Afr. J. Environ. Pollut. Health 1 (2): 41-50	ISSN = 1596-7425=

Marine garbage composition and dynamics : A Case study of Ibeno beach, Nigeria.

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Abstract: Oil related environmental degradation in the coastal regions of Nigeria have been a subject of intermittent civil disorder because of apparent and perceived negative impacts on the lives of the coastal dwellers. In this study, beach contamination by oil and non-oil materials collectively called garbage is reported. Data was collected fortnightly over a period of 7 months (Dec. 2000 – June 2001) along Ibeno-Okposo, one of the most popular beach resorts on the southeast coast of Nigeria. Results show that the beach garbage is composed of hydrocarbon residues (tar balls), plastics/ leather products, *Nypa fructicans* fragments, fishing materials, oyster shells and wood fragments. Concentration of tar balls ranged from 1 to 6 g/m^2. The non-hydrocarbon components were typically <20 g/m^2 and dominated by *Nypa fructicans* fragments (65%). Beach use was largely responsible for the plastic and other exotic wastes on the beach. The distribution of garbage on the beach is determined by a combination of climatic and hydrodynamic conditions. During the rainy season (April-October), surface run-off and river discharge as well as the wave energy are high and accumulation of garbage on the beach is low. The population of beach users is noticeably low and tourism-related contribution to beach garbage budget is also low due to the unfavorable weather conditions for beach use. In the dry season (November-March) when wave conditions are mild and beach tourism is intense, garbage concentration is high. Apart from garbage contribution by beach users, the high garbage concentration during the dry season is attributed to the net onshore transport of materials by waves. This study provides some baseline data for the modelling of environmental aesthetics of the Ibeno-Okposo beach with regards to tourism and recreation.

Key words: Beach garbage, composition, dynamics, resource development, Nigeria.

Introduction

Sandy beaches worldwide are excellent centers for commerce , recreation and tourism. Abundance and distribution of coastal garbage is of importance to the understanding of the extent of beach degradation. There are several reports on levels and distribution of marine garbage in temperate region (Dixon & Dixon 1981, Gregory 1983, Shiber 1987, McCoy 1988, Gabrielides *et al* 1991, Golik & Gertner 1992). Limited number of such reports are presently available in the Nigerian coastal environments (Asuquo 1991, Enyenihi *et al* 1992, Antia 1989, 1993). The latter reports were directed mostly to the quantification of a single component of garbage namely tar residues. The present report examines the composition of garbage found along the south–eastern Atlantic coastline of Nigeria and also attempts to suggest management strategies for an effective coastal resource management.

Study area

The Ibeno-Okposo beach is composed of well sorted fine to medium sand particles of diameter less than 350µm. The beach has low-lying profile and undergoes drastic morphological changes especially during the wet season (Antia 1989). Offshore of the beach are extensive oil prospecting and production facilities belonging to Exxon-Mobil oil company with terminal at Ibeno, Nigeria. Prevailing physical oceanographic variables influencing transportation and deposition of pollutants include waves (0.5 – 1.5 m high), winds predominantly offshore usually < 5 m sec^{-1} , longshore currents <1.0 m sec^{-1}, semidiurnal tides 2.5 – 2.8 m, water temperature 26 – 32 ^{o}Cm The dominant breaker wave is spilling breakers (Asuquo 1991, Enyenihi *et al*, 1992). The geology and geomorphologic characteristics of this coastline indicate it consist primarily of fine to medium grained sand, well sorted with a flat terrain (< 5^{o}) composed of micaceous clay (Antia 1989).

Data collection and analysis

Garbage sampling:

Five sampling stations were occupied for garbage monitoring lasting for 7 months from December 2000 to June 2001. Garbage assessment involved choosing a fixed station and marking out 1-m width of the beach portion. All garbage found along the 1-m transect, stretching from the water line to the back of the beach were collected and manually sorted out (hand picking) for quantification . The stations were chosen inequidistant from each other and areas of intense human activity such as sand mining and dredging were avoided since such activities can induce drastic morphological changes along the beach. All samples were collected at low tide fortnightly. The five beach stations occupied were Ibeno (St.1), Akwaha (St.2), (Itak Afaha) (St.3), New

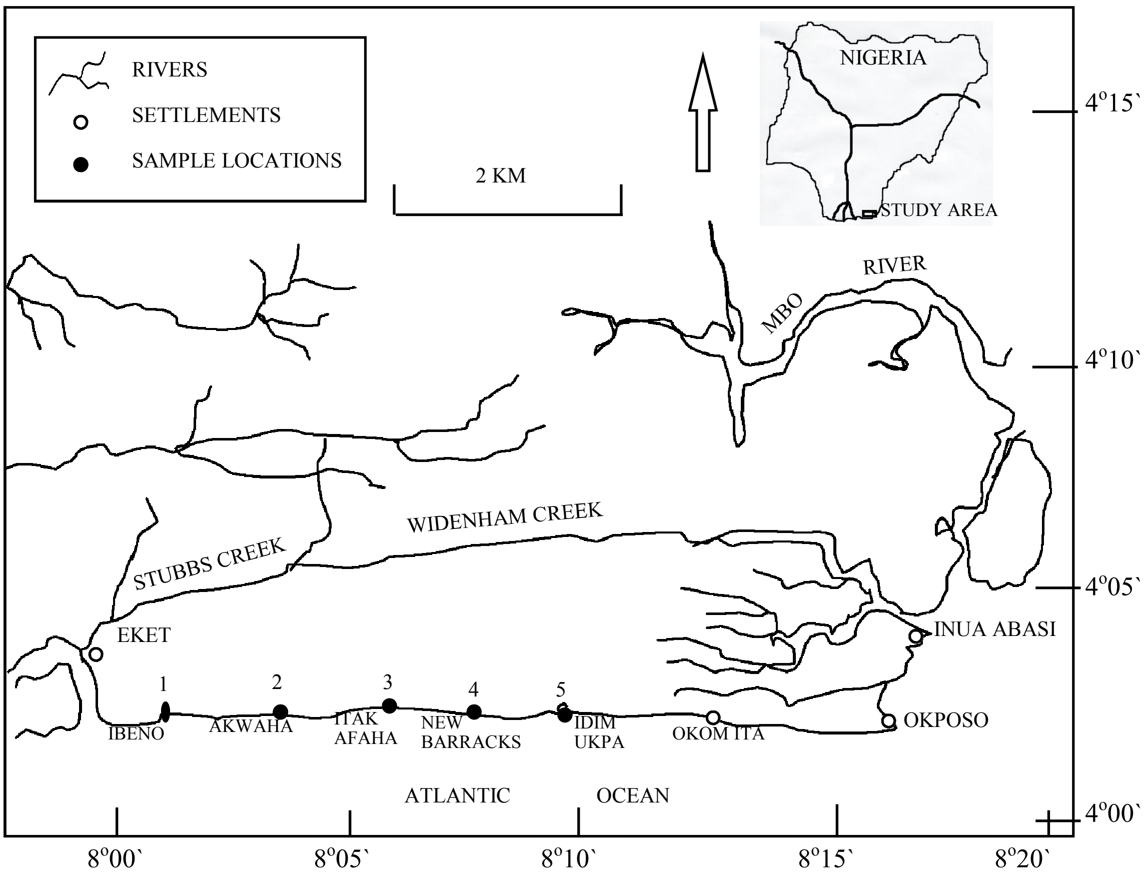

Fig. 1: Map of the study area showing sampling locations

Barracks (St. 4) and Idim Ukpa (St.5), (Fig. 1). The composition and nature of coastal garbage found along this coastline were noted.

Gravimetric Analysis:

Garbage components were separated by hand picking, brushed and weighed on a top loading balance (precision, ± 0.1 gm). The results obtained were expressed as garbage weight (gm) and garbage concentration (gm^2).

Chemical Analysis

Inorganic constituents of tar such as trace metals (Ni,V) were determined using Atomic Absorption Spectrophotometry (AAS) as described by Asuquo *et al* (1995). Organic constituents such as n-alkanes, isoprenoids (pristane, phytane) and phenanthrenes (m/z 192) were determined with Gas Chromatography-Mass Spectrometry (GC-MS) using, Hewlett – Packard GC-MS model 5993C. The analytical conditions for GC-MS analysis including oven temperature operated in splitless mode (0.5mm/at 40^oC), temperature programming was from 40 to 100 ^oC at 2^oC min^{-1} and 60 to 300 ^0C min^{-1}, hold time of 5 mins at 300^oC. Data acquisition of the mass spectrometer started 6.5 min after sample injection.

Results

Table 1 shows the mean values of garbage components obtained during the period (Dec.2000 – June 2001). The percentage abundances of respective components are as indicated in Fig. 2. The spatial trends in the distribution of the garbage components are as shown in Fig. 3.

Garbage composition:

Six garbage components were identified and enumerated. They consist of non-hydrocarbon components, *Nypa fructicans* fragments (NF) 65.4 %, plastics (P) 2.6 %, fishing nets (F) 1.8 %, oyster shells (OS) 1.4 % and wood fragments (WF) 24.8 % and tar particulates (T), 4 %, which constituted the hydrocarbon component (Fig. 2).

Characteristics of garbage components

Nypa fructicans fragments:

Fresh and dried fruits of *Nypa* constituted the most abundant (65%) garbage component (Fig. 2). Sizes ranged from 3 - 6cm in diameter. *Nypa* fragments originate from the *Nypa* stands flourishing within the mangrove swamps and creeks bordering the coastline. Deforestation of *Nypa* for farm lands and building purposes often release the fruits in large numbers which can float over a considerable distance before final deposition on the beach. This process enhanced their transportation and disposal along the beach front.

Wood Fragments:

Mangrove swamp destruction for peasant farming, road construction and harbour development generates wood particles (fragments) of various sizes into the environment. Wood particles ranged in sizes from 3 to 20 cm (small size) and 60-100cm long (large size). They were second in abundance (24.8%) after *N. fructicans* (Fig. 2). The large pieces of wood served as substrates for barnacles and marine oysters indicating that they have been released into the marine environment for quite sometime.

Plastics products:

Plastic materials (2.6%) consisted of plastic bags (polythene, drinking water sachets), bottles and pellets of various colours (white, opague, yellow, brown and grey). Most of the plastics appeared to be discarded materials left behind by beach tourists .

Tar Residues:

Dark-black to grey petroleum lumps otherwise called tar balls or residues constituted 4% of total garbage components observed (Fig. 2).

Oyster Shells:

Several empty oysters and bivalves shells were collected along the studied beach. Oyster shells constituted only 1.4% of garbage components observed. The shells comprised mainly of periwinkles, barnacles and clams of different ages . Most shells were of course inhabited by hermit crabs as secondary host.

Fishing Nets:

Fishing nets and lines were observed at some of the locations. They constituted only 1.8% of the total garbage quantified.

The spatial distribution patterns of garbage between the five stations were regular and displayed bimodal shapes for tar, Nypa and plastic materials whereas wood fragments and fishing nets gave unimodal shapes. Oyster shells showed no definite pattern between the locations (Fig.3). The temporal distribution of garbage components showed a decreasing trend from December to June at all the beach stations (Table 1).

Discussion

The marine garbage from Ibeno coastline are primarily composed of litter from nearshore origin. A survey of garbage characteristics from other coastlines of the world reveals that while plastic pellets are more common on the Mediterranean beaches (Golik 1982, Shiber 1987), used household containers discarded from ships were the most abundant litter on the shores of English Channel, North Sea and the East Atlantic (Dixon & Dixon 1981, Vank & Schrey 1987). Along the Ibeno beach , the most prevalent component was the *Nypa fructicans* fragments locally generated from deforestation activities. The greyish coloured plastic pellets suggest their close association with tar particulates especially at Stations 1 and 5 where the tars were more abundant than other locations. The source of tar balls previously reported on Ibeno beach have been traced to tanker discharges/washing into international waters having characteristics similar to Middle East crudes (Kuwait oils, Asuquo *et al* , 1995, 1996). Although tar on the beach does not cause a health hazard (Golik 1989), its presence is nauseating and unhealthy. It stains the foot and clothes of tourist and can cause serious damage to tourism industry. The fishing nets observed were seen attached to plastic beads suggesting their origin from artisanal fishery - which is a major occupation of the coastal communities. The initial high value for each garbage component is attributed to previous accumulation during the month of November 2000. Inorder words, garbage concentrations were high in the dry season and low in the rainy season. Results show that both the hydrocarbon component (tar) and most of the non-hydrocarbon components were from nearshore (owe their origin to mangrove swamps) and the open sea.

From this study, the garbage concentrations varied with seasons. The highest garbage concentrations occurred between December and March in the dry season but low in the wet season. The high dry season values are attributed to the dominating spilling breaker waves prevalent along the shoreline during the dry season (Asuquo 1991). Golik and Gertner (1992) made a similar observation on garbage concentration on Israeli beaches . They observed that the occurrence of moderate waves (ca 6m high) can drive garbage to the beach foreshore and beyond. Spilling waves are the primary oceanographic mechanism facilitating the transportation and deposition of entrained garbage on a fine sandy low gradient beach such as Ibeno coastline. Since the highest concentration of garbage monitored was relatively low (< 20 g/m^2) , it is likely that the wave energy associated with the spilling breakers are quite small compared to plunging breakers along steep and high gradient beaches such as Badagry beach, Nigeria (Antia 1993).

Assessing the inter-relationship between garbage components using a pair – wise regression analysis gave high correlation for most of the stations ($r \geq 0.90$ at $P < 0.05$, Table 2). From the relationship, it implies that stations with the same r value are not significantly different

Table 1: The mean concentrations of Garbage components obtained during 2000-2001 survey period (gm^{-2}).*

Months	Tar	Wood fragments	Oyster shells	Plastics	Fishing Nets	*Nypa fructicans*
Dec-00	0.99 ±0.19	4.2±2.1	0.24±0.2	0.46±0.3	0.28±0.2	14.0±8.9
Jan. 2001	0.13±0.1	1.42±0.7	0.17±0.2	0.23±0.2	0.2±0.3	3.8±2.1
February	0.04±0.03	1.03±0.4	0.02±0.01	0.14±0.1	0.1±0.3	1.8±1.6
March	0.1±0.04	0.1±0.4	0.02±0.01	0.03±0.02	0.04±0.02	1.7±0.6
April	0.08±0.04	0.6±0.3	0.020.01	0.03±0.02	0.04±0.02	0.98±0.8
May	0.05±0.02	0.4±0.1	0.02±0.01	0.03±0.01	0.03±0.01	0.3±0.08
Jun-01	0.04±0.01	0.01±0.01	0.02±0.02	0.02±0.02	0.02±0.02	0.2±0.2

* Mean ± standard deviation for 5 stations along the beach front.

Table 2.: Correlation between garbage components from Ibeno beach

	1	2	3	4	5
1	-	0.97*	0.97*	0.91**	0.91**
2			0.90**	0.98*	0.89
3				0.81	0.95
4					80

*, ** - Locations with comparable degree of pollution at $P < 0.05$

($P > 0.05$) from one another and have the same degree of pollution. For instance, the degree of contamination of Stations 2,3 and 4 on one hand and Stations 3,4 and 5 on the other are comparable (Table 2). The high and significant ($P < 0.05$) correlations observed are indicative of components emanating from a similar environment. These inter-relationships suggest that the same management approach can be used in the control of garbage pollution along the coastline.

Chemical characterization of hydrocarbon component of garbage

The chemical composition of tar (hydrocarbon component) collected from Ibeno beach when compared to Nigerian offshore oils were distinctively different (Table 3). While the Nigerian crude oils are V and Ni dominated, the tar particulates analysed were V and Pb dominated with almost a negligible amount of Ni. Gas chromatographic parameters show that the tar particu-

Table 3: Comparison of chemical constituents of tar particulates with crude oils from Nigerian offshore environment.

Parameters	Tar*	Nigerian oils*
n-alkane range	nC_{13}-C_{38}	NC_{13}-C_{32}
n-alkane distribution	Bimodal	Unimodal
C_{17}/Pr	0.82 ± 0.26	0.67±0.13
Pristane/Phytane	0.92±0.39	3-1±0.49
MPI – 3	0.64±0.12	1.24±0.09
V	18.7±23.1	1.0 ± 0.2
Ni	0.05±0.04	0.4±0.2
Pb	1.3±0.4	0.04±0.02
V/Ni	75.5±95.6	3.3±1.19

* Means ± standard deviation
MPI – Methyl Phenanthrene Index ratio

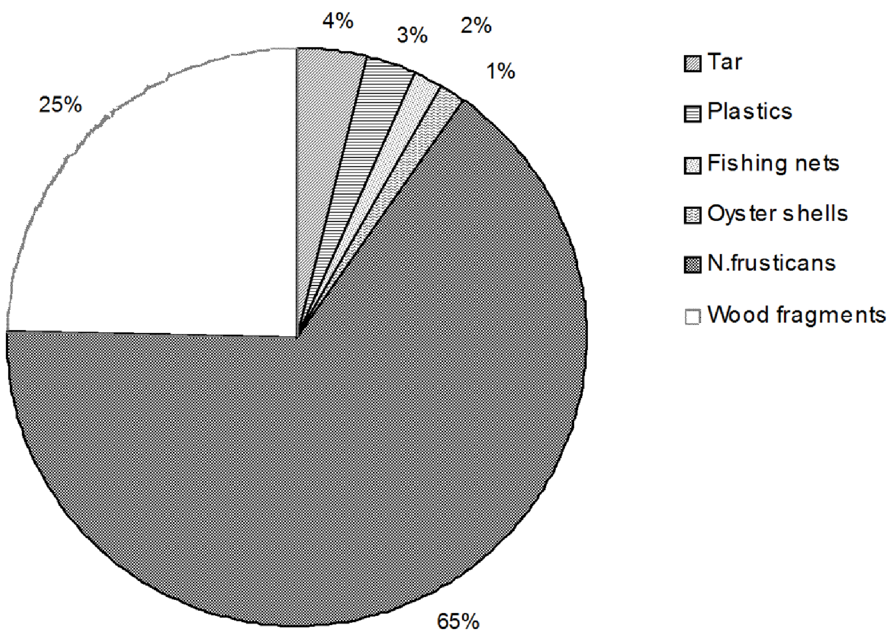

Fig. 2: Percentage composition of Garbage along Ibeno Beach, Nigeria

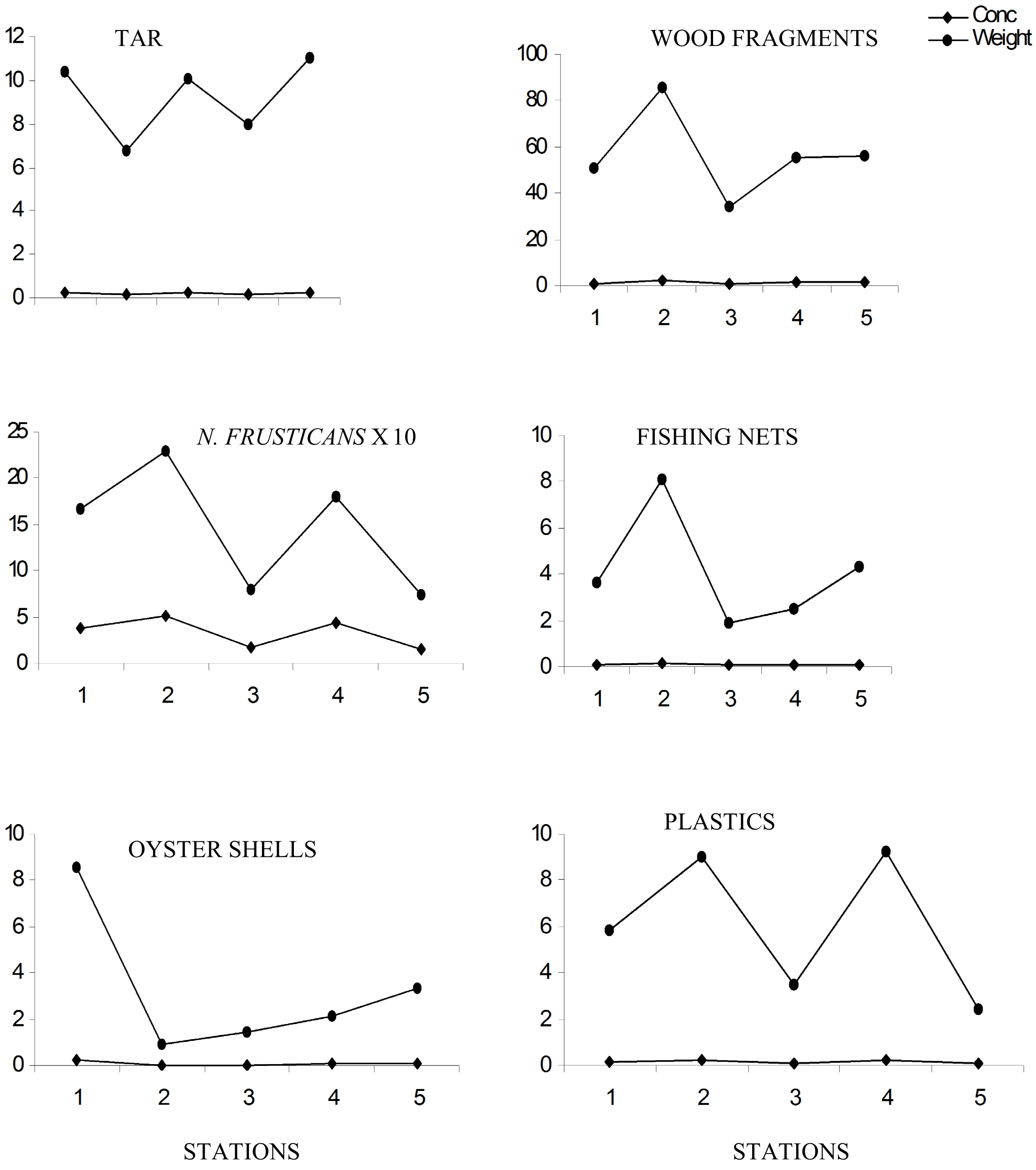

Fig. 3: Spatial variation of Garbage components from Ibeno Beach, Nigeria

lates are characterized by low Pr/Ph and low MPI-3 ratios (Methyl Phenanthrene Index) whereas the oils are identified by high Pr/Ph and high MPI-3 ratios. These characteristic compositional differences depict a foreign source probably tanker ballast waters for the tar balls (Asuquo *et al* 1995, 1996).

Conceptual Model of garbage dynamics on Ibeno beach

The Ibeno-beach is mesotidal with a low gradient of about 5^0 (Asuquo 1997). During the dry season , the results showed that garbage transportation from offshore is enhanced by prevailing calm coastal conditions (low wave amplitude and low wave energy) assisted by the buffering effect of NE trade winds which act in opposite direction to ocean waves and tides . The dry season is therefore designated the calm season in the model (Fig. 4a). The resulting impacts of these buffering action on onshore transport by waves are beach accretion and increased concentration of garbage along the shoreline (Fig. 4a)

In the transitional/storm season (April to October) there is predominantly high wave energy and enhanced rip currents along the shoreline (Asuquo 1991). The resulting impacts are offshore transport by waves culminating in increased beach erosion and decreased concentration of garbage stranded on the beaches. These processes are aggravated by the prevailing S.W Trade winds blowing onshore parallel to the devastating plunging breaker waves (Fig. 4b). The SW trade winds are the dominant winds blowing across the Atlantic ocean during this season. These further reduces the beach length but provides a cleaner beach. From the study, it is evident that a more conducive and soothing period for tourist attraction is during the calm season .

Garbage control and Beach management strategies

The problems of litter on the marine environment are principally two-fold: they constitute a serious hindrance along navigational channels by blocking the propellers of outboard engines and marine birds may get entangled by stranded fishing nets. Secondly, they reduce aesthetic beauty of the shoreline with negative impact on recreation activities like bathing, swimming, boating and walking. On the other hand, plastic pellets can be a source of PCBs in the marine environment (Shiber 1987) and excessive amounts of particulates can be misconceived as food by pelagic organisms especially fish which can eventually cause intestinal blockage (Kartar *et al,* 1973, Colton *et al,* 1974, Shiber 1987). The presence of tar lumps in the intestines of sharks have been reported previously (Horn *et al*, 1970). Garbage monitoring is therefore part of a conscious effort to identify and control garbage problems on beaches worldwide.

The nature and composition of garbage gives a unique signal on the possible source and origin of the contaminant. Information on the source of garbage is a necessity for design of proper management strategy. This report indicates that about 87 % of the garbage components are sea-based while 13 % are land-derived.

The control of coastal activities such as deforestation of the mangrove swamps, discarding of broken nets and used plastic bags (bottled water) could be achieved by enforcing existing regulations that restrict forest destruction and dumping of waste in the nearshore waters . Considering the above two-way model , beach protection and development during the calm season could be actualized by the formation of Clean Beach Youth Clubs (CBYC) as environmental watchdogs in the respective locations. The participation of environmental NGO's was applied in "SAVE SEA TURTLES " campaign in Ghana very successfully and could be another useful tool (Armah *et al* ,1997).

Other technical measures that could be adopted include community participation in weekly beach cleaning, environmental education of the coastal communities on the advantages of tourism, organization of workshops, seminars and conferences on the potentials of developing a beach as a commercial center and the use of print, mass and electronic media (including bill boards) to enlighten and encourage maximum participation in coastal resource conservation.

Acknowledgement

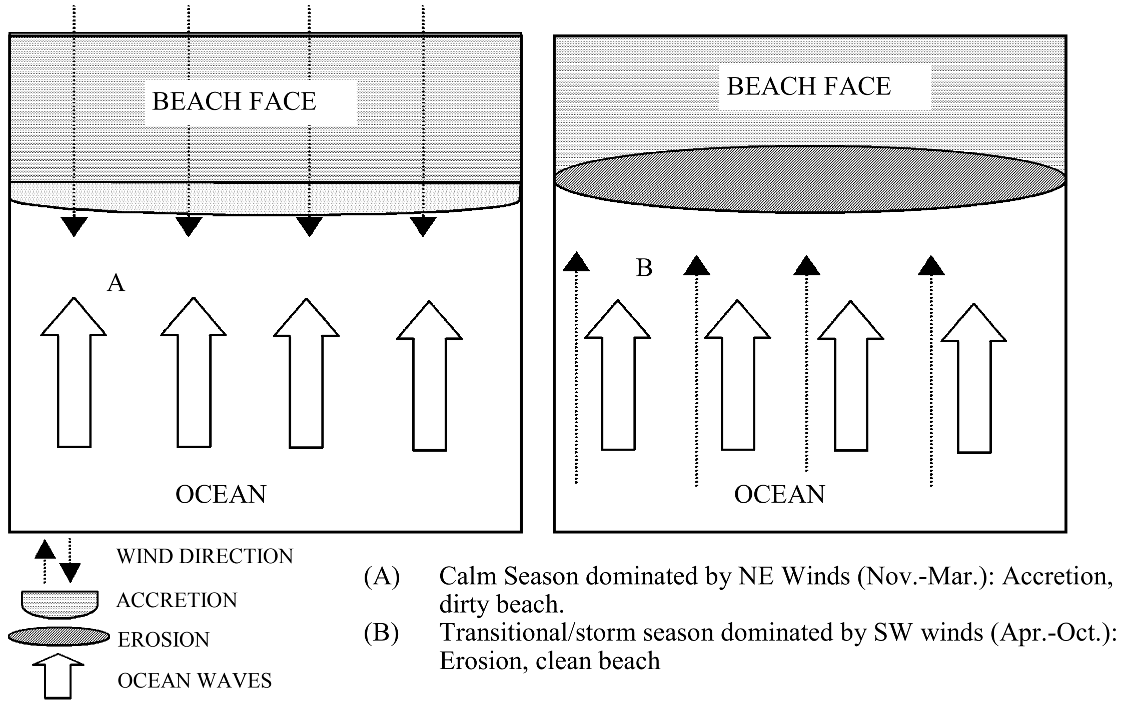

Fig. 4: Conceptual model of garbage dynamics along Ibeno coastline

The author appreciates the technical assistance given by Messrs Clement Esenam and Emmanuel Bassey during the field and laboratory work.. I thank Dr. Manfred Ehrhardt of Marine Chemistry Department, University of Kiel , Germany for the chemical analysis of the tar balls.

References

Antia EE (1989). A short term study of the effects of the changing coastal conditions on some geomorphic elements on Nigerian beaches. 7 Geomoph. N. F., 73, 1-16

Antia EE (1993). A morphodynamic model of sandy beach susceptibility to tar pollution and self-cleansing on the Nigerian. J. Coast. Res. 9:1065 – 1071.

Armah AK, Darpaah GA, Wiafe G, Adomako JK & Fiagbedzl S (1997). Save sea Turtles. A Primer on sea turtle conservation for coastal communities in Ghana. Resource and Environmental Dev. Organization, 32pp

Asuquo FE (1991). Tar balls on Ibeno – Okposo beach of south east Nigeria. Mar. Pollut. Bull. 22: 150-151.

Asuquo FE, Morah FNI, Nya AE & Ehrhardt ME (1995). Trace metals in crude oils and tar balls from the Nigerian coastline. Ind. J. Mar. Sci. 24:16-18.

Asuquo FE, Ukpabio EJ & Ehrhardt M (1996). Composition and potential source of Nigerian Beach tars. Global J. Pure and Appl. Sc. 2:171-182.

Asuquo FE (1997). Tar balls monitoring,. A classical tool for the assessment and evaluation of marine pollution by petroleum. Common wealth proceedings on Environment 1, pp20-25.

Colton JB Jr, Knapp FD & Burns BR (1974). Plastic particles in the surface waters of the North Western Atlantic. Science 185: 491-497

Dixon TR & Dixon JJ (1981). Marine litter surveillance.. Mar. Poll. Bull. 12,289 –95.

Enyenihi UK, Asuquo FE & Antia EE (1992). The levels of stranded pelagic tar residues on Ibeno

beach 2: 52 – 55.
Gabrielides GP, Golik A, Joizides L, Marino MG, Bingel F & Torregrossa, MV (1991). Man-made garbage Pollution on the Mediterranean coastline. Mar Poll. Bull 23:437-441.
Golik A (1982). The distribution and behaviour of tar balls along the Israeli coast. Estuarine Coast Shelf Sci. 15: 267-276.
Golik A (1989). Decrease in the quantity of beach stranded tar in Israel. Toxicol and Environ. Chem. 20-21: 59-63.
Golik A & Gertner Y (1992). Litter on the Israeli coastline. Marine Environmental Res. 33, 1-15.
Gregory MR (1983). Virgin plastic granules on some beaches on eastern Canada and Bermuda. Mar. Environ. Res. 10:73-83.
Horn MH, Teal JH & Backus RH (1970). Petroleum lumps on the surface of the sea Science 168:245.
Kartar S, Milne RA & Sainsbury M (1973). Polystyrene waste in the Severn Estuary. Mar. pollut. Bull. 4:144.
McCoy FW (1988).Ffloating megaliter in the eastern Mediterranean. Mar Pollut. Bull. 19:25-28.Shiber JG (1987). Plastic pellets and tar on Spains' Mediterranean beaches. Mar. Poll. Bull 18, 84-86.
Vauk GJM & Shery E (1987). Littler pollution from ships in the German Bight. Mar. Pollut. Bull 18 :316-319.