Assessment of Anthropogenic Marine Debris in Four Beaches Along the Coastline Gulf of Guinea South West Nigeria

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ABSTRACT

Anthropogenic marine debris is permeating in the marine environment and World's shores present a major sink. This study assessed the anthropogenic marine debris on four beaches along the South West Nigeria shoreline was sampled between November to December 2019. The marine debris was categorized into eight categories: Plastic, Glass, Metal, Wood, Fishing Aquaculture, Cotton fiber, paper and styro foam. The relationship among the abundances of each category were examined. The abundance of each anthropogenic marine debris category were; $2331/m^2$, $504/m^2$, $625/m^2$, $474/m^2$, $508/m^2$, $518/m^2$, $1044/m^2$ and $826/m^2$ (Plastic, Glass, Metal, Wood, Fishing Aquaculture, Cotton Fiber, Paper and styrofoam) respectively. Plastic was most abundant item across the beaches shoreline, it had highest loading value (0.92) among all the AMD categories. The study area was non-significantly related abundance of AMD. Similarity evidence was recorded in the pooled data set of hierarchical analysis showed the site had a related cluster across the sites.

Introduction

Ecosystems and its delivery services in various ways are affected by marine debris and tar contamination which have dexterous effects on the wildlife and habitat quality, economy, aesthetics, human health and safety [1]. The global and persistent environmental problem that has considerably increased over the last decades has been characterized as anthropogenic marine debris (AMD) mostly composed of plastics [2]. The accretion of AMD has multiple impacts that can be categorized into three types; biological, ecosystemical and socio economical (Kuo and Huang, 2014). Entanglement and consumption of Marine debris by marine organisms can be affected biologically [3,4]; this can lead to physical and chemical damage and even death [5,6]. Based on ecosystems and biogeography, AMD may serve as dispersal vehicle for invasive species, which can modify local ecosystems [7-9]. Coastal marine debris is aesthetically detrimental, it can affect the perception of beach users and coastal tourism, requiring high beach cleaning costs, causing losses in revenue which eventually lower the socio-economic values [10-12].

Packaging is a major environmental concern for many decades; due to waste associated with packaging, particularly plastic [13-16]. Escape of plastic packaging disposed to into natural environment due to its size, high dispersion rate and low residual value, thus

are commonly identified debris [17]. There is variety of causes of leakage including direct dumping, littering, as well as wind or water-borne transport such as via storm water runoff, from open dumps and landfills [17,18]. The underlying and common use of plastic for diverse applications, light weight nature, durability and low price made it commonly used [19]. Annual plastics production has increased greatly over the globe. Enormous quantities plastic is consigned to landfill, recycled, or are still in use. Nevertheless, huge volumes end up as marine debris as a result of insufficient treatment capacity, accidental inputs, littering, or illegal dumping [17]. The primary compositions of plastics are mostly polyethylene and polypropylene, recorded on the survey sand Island, Midway Atoll [20]. Marine debris can be categorized according to two main source categories: Ocean and Land-based debris, depending on where Anthropogenic Marine Debris entered the marine environment [2].

Ocean-based AMD sources include waste from shipping, fishing, oil platforms and aquaculture [21-24]. Land based AMD might enter the marine environment by rivers, outflow from industries, harbors, unmanaged landfills, sewage waters, extreme events (tsunamis hurricanes), or through direct littering by beach visitors [25-29]. The studies of Jamback, et al. [30] estimated over 8.4 million tons of plastic waste entering the ocean annually from land based sources. The composition of marine litter is very diverse consisting of plastics (such as bags, bottles), wood (boxes and fragments), glass(bottles), metals (cans, aerosol containers), rubber (tires, boots), cigarette butts, etc [31]. The primary plastic items of marine litter consist of bottles, plastic bags and packaging materials. Wood and glass correspond to another 10% of total marine litter each, some of the most common items of marine litter between 1989 and 2007 (at the global level) included plastic bags (9.4%), caps/lids (9.1%),food wrappers (8.9%), cups and cutler (7.2%) and small (less than 2.1), plastic beverage bottles (5.5%) [32]. Island Morphology can be affected by wind and ocean currents, it influences plastic debris accumulation and deposition [33]. Variations of AMD abundance over a period of time might be linked to the socio-economic and educational conditions of a country; pro-environmental behavior such as adequate waste disposal is generally higher in developed countries [34]. Developing countries focus on economic growth, often at the expense of environmental care. Environmental degradation might increase as the economy grows, up to a point where economic development leads to higher environmental awareness, thus, identification of the sources of

Anthropogenic Marine Debris is indispensable for satisfactory mitigation strategies, since it is of global concern [35].

Nigeria has a coastline of 853Km, a maritime area of 46,500km^2 and an exclusive economic zone of 210,900km. Nigeria covers a total of 923,768km^2 along the West African Gulf of Guinea. The coastal areas stretch inland for a distance of about 15km in Lagos in the West, which is the commercial capital of Nigeria. For a busy commercial activities in Lagos Nigeria, thus the amount of AMD of beaches are expected to be high, with a trend to increase over period. The data collected in this study will provide base-line information on Anthropogenic marine debris in four beaches along the coastline of south-West Nigeria, to

a. Determine composition,

b. Estimate abundance and spatial patterns on the four beaches.

Materials and Methods

The study was conducted on four sandy beaches, along the Nigerian coastline, the Gulf of Guinea, Eastern Atlantic Ocean, South-West Nigeria. The four beaches were located in Lagos coastline of Nigeria. New Lekki Beach (6.4589^{0}N; 3.6015^{0}E), Elegushi beach (6.4221^{0}N;3.48666^{0}E), Oniru beach (6.4230^{0}N;3.4429^{0}E) and Alpha beach (6.4225^{0}N;3.5236^{0}E). Five stations each were generated from each beach, New-Lekki (N1, N2, N3, N4 and N5), Elegushi beach (E1,E2,E3,E4 and E5), Oniru beach (O1, O2, O3, O4, and O5), Alpha beach (A1,A2,A3,A4 and A5).The survey at the four beaches were conducted during the period of November to December 2019, at each sampling site, five random stations were established with the aid of GPS(Garmin GPSmap62st, Switzerland). 10m x 10m larger quadrats (placed in locations that visually appeared to have the maximum and minimum amount of debris [36]. All natural and artificial debris with a depth of 5cm in the quadrats was sieved out. All AMD items found at each station were collected and counted after classifying them according to the following categories: Plastics, Stryofoam, Papers (cigarette butts), cotton(fibre), fishing aquaculture, woods, metals, and glass. Summary statistics were calculated overall and by site. Items making up 1% or more of the debris category mean total were tabulated. ANOVA was used to test for site differences in total debris, Duncan and Fisher's Least significant Difference was used to compare among sites. Principal coordinate Analysis and Cluster Analysis were done to compare relationship of marine debris among sites (Figure 1).
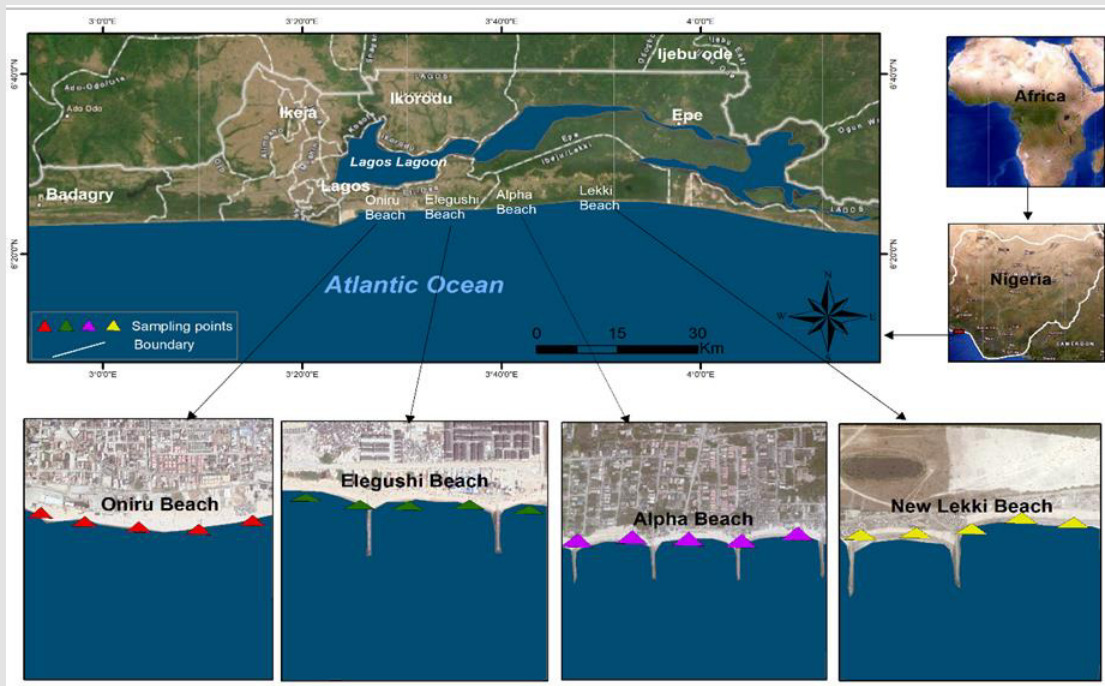
Figure 1: Map of the study area showing the sites.

Results

The mean value (mean value ±STE) of AMD surveys across the sites were 41.30± 4.99, 47.62± 5.78, 43.77 ±7.71 and 38.07± 5.17 (Elegushi, Oniru, New-Lekki and Alpha Beach) respectively. Oniru beach had the highest AMD during the survey. The highest mean value was also registered in Oniru beach, there were no significant difference in the composition of different marine debris at the different sites (Table 1), plastics dominated New lekki beach (34.40%),and Papers Cigarette butts in Elegushi beach (31.13%). Metal presented a higher percentage in Oniru Beach the Shannon weiner diversity of each classified AMD was > 2 across the sites, evenness was > 0.7, it implies high composition and abundance of AMD during the period of survey. The proportions of the different items of AMD found in this study are relatively similar among the sandy beaches (Table 1). Plastics dominated the shoreline, most common plastics belong to household and fishing Aquaculture such as shopping bags, plastic bottles, plastic lids, plates, spoons, pieces of hard and soft plastic (> 30%). Paper (cigarette butts) and Styrofoam also had high percentage of the total (>10%), other items were glass, metals, wood cotton fiber were moderately abundance along the shoreline in the four beaches. There are no clear differences found in the composition of AMD among the sites. The ANOVA revealed no significant difference (P<0.05) in the composition of AMD across the study sectors. All the marine debris contributed to the similarities among the stations in the beaches (Figures 2-6).

**Table 1:** Mean value of different anthropogenic marine debris in the four Beaches.

Anthropogenic Marine Debris	Sites			
	Elegushi Beach	Oniru Beach	New Lekki Beach	Alpha Beach
Plastics	93.40±18.16[c]	113.40±27.18[b]	160.40±17.61[b]	99.00±15.68[c]
Glass	20.40±6.05[a]	36.40±11.82[a]	26.80±7.80[a]	17.20±3.77[a]
Metals	32.80±7.09[a]	44.00±10.43[a]	25.80±8.18[a]	22.40±6.86[a]
Wood	35.40±7.82[ab]	33.80±6.43[a]	15.20±1.98[a]	10.40±1.50[a]
Fishing Aquaculture	30.40±4.89[a]	30.00±3.94[a]	18.80±5.28[a]	22.40±3.85[a]
Cotton Fibres	25.20±8.86[a]	32.20±3.51[a]	25.80±8.70[a]	20.60±2.48[a]
Papers (cigarette butts)	65.00±16.28[bc]	41.00±10.45[a]	42.00±4.41[a]	60.80±7.90[b]
Styrofoam	27.80±2.65[a]	50.20±11.43[a]	35.40±8.19[a]	51.80±9.70[b]
Total	41.30±4.99	47.62±5.78	43.77±7.71	38.07±5.17
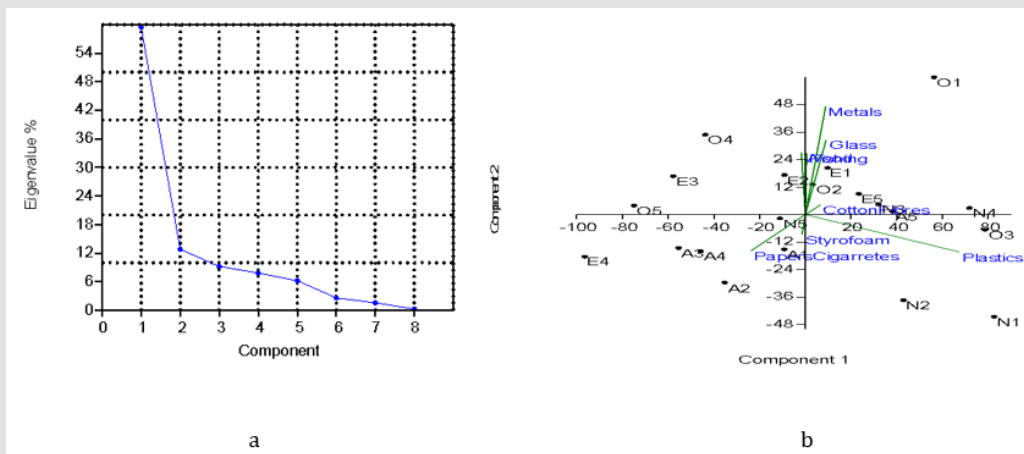
Figure 2:
a. The scree plot showing the eight components
b. Principal Component Analysis Scatter Diagram.
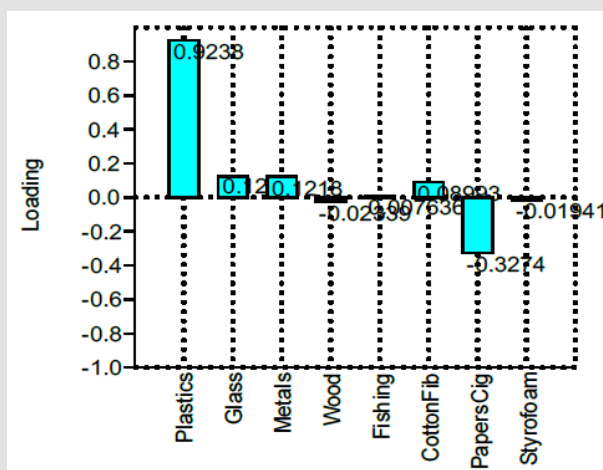
Figure 3: The loading values of different anthropogenic marine debris in the four beaches.
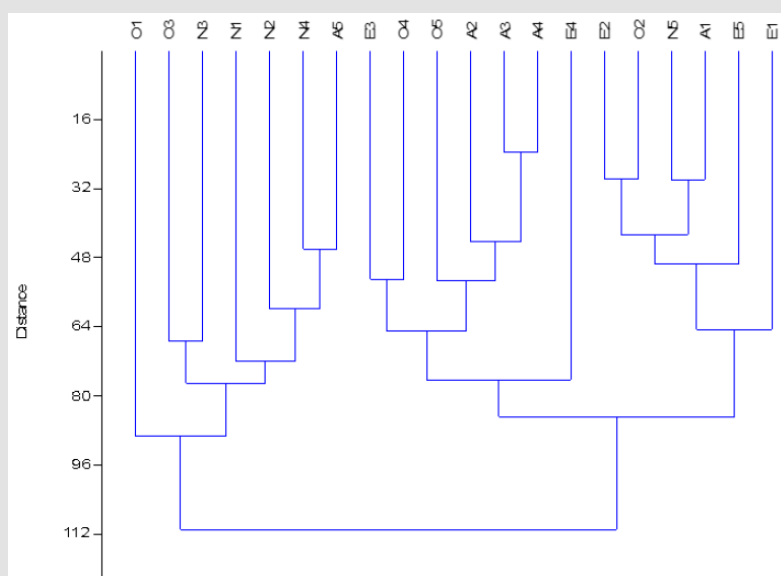
Figure 4: The Hierarchical Cluster analysis. (E1, E2, E3, E4, E5= five stations in Elegushi Beach; O1,O2,O3,O4,O5= five stations in Oniru Beach; N1,N2,N3,N4, N5= Five stations in New-Lekki Beach; A1,A2,A3,A4,A5= five stations in Alpha Beach).
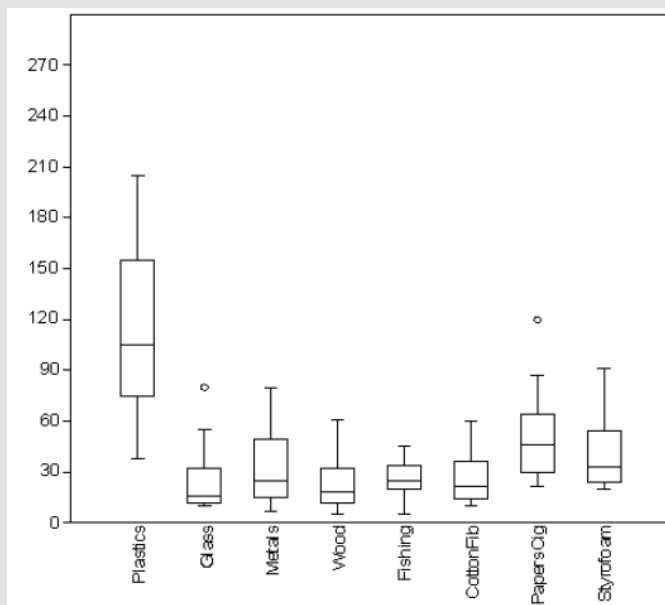
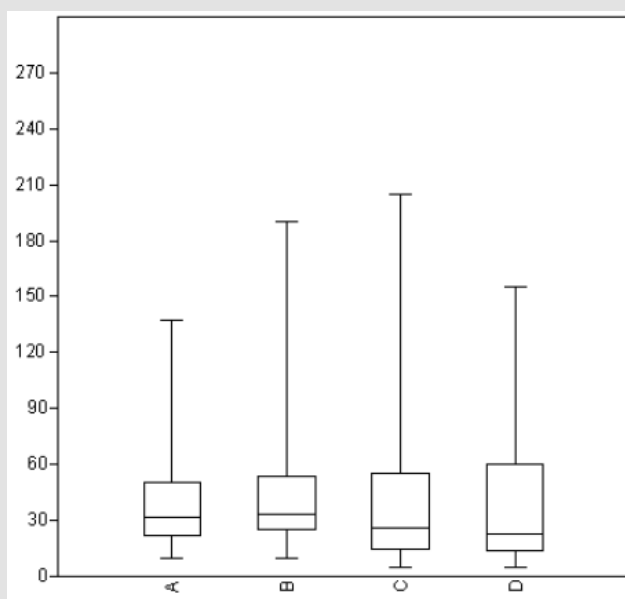**Figure 5:** Box plot of the Anthropogenic marine debris categories.

Figure 6: Box plot of the Anthropogenic marine debris in the different sites
A. Elegushi beach,
B. Oniru beach,
C. New Lekki beach,
D. Alpha beach.

The numeric abundance of the anthropogenic marine debris ascending order is Plastics> papers (cigarette butts)> Styrofoam> metals> cotton Fibres> Fishing Aquaculture> Glass> Wood. Plastics and papers (cigarette butts) had very high abundance along the shoreline beaches over $1000/m^2$. The mean densities of plastics were higher across the four sites than paper. The Styrofoam had high abundance after the order of plastics and paper, which can still be classified under rubber. 2331 prospective plastic particles were found during the period of survey across the shoreline of the four beaches (Elegushi, Oniru, New-Lekki and Alpha Beach), 98.9% of the particles were identified as plastic debris. This resulted in an average abundance of 116.55±40.62 plastic marine debris (mean ± standard deviation). The mean values were 93.40±18.16, 113.40±27.18, 160.40±17.6, and 99.00±15.68, across the four

beaches (Elegushi, Oniru, New-Lekki and Alpha Beach) respectively. The plastic abundance was highly variable between the four sites. At Oniru and New Lekki > 500/m^2 were registered, whereas at Elegushi and Alpha beach fewer than 500/m^2.

The scree plot (Figure 2) shows that the first two principal components are significant for the variation among the stations based on their Anthropogenic marine debris compositions. This is because the plot starts to flatten out at third component. Approximately 72.2% variation among the stations based on their debris composition is explained by the first two principal components. The principal coordinates Analysis clearly separated stations from the four different beaches in the ordinations space, where negative values of the first axis (PCO1) were attributed to Apha and New-Lekki beach (A1,A2,A3,A4, N1,N2, and N5) and the positive values (PCO2) to the Oniru and Elegushi beaches (E1, E2, E3, E4, E5,O1,O2, O4 and O5). The PC1, on the positive axis , plastics showed high loading and positive association with station (under New-Lekki and Oniru beaches), on the contrary, the PC 1 negative axis, Paper Cigarettes marine debris (paper Cigarettes) showed weak association with E4,A2,A3and A4 (Elegushi and Alpha beach). The PC2 axis on the bi-plot, stations under Elegushi and Oniru beaches showed positive association with marine debris (metals, glass, and fishing Aqua culture). Metals, glass fishing Aquaculture debris showed high loadings on the axis. The five stations each in the four beaches clustered together according to their marine debris composition (Figure 5).

Discussion

The abundance and composition of Anthropogenic marine debris across the four beaches (Elegushi, Oniru, New-Lekki and Alpha beaches) shorelines along the Atlantic Coast were spatially variable. The sites were generally more diverse in terms of plastic litter, dominated by expanded polystyrene, Styrofoam, and small foil fragments. The different categories of AMD collected during this study in the coastal system shoreline of the south-west Nigeria agreed with the report of Thiel, et al. [37] who found considerably high proportions of plastics, Styrofoam that are categorized under household, fishery and aquaculture sources; which was contrary to the findings in Chilean coast by Bravo, et al. [38], that stated significantly higher quantities of metal and glass. The sampling done in this work were on beaches in coastal city, which might receive higher numbers of visitors, this was similar to the study conducted and reported by Bravo, et al. [38]. Plastic particles and fragmentation relocated by wind may have influence on the local plastic debris abundance of small and light weight plastic including Styrofoam, plastic bottles, expanded polystyrene which have a good windage such as large surface area combined with low weight [39,40]. Meanwhile, glass and metal might last longer in the upper zone of the beach than paper and plastic which are blown away by strong onshore winds; that usually occur along (Nigerian coast), thus ending up in the dunnes or behind shoreline [37,41-43]. Plastic are practically always dominant on shores worldwide, where they often reach correspondingly high proportion as recorded in this study (>30%).

The foremost cause for this is the extensive use of plastic for a diversity of purposes and its long persistence in marine environment [44]. The type and similarity of AMD composition across the local shore found herein intensely indicate that it has local sources which point mostly at recreational beach visitors, fishing and aquaculture activities. Other studies from (Golik and Gertener, 1992; Madzena and Lasiak, 1997; Martinez-Ribes et al., 2007; Thiel et al., 2013) reiterated sources of AMD composition on beaches from local sources such as tourism. This similarity was evident in the pooled data set of hierarchical analysis (Figure 4) showed the sites had a related cluster across the stations, this result aligned with the result of Honorato-Zimmer et al., 2019 as the different geographical zones surveyed in Chile and Germany shoreline showed strong grouping tendencies according to their main economic activities (tourism, shipping, fisheries/ aquaculture) as major litters. Fishing and Aquaculture activities such as landing sites was observed in the beaches of this study, however, fishing and aquaculture contributed noticeably to the Anthropogenic marine debris, but did not reach the high input observed from previous reports of (Thiel et al., 2013) , most likely due to high contributions from other sources (beach users) in the south west Nigerian coastline [45-53]. Similarly no indication was found that some of the shorelines accumulated AMD than others.

Conclusion

The results propose that a high proportion of the AMD on local shores has been directly deposited there by beach user. The abundance of the marine debris on those beaches evidently specified sources from anthropogenic activities such as recreational tourism, fishing and aquaculture, shipping. This emphasizes the strong need for local solutions in the pursuit for keeping local beaches along the Nigerian coastline clean.

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