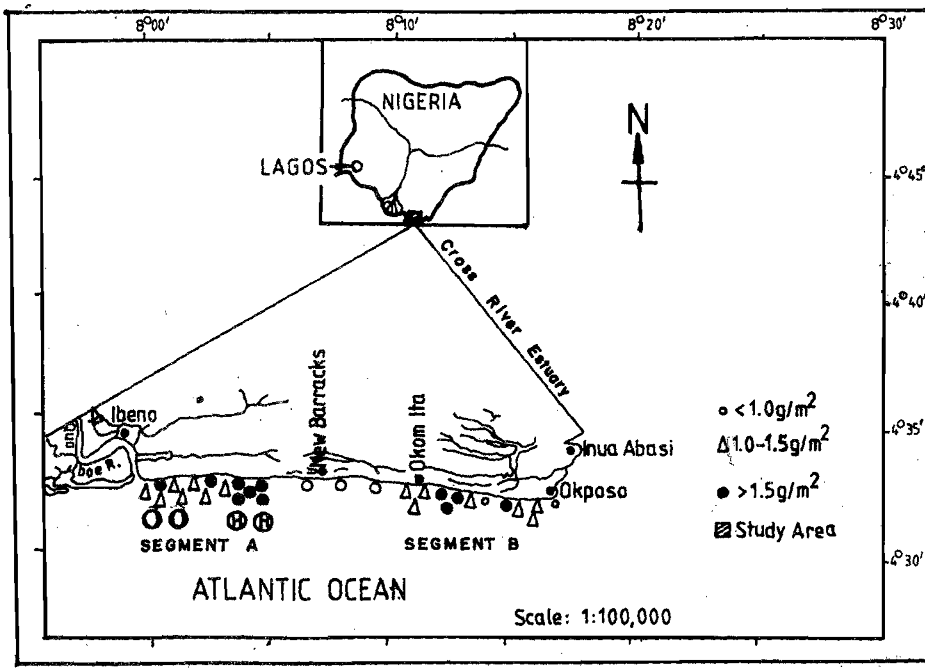

Fig.1 : The study area showing the distribution of beach tars along the shore

and 2cm below surface along a previously marked 1m wide transect extending from the water line to the bachshore (the point where a stable vegetation begins to grow). Tars were collected from a total of 30 transects monthly. The length of the transects monitored varied from 80 - 150m. After collection, the tar was washed with clean water and air dried for at least 24 hours at room temperature. The air-dried tar was weighed directly on a top loading balance (sensitivity $\pm$ 0.05g) and the results expressed as tar per unit beach area per month (gm $^{-2}$ month $^{-1}$). This method allowed the rate of accumulation of tar over a fixed period to be assessed and also the density of tar on a chosen transect to be calculated. Throughout the study period, tar was collected at or near ebb tide. A total of 472 beach tar samples were collected from thirty stations along the beach front. Prevailing oceanographic factors, (wind speed, current velocity etc.) were measured as reported by Enyenihi and Antia (1985). Water temperature was measured insitu using a 50 °C mercury thermometer and rainfall data was obtained from the meteorological unit, Geography Department, University of Calabar, Nigeria.

RESULTS:

Table 1 contains the level of beach tar concentrations at four different locations along the studied beaches. Table 2 shows tar concentrations on Nigerian beaches while Fig.2 illustrates the monthly variation of the beach tars with observed environmental factors. The monthly range for tar and prevailing environmental factors were as follows: Beach tar(0.02 - 5.46gm $^{-2}$ month^{-1}). total rainfall (93.8 - 602.4mm). wind speed (1.26 - 4.31 msec $^{-1}$), longshore current velocity(0.14 - 0.29 msec^{-1}) and water temperature(26.3 - 31.4 °C).

DISCUSSION:

The highest tar concentration (5.46 gm^{-2}) was recorded in June 1989 while the lowest (0.02 gm^{-2}) was obtained in November 1989 (Table 1).

These showed that there was a gradual accumulation of tar during the months of April 1989 through June 1989 and a down drop from December 1989 through January 1990. Very high levels were visible only in June 1989 and August 1989. This observation is similar to previous reports made on the same beach (Enyenihi and Antia 1985, Enyenihi et al. 1992). The enhanced concentration of tar as

Table 1. Mean, range and standard deviation of beach tars (gm^{-2}) at different locations along the studied beach in 1989/90

Months	Ibeno (19st)	New Barracks (4st)	Okom Ita (3st)	Okposo (4st)	*Mean ± SD
Jan.(89)	0.05-1.8	0.01-0.06	09-0.15	0.02-0.09	0.11±0.33
Feb.	0.02-0.51	0-0.17	0.54-.08	0.02-0.05	0.09±0.16
March	0.06-3.37	0.2-1.22	0.12-.97	0.14-0.80	0.4±0.63
April	0.03-0.88	0.3-0.14	0.1-0.41	0.20-0.81	0.25±0.23
May	0.05-0.50	0 - 0.05	0.05-0.2	0.3-0.18	0.07±0.10
June	1.05-18.3	2.22-4.05	0.6-2.18	ND	5.46±7.9
July	0.05-.64	0.38-0.53	0-0	3.79-8.56	0.68±1.68
Aug.	0.23-6.14	0.46-0.71	0.05-0.5	0.10-0.25	3.42±1.16
Sept.	0.13-0.32	0.11-0.34	0.0-0.12	0.05-0.29	0.05±0.10
Oct.	0.03-0.68	0.29-0.58	0.0-0.2	0.15-1.15	0.13±0.31
Nov.	0-0	0.08-0.23	0-0	0-0.34	0.02±0.07
Dec.	0.05-1.07	0.01-0.44	0.1-0.15	0.3-0.36	0.24±0.27
Jan.(90)	0.06±1.9	0.13-0.17	0.2-0.31	0.08-0.12	0.19±0.38
Feb.	0.03-0.71	0.10-0.20	0.2-1.07	0.1-0.26	0.18±0.25

*mean of 30 stations (st)
ND = No data

observed in June is attributed to tar residues from tanker ballast waters transported to the beaches by tidal currents and waves. Chemical analysis of the beach tars confirmed that they are of Kuwait origin (Asuquo et al, 1996). The tar concentrations measured were generally comparable to those reported for beaches in the Caribbean region, although recent data have shown a considerable variation in the amount of stranded tar in this region also (Otero et al, 1987).

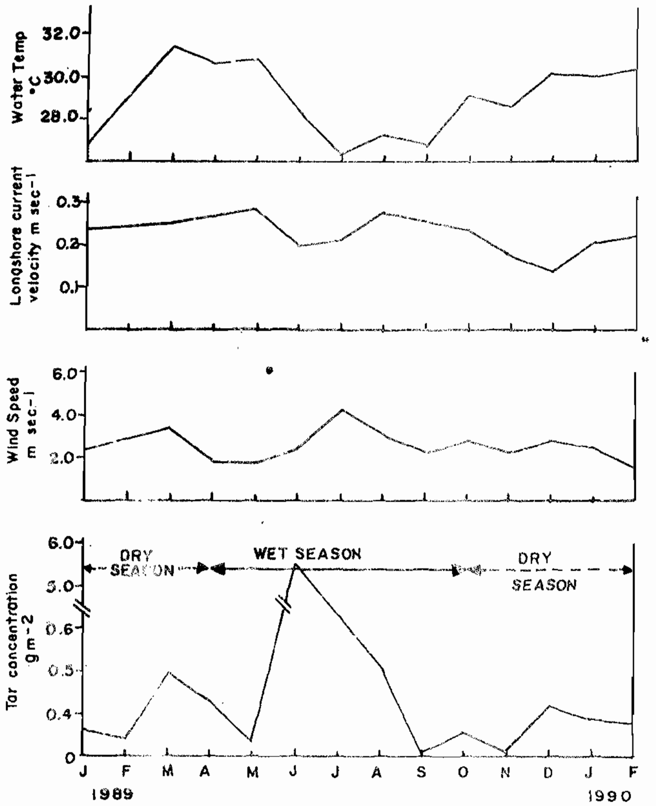

FIG. 2 : The variation of tar concentration with observed oceanographic factors.

Beach pollution by tar constitutes the greatest marine pollution in Nigeria especially along the western coast (Badagry beach, Lagos). A comparison of the tar levels from Ibeno/Okposo beaches with data from Badagry beach indicate a low input (5.46 gm^{-2}) of tar to Ibeno beach, while Badagry beach has a relatively high (95.16 gm^{-2}) input of tar (Table 2). The high rate of tar accumulation on the latter beach is attributed to the coarse and steep gradient or topography of the beach (Asuquo, 1998). Steep and sandy beaches have the potential of retaining and accumulating petroleum pollutant longer than fine-grained low profile beaches. While the fine-grained beaches are largely compacted, the coarse sand or gravel beaches are loosely packed because of large sizes of sand grains and this enhances their retentive capacity to accumulate stranded tars.

Table 2. Mean tar concentrations on Nigerian beaches

Sampling location	Tar conc. (gm^{-2})	Reference
Badagry Beach 1984	26.90	Okonya and Ibe, 1985.
Badagry Beach 1985	18.83	Okonya and Ibe ,1985
Badagry Beach 1986	95.16	Okonya and Ibe ,1986
Ibeno Beach 1985.	1.23	Enyenihi and Antia,1985.
Ibeno/Okposo Beach 1988	1.86	Enyenihi et al ,1992.
Ibeno/Okposo Beach 1989	5.46	Present report.

Reports from existing literature show that the concentration of tar from the beaches of most other African countries (0.52 - 67.97 gm^{-2}) are higher than that obtained during this study (0.02 - 5.46 gm^{-2}, Tables 1 and 3).

Table 3: Mean tar concentrations on beaches in other West and Central African countries.

Sampling Site	Year	g/m/month	g/m^2/month	References
Cameroon Bota	1984	47.9	21.6	Njock and Ikome, 1985
Essongo	1984	25.2	15.34	- do -
Dabauncha	1984	21.83	17.96	- do -
Idenua	1986	938.0	67.97	Njock and Ikome, 1986
Ivory Coast Moundonkon	1985	0.19 - 4.9	-	Koffi ,1985
Bassam	1985	3.4 - 10.83	-	Golik 1985
Congo La Loya	1983	83.51	5.62	Robertson-Smith and Knap, 1985
La Loya	1984	54.28	4.1	- do -
Senegal Malika	1984	80.5	0.52	Otero et al, 1987

This shows that the level of tar on Ibeno/Okposo beaches are generally low and the beaches are unpolluted. Polluted beaches have tar levels greater than 10 gm^{-2} of beach front (GESAMP, 1990). The low level indicates that the development of the beach front for tourism and recreational activities can be a worth while economic venture especially when considering the strategic location of the beaches (sandwiched between the Cross river and Qua Iboe river estuaries). Secondly, the observed temporal trend can be an effective tool in predicting periods of beach cleaning and recreational activities on the beach. Clean beaches are tourist attraction worldwide where sunbathing and games such as football, hockey, etc. are enjoyed by tourist. The presence of tar is unpleasant to sight and nauseating in addition to inducing a feeling of insecurity and unfriendliness. Tar is sticky to touch and gums the sole of foot. It hinders free movement where found in high concentrations and can discourage tourism.

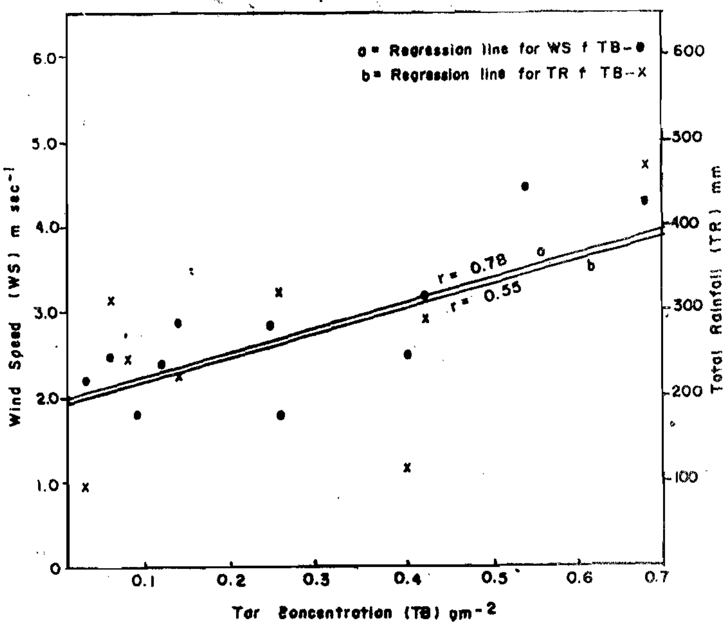

FIG. 3 : **Regression curves for the relationship between tar concentration (TB), wind speed (WS) and total rainfall (TR) during the study period.**

A convenient method for assessing beach state has been proposed by Wong et al 1976 and subsequently used by other authors (Eagle et al, 1979, Van Vleet et al, 1983). This method provides a direct approach for evaluating tar density from different portions of the beach and different regions of the world. Based on Wong et al, 1976 classification, the

distribution of tar along the studied beaches are, given as:

O < 1.0 gm^{-2} (Trace amounts)

Δ > 1.0 < 1.5 gm^{-2} (below medium contamination)

O > 1.5 < 5.0 gm^{-2} (medium contamination, Fig. 1)

Θ > 5.0 gm^{-2} (high contamination)

Each sampling location is identified by a symbol along with the average concentration of tar at that location. Fig. 1 shows that tar concentration greater than 1.0 g m^{-2} was obtained mostly in segments A (Ibeno) and B (Okposo) implying that there is a higher contamination near the mouth of adjourning Qua Iboe and Cross River estuaries. Trace amounts of tar were found in the middle portion of the studied beach.

The Ibeno - Okposo coastline is located in the tropical rainforest belt of Nigeria which is characterised by wet and dry seasons. The wet season (April - October) is usually dominated by increased volume of ocean water, high choppy waves and occasional storm surges. Entrained tars are transported over the intertidal (surf zone) area of the beach into the backshore zone where they cannot be easily washed back into the ocean by retreating waves. Thus, the rate of tar deposition and accumulation is enhanced unlike the dry season (November - March) where the sea is generally calm with little or negligible influence from rainfall. Almost all the tars collected during the wet season were highly degraded and aged , indicating that they have spent a long time (many months) drifting in the sea before final deposition on the beach (Eagle et al, 1979).

The inter-relationships between tar concentration and the prevailing environmental factors were investigated. A strong positive correlation was obtained between tar concentration and wind speed ($r = 0.78$, $P<0.05$, $n = 11$) and a fairly good correlation for tar concentration and total rainfall ($r = 0.55$, $P<0.05$, $n = 11$) Fig 3. This infers that during the storm season or onshore wind, the rate of accumulation of tar on the beach increased and vice versa. This relationship which is highly significant ($P<0.05$) can be used as a convenient tool to predict the variation in the magnitude of tar along the studied beach.

CONCLUSION:

The present report has shown that concentrations of beach tar found along Ibeno/Okposo beaches were relatively lower than value reported for other African beaches. Tar concentrations were extremely patchy and highly variable along the studied coastline. Seasonal trend depicts that high concentration of tar exist in the wet season especially the month of June 1989 than the dry season. There exist a significant relationship between tar accumulation, wind speed and precipitation along the flat-sandy beach. These results are useful for predicting periods of beach cleaning and for establishing recreational periods/centres along the coastline for tourism development and other economic ventures

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