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Ecological and Socio-Economic Assessment of Ecotourism-Driven Microplastics Pollution at Elegushi Beach, Lagos, Nigeria

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Abstract

This study assessed ecotourism-driven microplastic pollution at Elegushi Beach, Lagos, Nigeria, through integrated analysis of water and sediment samples (January--March 2026) and public perception surveys (n=60). Microplastics were extracted through density separation and quantified using FTIR spectroscopy. Metallic elements and organic contaminants were analyzed using SEM-EDX and GC-MS, respectively. Microplastic concentrations in water ranged from 865 to 2,105 particles/m³ (mean: 1,370--1,574 particles/m³), increasing by 14.9% over three months. Sediment concentrations ranged from 1,320 to 3,730 particles/kg dw (mean: 2,093 - 2,958 particles/kg dw), increasing by 41.3% ($p<0.05$). This temporal increase coincides with the peak dry-season tourism period (January–March), characterized by intensified recreational activity and waste generation. Water samples were dominated by polyethylene (48.2%) and polypropylene (32.4%), while sediments were dominated by PET (33.7%), polyamide (21.5%), and polystyrene (19.3%). Metallic element concentrations included zinc (15.8 wt%) and copper (7.2 wt%) at station MCP 2, indicating antifouling paint inputs. Phthalates were highest at MCP 1 (7.3% area, DEHP 4.2%). Public awareness of microplastics was high (82.7%), yet only 50.0% recognized the tourism-pollution

linkage; nonetheless, 73.8% supported stronger conservation policies. Ecotourism activities directly drive microplastic, metallic element, and organic pollutant accumulation at Elegushi Beach although it boosts the economies of Lagos State. Therefore, urgent regulatory interventions, improved waste management, and targeted environmental education are recommended to mitigate further ecological degradation.

Keywords: Microplastics, Ecotourism, Coastal Pollution, Sediment Analysis, Public Perception, Lagos Coastline.

Introduction

Coastal ecotourism supports livelihoods and environmental awareness but can degrade marine ecosystems through increased pollution and habitat alteration (UNEP, 2021). Tourism-related activities accelerate plastic fragmentation into microplastics (<5 mm) in sediments and coastal waters (Hidalgo-Ruz *et al.,* 2012). Microplastics are primarily fibers, fragments, films, and pellets of polyethylene, polypropylene, and polyethylene terephthalate that are ubiquitous in coastal environments with higher abundances in tourism intensive areas (Li *et al.,* 2016 and Peng *et al.,* 2017). Globally, microplastics persist in beach sediments and nearshore waters with documented ecological consequences including ingestion by aquatic organisms, sediment alteration, benthic impacts, and disrupted trophic relationships. Such accumulation threatens marine conservation, biodiversity, and ecosystem services essential for sustainable tourism (Browne *et al.,* 2011 and UNEP, 2021). Despite community responses like beach clean-ups and recycling initiatives, empirical research on grassroots strategies remains limited.

Emerging West African studies confirm microplastic presence in Lagos, Ghana, and South Africa Lagoon (Olarinmoye *et al.,* 2020). However, most existing research examines either environmental contamination or socio-economic perceptions in isolation. A critical gap exists for integrated assessments that simultaneously quantify multi-compartment pollution (water, sediment, metals, organic additives) and validate findings against stakeholder perceptions. No study has explicitly tested the ecotourism–microplastic linkage at a Nigerian beach using a convergent mixed-methods design.

This study provides the first integrated ecological and socio-economic assessment of ecotourism-driven microplastic pollution at Elegushi Beach, Lagos, Nigeria, a major tourist attraction. Using an ecological impact assessment approach in quantifying microplastic abundance, size distribution, and polymer composition in sediments and coastal waters. Evaluate spatial and temporal variations in relation to tourism activity and propose evidence-based conservation strategies for this high-use coastal area.

MATERIALS AND METHODS

Study Area

The study was conducted at Elegushi Beach, Lekki, Lagos State, Nigeria (6°25′31.19″ N; 3°24′34.19″ E), (Figure 1.) Elegushi Beach is a highly frequented coastal tourism site characterized by intensive recreational activities, hospitality services, and periodic mass gatherings. These activities expose the coastal environment to sustained anthropogenic pressure, including plastic litter inputs and altered shoreline dynamics. Two representative sampling zones were established, point-source areas (stormwater discharge points and runoff channels) and non-point-source areas (high-density tourist and recreational zones). Sampling points were geo-referenced using a handheld GPS Germaine model 720H device to facilitate spatial analysis and mapping.

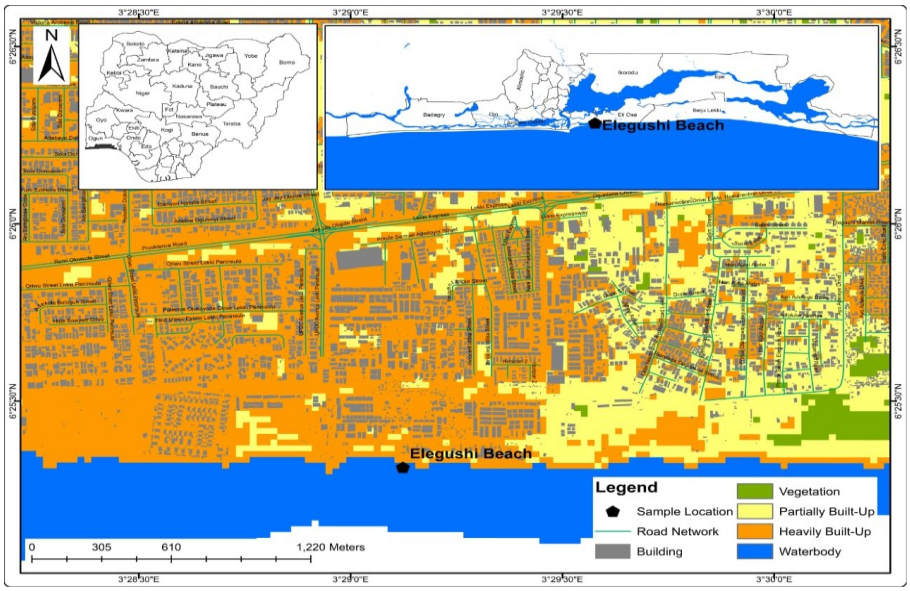


Figure 1. Map of Research Location

Sampling Regime

Sampling was conducted over a three-month period (January - March 2026) to capture early dry-season conditions and associated variations in tourism intensity along the study coastline. A monthly sampling regime was adopted, targeting both point and non-point source locations to reflect spatial heterogeneity associated with anthropogenic activities. A total of twelve (12) surface water samples for microplastic analysis and twelve (12) sediment samples were collected between January and March, consisting of two samples from point-source locations (e.g., discharge zones and high-use recreational areas) and two samples from non-point source locations per month.

Surface water samples (700 mL) for microplastic analysis were collected using pre-cleaned glass jars fitted with glass lids to minimize plastic contamination. Water samples were collected approximately 1 m from the shoreline and just below the water surface. Prior to final

collection, all sampling containers were rinsed three times with site water. Water samples were transported in ice chests and stored at 4 °C for laboratory analysis.

Sediment samples were collected concurrently with water sampling using a stainless-steel grab sampler to obtain the top 0–5 cm of surface sediment which is most representative of recent deposition and anthropogenic influence. At each sampling point, replicate subsamples were composited to improve representativeness. Sediment samples were placed in aluminum foil–lined glass containers, sealed, labeled, and transported to the laboratory under cooled conditions. In the laboratory, sediments were air-dried at room temperature, homogenized, and stored in clean glass containers prior to microplastic extraction and subsequent analyses.

All sampling locations were geo-referenced using a handheld GPS to enable spatial analysis and mapping of pollution patterns. Field blanks were included periodically to assess potential contamination during sampling and transport.

Extraction of Microplastics from Water and Sediment

Microplastic extraction followed established protocols used by Olarinmoye *et al.,* (2020) and González-Pleiter *et al.,* (2021) with slight modifications. Water samples were vacuum-filtered through pre-combusted glass fiber filters (Whatman™ GF/D, 2.7 µm). Sediment samples were air dried, homogenized, and sieved (5 mm) before density separation of 50 g dry sediment using saturated potassium formate solution (1.6 g mL^{-1}). Samples were agitated and allowed to settle for 72–96 hours, after which the supernatant was recovered. Organic matter was digested using 35%–36% hydrogen peroxide (H_2O_2) under continuous agitation at room temperature for 5–7 days until complete digestion. A second density separation was performed, and the supernatant was vacuum-filtered onto anodisc inorganic membrane filters (0.2 µm). Filters were dried at 50 °C and stored in covered glass petri dishes prior to analysis.

Visual Identification and Quantification

Filters were examined using a digital microscope. Suspected microplastics were identified based on standardized visual criteria including uniform thickness, homogeneous coloration, absence of biological structures, and resistance to fragmentation (Hidalgo-Ruz *et al.,* 2012). Particles were classified by shape, color, and size. Abundance was expressed as particles L^{-1} for water and particles kg^{-1} dry weight for sediments. Particles >20 µm were analyzed using ATR-FTIR in the range 4000–600 cm^{-1} at 4 cm^{-1} resolution. Polymer types were identified by comparison with reference libraries, and only spectra exceeding accepted similarity thresholds were retained (Primpke *et al.,* 2018).

Surface Morphology and Elemental Analysis (SEM–EDX)

Selected particles were examined using SEM to assess surface weathering and degradation features. Elemental composition and inorganic residues were determined using coupled EDX analysis following standard preparation and sputter-coating procedures.

Chemical Characterization (GC–MS)

Representative microplastic samples (12 water and 12 sediment samples) were analyzed using Pyrolysis Gas Chromatography Mass Spectrometry (Py-GC–MS) at the central laboratory, Ahmadu Bello University, Zaria, Nigeria. Analyses followed established Py-GC–MS conditions optimized for common polymers in coastal environments and were used primarily for qualitative identification of polymer-specific pyrolysis products and associated additives (Fischer and Scholz-Böttcher, 2017).

Quality Assurance and Quality Control

Field blanks, procedural blanks, and duplicate samples were processed alongside environmental samples. Cotton laboratory coats, nitrile gloves, and glass equipment were used exclusively. All reagents were pre-filtered, and samples were covered during processing to minimize airborne contamination (Hermsen *et al.,* 2018).

Socio-economic Data Collection

Structured questionnaires were administered to beach users, residents, and tourism operators using a quota sampling approach (n=60 over the three-month period). Quotas were pre-defined to ensure inclusion of key stakeholder groups (local residents, beachgoers, vendors, and tourism operators). A sample size of 60 was selected as a pragmatic trade-off between analytical depth, field feasibility, and temporal coverage (20 respondents per month). While this sample does not claim statistical representativeness of the entire Elegushi Beach visitor population, it provides robust qualitative-to-quantitative insight into dominant perceptions and is sufficient for hypothesis generation and triangulation with environmental data (Guest *et al.,* 2006). Semi-structured interviews and focus group discussions were conducted with beach managers, community leaders, and ecotourism stakeholders to assess perceptions of tourism-driven environmental change and management challenges.

Data and Spatial Analysis

Descriptive and inferential statistics were applied to summarize water quality, microplastic abundance, and socio-economic data. Geographic Information Systems (GIS) were used to map sampling locations and visualize spatial patterns of microplastic pollution in relation to ecotourism intensity.

RESULTS

Following the field surveys and laboratory analyses conducted from January to March 2026 on Elegushi beach, Lagos Nigeria, the integrated results of the ecological assessment of ecotourism-driven microplastic pollution are as presented.

Microplastic Concentrations in Water

The quantification of microplastics concentration in water samples from four sampling stations denoted with MCP 1, MCP 2, MCP 3, and MCP 4 were conducted using FTIR procedures (particles/m³) between January and March 2026 at Elegushi Beach (Table 1)

Table 1: Microplastic concentration in water (particles/m³, mean ± SD)

Month	Mean concentration	Range	Dominant Polymers
January	1,370 ± 285	980–1,650	PE (48.2%), PP (32.4%)
February	1,485 ± 430	920–1,940	PE (47.2%), PP (32.4%)
March	1,574 ± 510	865–2,105	PE (46.5%), PP (32.0%)

The total microplastic concentration increased by 14.9% from January to March. MCP 1 consistently showed the highest contamination ($p < 0.01$), while MCP 4 recorded the lowest. Particle morphology was dominated by fragments (75%–78%), followed by fibers (15%–17%) and films (7% – 8%). Mean particle size decreased from 467 µm (Jan) to 420 µm (Mar) though not significant. Moreover, Polymer composition remained stable over time (Pearson $r = 0.89–0.97$, $p < 0.01$).

Microplastic Concentrations in Sediment

Sediment samples labeled MCP 1, MCP 2, MCP 3, and MCP 4 were analyzed for microplastics (particles/kg dry weight) over the same period (Table 2).

Table 2: Microplastic concentration in sediment (particles/kg dw, mean ± SD)

Month	Mean concentration	Range	Dominant Polymers
January	2,093 ± 660	1,320–2,850	PET (33.7%), PA (21.5%), PS (19.3%)
February	2,488 ± 670	1,650–3,260	PET (32.8%), PA (20.8%), PS (19.2%)
March	2,958 ± 720	2,060–3,730	PET (32.0%), PA (20.5%), PS (19.0%)

Microplastic concentration increased significantly by 41.3% from January to March. MCP 3 was the most contaminated station across all months ($p < 0.01$) while MCP 4 recorded the lowest. Particle morphology was fragment-dominated (78–81%) with fibers (17%–19%) and films (2%–3%). Sediment particles (272 µm –298 µm) were significantly smaller than water particles (420 µm – 467 µm) from the same period ($p < 0.01$).

Organic Contaminants

The results on organic contaminants via GC-MS analysis in water samples from Elegushi beach showed that total phthalates were highest at MCP 1 (7.3% area) driven by DEHP (4.2%). Halogenated hydrocarbons ranged from 1.8%–4.0% area with the antioxidant 2,4-di-tert-butylphenol at 0.12%–1.4% and squalene at 2.2%–4.4%. The Total fatty acids from the sediment samples were highest at MCP 2 (45.5%), dominated by n-hexadecanoic acid (15.2%) and cis-13-octadecenoic acid (17.2%). Halogenated hydrocarbons were lower in sediments

(0.8%–1.5%) than in water while squalene (3.7–3.9%) and the antioxidant (0.7%–0.8%) were slightly elevated, indicating preferential partitioning into sediments.

Metallic Elements Analysis

The metallic elements analysis revealed strong spatial heterogeneity (Table 3). MCP 2 was a distinct epic center for zinc (15.8%) and copper (7.2%) individually which is consistent with inputs from antifouling paints and industrial discharges. MCP 3 had the highest silicon content (88.5%) and lowest anthropogenic metals, representing natural sediment among other members. However, zn and cu were not detected (ND) in MCP 1 and MCP3 while Zr was not detected in MCP2 and MCP 3.

Table 3: Selected elemental composition (wt%) in sediment

Element	MCP 1	MCP 2	MCP 3	MCP 4
Silicon (Si)	68.5	58.2	88.5	69.2
Zinc (Zn)	ND	15.8	ND	9.5
Copper (Cu)	ND	7.2	ND	5.1
Zirconium (Zr)	3.8	ND	ND	3.2

*ND = Not detected.

Socio-economic Survey

A total of 60 unique respondents participated in the questionnaire survey (once during the January–March period). All percentage values reported below are based on this single cross-sectional sample (n=60). Where temporal comparisons are presented (e.g., perceived change from January to March), these refer to respondents' retrospective perceptions, not repeated sampling of different individuals. Demographic analysis shows that the sample is dominated by economically active individuals aged 26–35 years (36.0%) and 18–25 years (26.0%), indicating strong youth and working-age participation. Gender distribution shows a slight female majority (55.1%) versus male (44.9%). Educational attainment is relatively high, with 60.8% of respondents possessing tertiary or postgraduate education. Occupational distribution reflects a mixed livelihood structure, with students and civil servants each accounting for 25.5%, followed by traders (19.6%) and private sector workers (15.7%). Local residents (32.3%) and beachgoers (16.1%) form the largest respondent groups.

Tourism activity patterns indicate sustained interaction with the coastal environment. Monthly visitation dominates (34.7%), followed by daily and weekly visits (each approximately 26%). The primary purpose of visit is overwhelmingly business-related (56.5%). Tourism intensity is predominantly classified as moderate to high (81.4%). Perceived sources of pollution are strongly linked to tourism-related activities, with plastic bottles (33.3%) and food packaging waste (32.7%) identified as dominant contributors. Awareness levels are high, with 82.7% of respondents reporting prior knowledge of microplastics and 65.3% demonstrating good understanding. However, only 50.0% explicitly recognize the tourism-microplastic linkage, suggesting partial conceptual awareness.

Environmental perception indicators show that the beach is generally considered moderately clean (70.0%), yet microplastic debris is frequently or occasionally observed by over 76% of respondents. Temporal perception of environmental change indicates that 47.3% of respondents believe conditions have improved, while 38.7% report no change. However, a substantial proportion (78.3%) classifies microplastic pollution as serious or very serious. Community response indicators reveal that waste management structures are present (58.7%) and largely effective (68.0%), yet participation in clean-up activities remains low (46.0%). Satisfaction levels are generally positive, with 54.7% satisfied, although a significant neutral group (31.3%) indicates room for improvement.

Ecological impact perception is strongly aligned with scientific expectations, as 70.1% of respondents acknowledge that microplastics affect marine organisms. The most cited impacts include biodiversity loss (30.6%), contaminated seafood (24.3%), and aesthetic degradation (25.7%). Furthermore, 76.6% of respondents agree or strongly agree that tourism pressure increases ecological stress.

Policy preferences indicate strong support for intervention strategies, particularly increased waste infrastructure (24.4%), regulatory measures (24.0%), and clean-up enforcement (23.7%). Government policy support is high (73.8%), suggesting favorable conditions for implementing conservation policies.

The integrated dataset reveals a clear ecotourism-driven pollution gradient at Elegushi Beach, characterized by highest microplastic contamination in water at MCP 1 (recreation zone) and sediment at MCP 3 (accumulation zone) with metallic element and phthalate epicenters at MCP 1 and MCP 2. These results demonstrate that ecotourism activities at Elegushi Beach are directly contributing to microplastic, metallic element, and organic pollutant loads with clear spatial and temporal accumulation patterns. The results also show a coherent socio-ecological system in which tourism activity, environmental perception, and policy support are interlinked. Although environmental conditions are not yet critically degraded, the high awareness of microplastic impacts and strong policy support indicate an emerging transition toward proactive environmental governance.

DISCUSSION

Elegushi Beach represents both a vital economic asset for Lagos State and a sentinel site for understanding the ecological costs of unmanaged coastal tourism. This study provides an integrated ecological assessment of ecotourism-driven microplastic pollution at Elegushi Beach, Lagos, Nigeria, one of the most frequented coastal tourism destinations in the country. The findings demonstrate clear spatial and temporal gradients in microplastic contamination, metallic elements enrichment, organic pollutant loads, and public perception which revealed a collective indicator that ecotourism activities are exerting significant anthropogenic pressure on the coastal environment.

The elevation Microplastic concentrations in water indicates uncontrolled disposal of plastic materials around the beach areas as well as contributions from catchment areas to the beach.

The MCP abundance and spatial distribution from Elegushi beach these agreed with those reported from other tourism-impacted beaches globally. For instance, Browne *et al.,* (2011) documented microplastic abundances of 1,000–7,000 particles/m³ in coastal waters adjacent to high-tourism zones in Europe and North America. Similarly, Peng *et al.,* (2017) reported mean microplastic concentrations of 2,500 particles/kg dw in sediments from tourist beaches in China, which aligns closely with the present findings.

The consistently higher contamination at MCP 1 (water) and MCP 3 (sediment) reflects a clear functional differentiation between recreational input zones and hydrodynamic accumulation zones. This pattern has been observed in other studies where beach morphology and current dynamics create differential deposition environments (Li *et al.,* 2016). The significant increase in microplastic concentration over the three-month period (14.9% in water and 41.3% in sediment) indicates ongoing and accelerating inputs likely driven by sustained tourist activity during the dry season (January–March). Similar temporal trends have been reported by Hidalgo-Ruz *et al.,* (2012), who noted that seasonal tourism peaks correspond with elevated microplastic deposition.

The dominance of polyethylene (PE) and polypropylene (PP) in water samples (collectively >75%) and PET, polyamide, and polystyrene in sediment samples (>70%) is consistent with known tourism-related plastic waste streams. PE and PP are the most common polymers used in food packaging, disposable cutlery, bottles, and bags. These are items frequently discarded by beachgoers (UNEP, 2021). The higher proportion of high-density polymers (PET, PA, PS) in sediments reflects selective settling of denser particles, a phenomenon also reported by Peng *et al.,* (2017) and Fischer and Scholz-Böttcher (2017). The temporal stability of polymer composition suggests a persistent and consistent source of contamination over the study period.

Fragment-dominated morphology (75%–81%) indicates that secondary microplastics derived from the fragmentation of larger plastic items are the predominant form of contamination at Elegushi Beach. This is typical of high-energy recreational beaches where mechanical abrasion, UV radiation, and tidal action accelerate plastic degradation (Hidalgo-Ruz *et al.,* 2012). The presence of fibers (15%–19%) and films (2%–8%) suggests additional contributions from fishing gear, clothing, and packaging materials, consistent with the survey finding that 14.3% of respondents identified fishing gear residue as a pollution source. The decreasing mean particle size from January (467 µm) to March (420 µm) in water, and from January (298 µm) to March (272 µm) in sediment, although not statistically significant suggests ongoing fragmentation. Smaller particles are of greater ecological concern because they are more readily ingested by a wider range of organisms and can bio-trans accumulated across biological barriers (Li *et al.,* 2016). The observation that sediment particles were significantly smaller than water particles indicates that sediments act as a sink for highly fragmented microplastics This corroborates the findings of González-Pleiter *et al.,* (2021) on Beach water microplastics pollution

The elevated concentrations of zinc (15.8 wt%) and copper (7.2 wt%) at MCP 2, coupled with phthalate enrichment at MCP 1 (7.3% area, dominated by DEHP at 4.2%), indicate that ecotourism infrastructure and activities introduce not only microplastics but also associated chemical additives and metallic elements. DEHP is a common plasticizer used in PVC products and its presence at nearly double the levels of other stations suggests localized inputs from tourism-related materials such as beach mats, footwear, and recreational equipment (Peng *et al.,* 2017). The spatial pattern of metallic elements in MCP 2 as a distinct epic center for Zn and Cu is consistent with inputs from antifouling paints used on boats and recreational watercraft, as well as industrial discharges transported via stormwater runoff. This observation is supported by the survey finding that 24.5% of respondents recognized stormwater runoff as a major microplastic source. Similar metal/plastic associations have been documented in coastal sediments near marinas and high-traffic boating zones (Fischer and Scholz-Böttcher, 2017).

The GC-MS results revealed distinct partitioning evaluation. Halogenated hydrocarbons were more prevalent in water (1.8%–4.0% area) than in sediment (0.8%–1.5%) while squalene and the antioxidant 2,4-di-tert-butylphenol were slightly elevated in sediments. This pattern indicates that hydrophobic organic compounds preferentially associate with particulate matter and accumulate in benthic environments where they may persist longer and pose chronic exposure risks to benthic organisms as reiterated by Hermsen *et al.,* (2018) and Olarinmoye *et al.,* (2020). The high total fatty acid content in sediments (40.7%–45.5% area) particularly at MCP 2 and MCP 3 suggests efficient sequestration of organic matter in the central-eastern sector of the study area. This zone may function as a depositional basin where both natural organic matter and pollutant-laden particles accumulate and amplifying ecological risk.

The socio-demographic analysis revealed that the majority of respondents were within the economically active age bracket of 26–45 years, consistent with findings from Ayo-Dada *et al.,* (2024), who reported that younger and middle-aged adults constitute the primary users of coastal recreational facilities in Nigeria. The relatively high educational attainment among respondents is significant, as educational attainment is positively correlated with environmental awareness and pro-conservation behavior (Milfont *et al.,* 2012).

The high awareness level of microplastics (82.7%) at Elegushi Beach is notably higher than that reported in similar studies from developing coastal regions. Deng *et al.,* (2020) found that only 45% of beachgoers in China were aware of microplastic pollution. This elevated awareness may be attributed to increased media coverage and environmental education campaigns in Lagos State. However, only 50.0% of respondents recognized a direct link between tourism activities and microplastic pollution, indicating a gap between general awareness and specific source attribution. The majority of respondents (93.3%) rated beach cleanliness as moderately clean to very clean, despite 76.7% reporting occasional to frequent observation of plastic debris. This apparent contradiction may reflect normalization of plastic presence or differing standards of cleanliness. Similar findings were reported by Hartley *et al.,* (2018), who noted that regular beach users often become desensitized to plastic pollution

over time. Importantly, 52.4% of respondents considered microplastic pollution a very serious issue, while only 2.7% viewed it as not serious, indicating strong public concern that could support policy interventions.

The preferred mitigation strategies identified by respondents included provision of more waste bins, operator regulation, and enforcement of clean-up activities. This multi-faceted preference suggests recognition that no single intervention will adequately address the problem, consistent with the integrated management approach advocated by Rochman et al. (2016). The strong support for government policy interventions (73.8%) provides a mandate for regulatory action, including potential bans on single-use plastics, a measure that has proven effective in other coastal nations (Xanthos and Walker, 2017).

LIMITATIONS

This study has two primary limitations. First, the socio-economic survey (n=60) is modest in size and, while informative, does not permit robust statistical generalization to the broader beach user population. Second, the three-month study period (January–March) captures only the dry-season peak; seasonal comparisons (e.g., wet season vs. dry season) are absent. Future studies should employ larger, random sampling frames and extended temporal coverage.

CONCLUSION AND RECOMMENDATIONS

This study provides the first integrated ecological and socio-economic assessment of ecotourism-driven microplastic pollution at Elegushi Beach, Lagos, Nigeria, combining microplastic quantification in water and sediment, metallic element concentration analysis, organic contaminant characterization, and public perception surveys. The findings strongly suggest that ecotourism activities are a significant driver of microplastic and associated chemical pollution in this high-use coastal environment. These results demonstrate that ecotourism at Elegushi Beach is directly contributing to microplastic, metallic element, and organic pollutant loads with clear spatial and temporal accumulation patterns.

However, these conclusions should be interpreted in light of two limitations: the modest socio-economic sample size (n=60) and the dry-season-only sampling window. Despite these caveats, the convergence of empirical contamination gradients, polymer-source attribution, and stakeholder perceptions provides compelling evidence for the ecotourism-pollution linkage. Without immediate and sustained interventions, continued environmental degradation will likely jeopardize marine biodiversity, fishery livelihoods, and the long-term sustainability of ecotourism itself.

Based on the findings from this study, the following are recommended for policymakers, beach managers, tourism operators, and the local community: regulatory enforcement, infrastructure investment, community engagement, and continued scientific environmental monitoring of the Elegushi Beach environment. These combined interventions are essential for the transition of Elegushi Beach from a pollution epicenter to a model of sustainable ecotourism in West Africa.

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