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Microplastic Contamination in Surface Water of the Lower Forcados River, Burutu, Delta State, Nigeria

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ABSTRACT

Background and Objective: The world's rivers, estuaries, and coastlines are all contaminated with microplastics, which are also frequently seen in beaches, seafloor sediments, shorelines, and industrial wastewater, among other places. This study was carried out to determine microplastic contamination in the water of the lower Forcados River, Burutu, Delta State, Nigeria. **Materials and Methods:** Water samples were collected from four locations for 12 months between March, 2022 and March, 2023, along the lower Forcados River, Burutu, Delta State, Nigeria. The extracted microparticles were virtually identified using an EDMS11 digital microscope and were classified and categorized according to their types. A one-way ANOVA ($p<0.05$) was performed to compare microplastic pollution across four water samples using IBM SPSS Statistics version 26. **Results:** The abundance and composition of contamination in the surface water were a 44 item/L and microfiber 14 (31.81%), microfragments 6 (13.63%), microfilms 7 (15.90%), microfilaments 12 (27.27%) and microfoams 5 (11.36%) which also account for densities ranging from microfilms (ρ = 0.00001) to microfragments (ρ = 6.6). Microplastic contamination ranges from microfoam 0.1±0.04 item/L to 0.29±0.06 item/L (microfibers). However, filaments showed a similar blueprint to the microfilms in the study. **Conclusion:** This study helped to clarify how microplastics appeared and were distributed in the lower Forcados River, and it is now possible to assist the general public by offering guidance on how to reduce microplastic contamination in aquatic water bodies.

KEYWORDS

Microplastics, contamination, water, Forcados River, Delta State, Nigeria

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INTRODUCTION

Microplastics are defined as a subclass of plastic substances with sizes below <5 mm in the environment. All water-related life forms are impacted by microplastics, which are largely the result of human activity and can be found in the atmosphere, biosphere, and hydrosphere[1]. Microplastics readily spread throughout aquatic ecosystems due to their pervasive presence and floating characteristics[2]. An enormous amount of microplastics as well as plastic waste get released into the oceans through rivers tide[3]. In addition to surface water, there are traces of microplastics in underwater trenches, sediment, and aquatic live[4]. Compared to the ocean, brackish and freshwater environments are closer to the activities that humans engage in. Road markings, city dust, synthetic textiles, automobile tires, marine coatings, personal care items, and garbage dumps are some of the sources of microplastics[5].

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Contamination is the act of humans spewing undesirable waste into the environment at very low concentrations that alter the natural structure but are not harmful to biotic creatures[6]. The quality of the water and its fitness for use by humans can be determined from surface water[7]. There is growing worry about the absorption of microplastics by aquatic species, and the contamination of freshwater and marine habitats is overlook[8].

In addition to water, motorized and non-motorized watercraft are also responsible for the movement of microplastics into the oceans. Microplastics are pervasive on shorelines, in undersea sediments, along the coasts, and in industrial wastes, among other places. They degrade rivers, estuaries, and coastlines around the world. Certain microplastics float close to the water's surface, whereas denser ones may sink. Their behavior varies according to their shape and density[9].

The Forcados River serves as a key hub for fishing, oil exploration, and navigation in the Niger Delta, Southern Nigeria. It flows into the Atlantic Ocean and is distinguished by a vast network of interconnected creeks and rivers, all running in long, parallel stretches. The river transverses five local government areas in Nigeria, including Burutu, Bomadi, and Patani in Delta State, as well as Ekeremor and Southern Ijaw in Bayelsa State. Temperatures in the region remain fairly stable throughout the year, with slight fluctuations ranging between 27 and 34°C.

Microplastics are recognized as a significant menace to various ecosystems and creatures because of their conceivable physical and chemical dangers[10]. Countless marine species, including zooplankton, bivalves, shrimp, fish, and whales, have been documented to ingest these tiny plastic particles[11]. Thus, shellfish, fish[12], Seabirds[13], Sea turtles[14], and even mammals might accidentally consume microplastic particles, leading to harm to vital organs, clogging in the gastrointestinal tract, and limiting growth[2]. Engulfing these microscopic particles can seriously injure aquatic life, leading to decreased development rate, oxidative stress, pathological stress, and reproductive issues. Additionally, due to ample space and the superior adsorption ability of microplastics, harmful substances affixed to the particles also represent a significant hazard to marine life[15]. Aquatic ecosystems are exposed to anthropogenic pressure, leading to environmental degradation. Since a lot of soaring man's structures surround the river ecosystem, the present study aimed to determine microplastic contamination in the surface water of the lower Forcados River, Burutu, Delta State, Nigeria.

MATERIALS AND METHODS

Study area: The research was conducted in the lower stretches of the Forcados River in Burutu and of Burutu Local Government Area of Delta State, Nigeria. Samples were retrieved from four locations at 8:00 am to 4:00 pm once monthly for twelve months between March, 2022 and March, 2023 (Fig. 1).

The Forcados River serves as a significant channel for fishing and navigation in the Niger Delta Region of Southern Nigeria. The Forcados River serves as a vital fishing and shipping route. The region is distinguished by the wide interconnection of creeks and other rivers, all of which run parallel to one another for extended periods. The river drains into the Atlantic Ocean. The coordinates of the region lie between latitudes 5.43160°N, and longitudes 5.45839°E (Table 1).

Samples collection: Surface water was retrieved from each study site by lowering a 500 mL glass bottle connected to a 55 μm plankton net and towing it for 10 min during a sail[16]. Afterward, the net was retrieved and covered, and the samples were transported to the Department of Fisheries and Aquatic Sciences at Rivers State University in Port Harcourt, Nigeria. Two duplicate 300 mL water samples were taken in the laboratory using a measuring cylinder, and they were then successively passed through three sets of stainless-steel sieves with mesh sizes of 5 mm, 0.3 mm, and 50 μm. For additional processing (filtration), the filtered residues from the 0.3 mm and 50 μm sieves were rinsed with distilled water and placed in a 250 mL glass bottle.

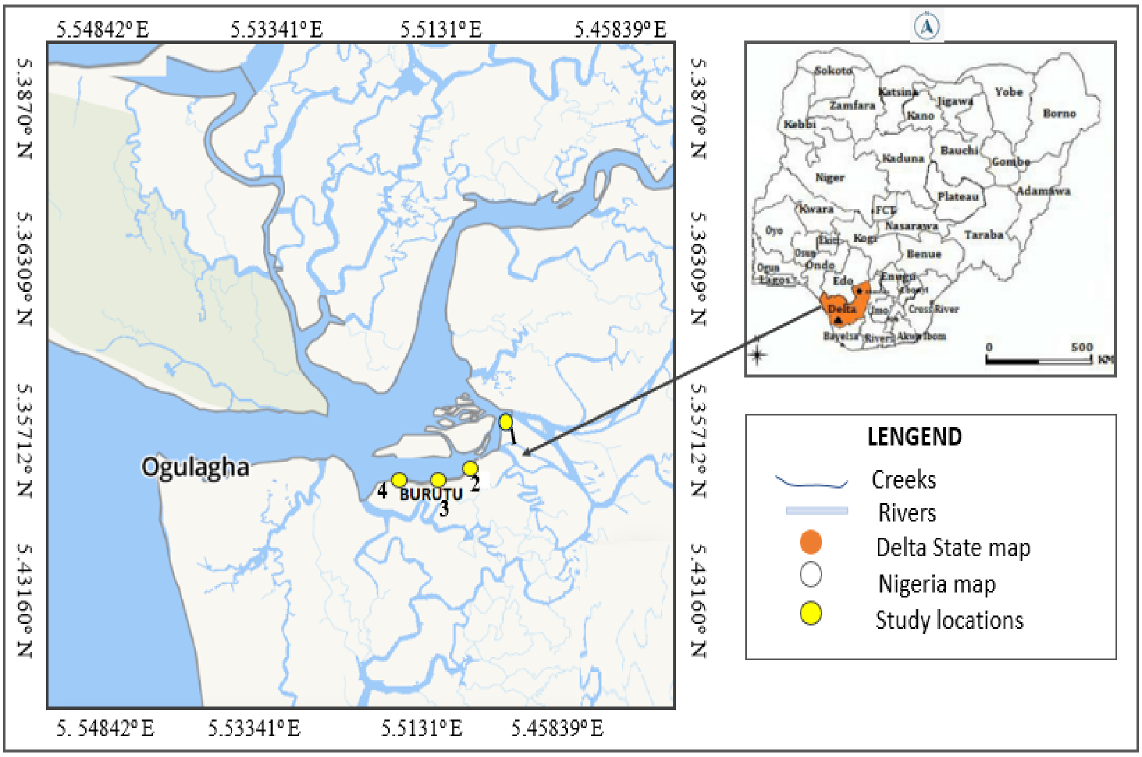

Fig. 1: Map of the study area

Table 1: Description of the sampling stations and locations of the study area

Sites/stations	Sites/location names	Geographical locations	Descriptions
1	Eniyobogbene	5.23'10"N 5'23'42"E	Fishing camp locations with ongoing serious fishing activities, major boating route
2	Okorodudu Burutu	5.21'12"N 5.30'03"E	Boating, fishing camp, net weaving, fishing trap constructions, boat repairs, fish landing site, market
3	Old wharf Burutu	5.21'25"N 5.30'45"E	Floating badge of the NNPC petroleum filling station is anchored at the river. Passengers loading and offloading boating point, used for boat engines repair, fibre boats repair and building, fishing and wastes deposits
4	Marine Jetty Burutu	5.35'32"N 5.50'09"E	Toilets built along the river sides, the station was used for cargos ships transports, mini sea port and ships repairs. Previously used as different companies' sites

Microplastic extraction in the water: To digest the organic matter, the filtration residues from surface water samples were placed in foil with the filter paper and oven-dried at 65°C for 5 min. The samples were then transferred into a 500 mL beaker, and 60 mL of each of the 0.05 M Ferrous Sulfate ($FeSO_4$) solution (AR, Aladdin, China) and 30% hydrogen peroxide (H_2O_2) (AR, Aladdin, China) were added to the glass bottle containing the residues[17] and stir for 10 min. Subsequently, 300 mL of NaCl solution (6.0 g per 20 mL) was added and stirred for an additional 5 min for density flotation[18]. The supernatant was then filtered using a 0.45 μm membrane filter (Whatman Membrane Filters) with the aid of a suction pump. A spatula was then used to transfer the filter paper and filtrate into a glass petri dish, which was placed in a desiccator to dry at room temperature for 24 hrs.

Microplastics identification: Microplastics were identified under a digital microscope with a camera (Model Elikliv EDM 11S) made in China. The microplastic particles were quantified, and their physical characteristics, including type classification (microfiber, microfilm, micro-fragment, and micro-pellet), were determined[19,20,21].

Statistical analysis: One-way Analysis of Variance (ANOVA) ($p<0.05$) was used to compare the microplastic pollution between the four water samples. Statistical analysis was conducted using IBM SPSS Statistics version 26 (IBM Corp., Armonk, New York, USA).

RESULTS AND DISCUSSION

This study represents the first assessment of microplastics in the lower Forcados River, Delta State, Nigeria. Microplastics were observed in all the surface water samples collected from the four stations of the lower Forcados River, Delta State, Nigeria (Plate 1). A total of 44 microparticles were recorded in the study. The number of microplastic polymers was five namely; fiber 14 (31.81%), fragments 6 (13.63%), films 7 (15.90%), filaments 12 (27.27%) and foams 5 (11.36%) which also accounted for densities ranging from films (ρ = 0.00001) to fragments (ρ = 6.6). Fiber was the most dominant type of microplastic in the surface water, while filaments and films accompanied microfiber in abundance in the whole of the surface water samples, are shown in Table 2. Table 3 provides the concentration of various microplastic types (items/L) across four stations (1-4), as well as the overall mean for each type and station. Microplastics are categorized into fibers, fragments, films, filaments, and foam.

Fibers: Fibers were most abundant at Station 3 (0.67±0.18 items/L), contributing to an overall highest mean value of 0.29±0.06 items/L, significantly higher than other stations ($p<0.05$). Station 2 and 4 recorded moderate fiber concentrations (0.25±0.09 and 0.17±0.08 items/L, respectively), while Station 1 exhibited the lowest concentration (0.08±0.04 items/L). The high prevalence of fiber could be attributed to the proximity of fishing camps with regard to fishing gears, ropes, nets, and arbitrary waste dump site along the shoreline. The study conformed with the report by Zhu *et al.*[22] that the disposal of waste and the collapse of bulkier plastics are also thought to be significant passage that launches fibers, lines, and other bits of atmospheric substance into the water environment.

Table 2: Microplastics mass concentration based on five polymer types and densities (6.0 g/20 mL) in the water of the lower Forcados River, Delta State

Microplastics types	Number	Percentage	Individual mass	Density (ρ)
Fiber	14	31.81	0.01	3.3
Fragments	6	13.63	0.002	6.6
Films	7	15.90	0.003	0.00001
Filaments	12	27.27	0.004	1.3
Foam	5	11.36	0.001	3.3
Total	44			
Total mass (g)	0.02			
Sample volume (L)	300			

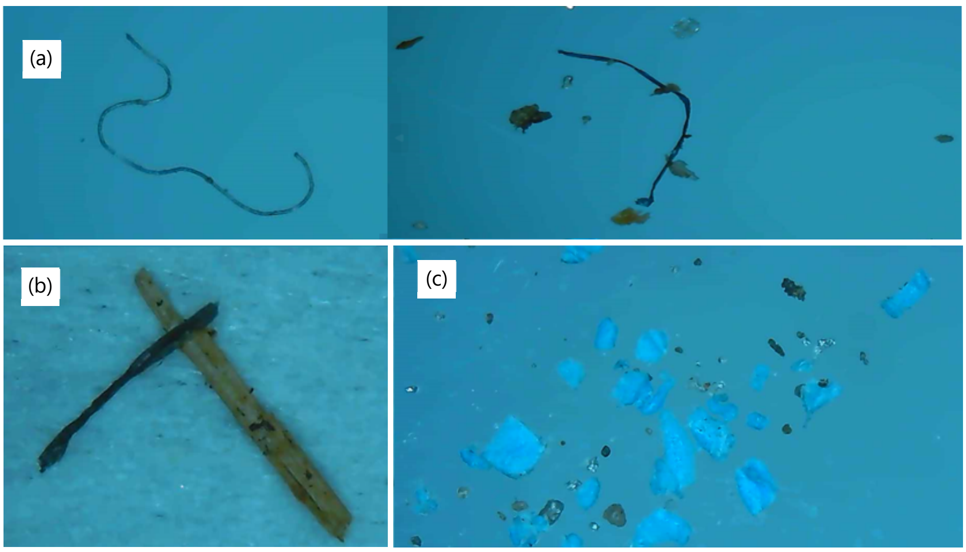

Plate 1: Microplastics of the surface water, (a) Fiber, (b) Fragment and (c) Filament

Table 3: Spatial mean variation of microplastics in the water of lower Forcados River, Nigeria (Mean±SE)

	Station				
Microplastics type (items/L)	1	2	3	4	Overall mean
Fiber	0.08±0.04[b]	0.25±0.09[b]	0.67±0.18[a]	0.17±0.08[b]	0.29±0.06
Fragments	0.00±0.00[b]	0.00±0.00[b]	0.33±0.10[a]	0.17±0.08[ab]	0.13±0.04
Films	0.00±0.00[a]	0.17±0.08[a]	0.08±0.04[a]	0.33±016[a]	0.15±0.05
Filaments	0.42±0.11[a]	0.08±0.04[a]	0.33±0.16[a]	0.17±0.08[a]	0.25±0.05
Foam	0.00±0.00[b]	0.42±0.16[a]	0.00±0.00[b]	0.00±0.00[b]	0.10±0.04
Total	0.50±0.15	0.92±0.37	1.41±0.40	0.84±0.40	0.92±0.24

Means within the rows with different superscript letters are significant at $p<0.05$

Fragments: Fragments showed the highest concentration at Station 3 (0.33±0.10 items/L), with a significant difference compared to Stations 1 and 2, where no fragments were detected. Station 4 showed a moderate level (0.17±0.08 items/L). The overall mean concentration of fragments was relatively low at 0.13±0.04 items/L. Films were present across all stations but were most concentrated at Station 4 (0.33±0.16 items/L). Moderate concentrations were recorded at Station 2 (0.17±0.08 items/L) and Station 3 (0.08±0.04 items/L), while Station 1 exhibited no detectable films. The overall mean concentration of films was 0.15±0.05 items/L. Fragments were less common, indicating the breakdown of heftier plastic debris; it could be a function of distance to the Atlantic Ocean, which tends to submerge the microplastic material in the water column and sink them to different aquatic zones during mixing from wave motions. However, their presence could be attributed to seafarers' and visitors' discarded plastic products, packing materials, domestic debris, and trash from plastic along the shore. This study supported the report by Dai *et al.*[23] that decreasing fragments could be a function of increasing distance to empty microplastic waste into the Ocean on the basis of microplastic materials being sequestered by the ecological life forms.

Films and foam: These were found in low abundance, likely influenced by nature-driven aspects such as tides, wind, and shoreline debris reshuffling. The detected level of microplastic concentrations was lower than the reported ranges of 1.2-10.1, 0.4-5.2, and 4.1 items/L found in surface waters of mariculture bays in the Maowei Sea, Bohai Sea, and Yangtze Estuary, China, respectively[24-26]. This reduction in microplastic levels may be influenced by factors such as ultraviolet (UV) radiation, wave motion, and water temperature.

Filaments: Filaments were detected in all stations, with the highest concentration at Station 1 (0.42±0.11 items/L), significantly higher than other stations. Stations 2, 3, and 4 had similar lower concentrations (0.08±0.04, 0.33±0.16, and 0.17±0.08 items/L, respectively). The overall mean concentration was 0.25±0.05 items/L. Foam was primarily detected at Station 2 (0.42±0.16 items/L), with no significant levels at other stations. The overall mean concentration of foam was the lowest among all types at 0.1±0.04 items/L. The findings indicate that surface water contained a lower concentration of microplastics, measured at 0.92±0.24 items/L (Table 3). The distribution of microplastic types across the sampled stations exhibited significant variability in both occurrence and abundance. Among all microplastic types, fibers were the most dominant across all stations. This dominance is consistent with the previous report, which has highlighted fibers as the most pervasive microplastic type, primarily affiliated to woven fabrics and metropolitan discharges[27].

The monthly microplastics are presented in Fig. 2a-e. Figure 2a, showed fibers exhibited fluctuating concentrations across the months, with prominent peaks observed in September, 2022 and February, 2023. These variations may reflect increased fishing-related discharges, such that dry months heightened industrial activities and waste releases. Similarly, studies have shown that monthly patterns of fiber abundance occur in aquatic ecosystems, where fibers are prevalent due to their common proximity

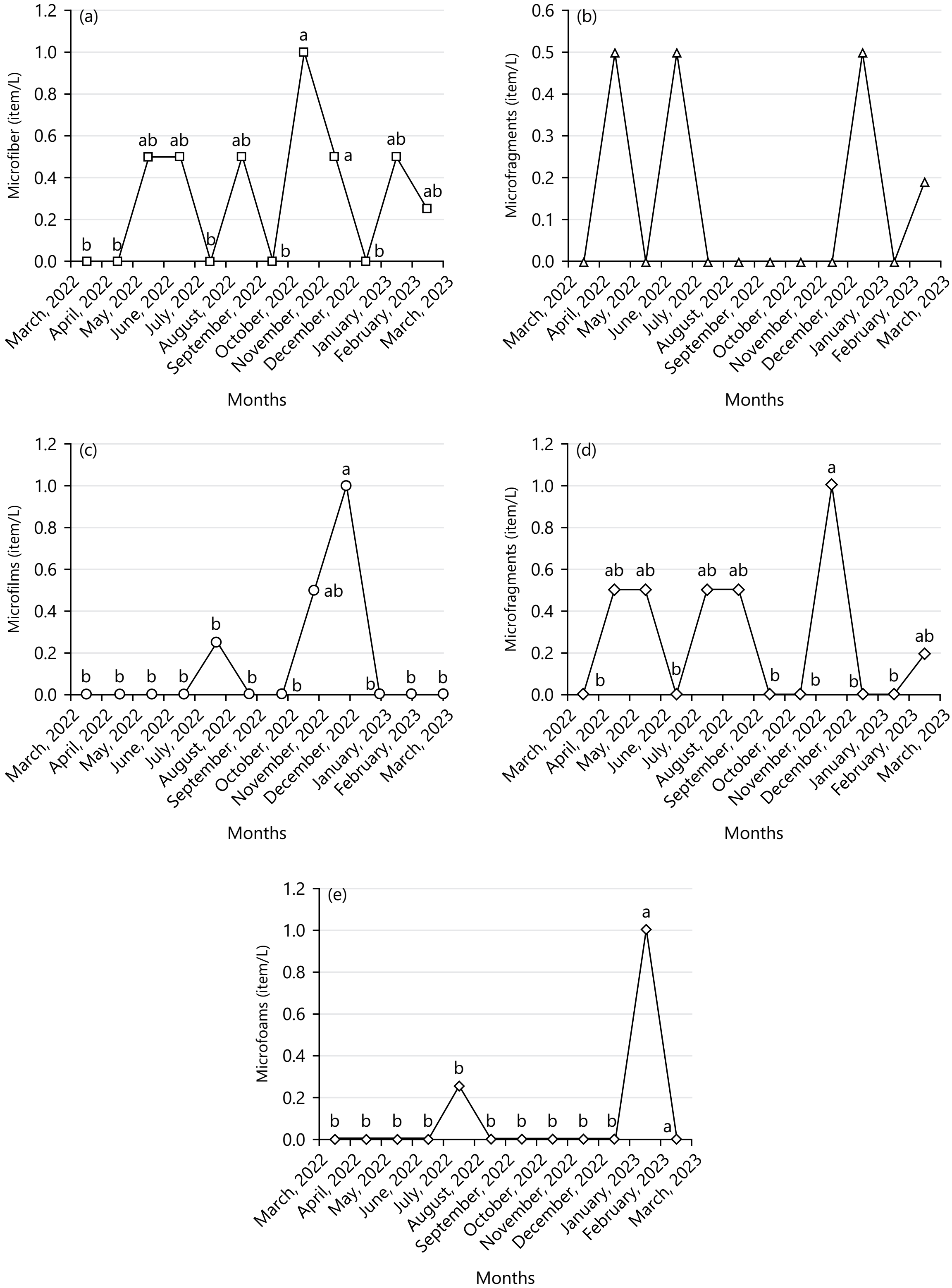

Fig. 2(a-e): Monthly microplastics in the water of lower Forcados River, Delta State, Nigeria, (a) Fiber: Monthly variation in fiber concentration, (b) Fragment: Monthly variation in fragment concentration, (c) Film: Monthly variation in film concentration, (d) Filament: Monthly variation in filament concentration and (e) Foam: Monthly variation in foam concentration

to laundry discharges and the breakdown of synthetic textiles[28]. However, the study indicated that fishing nets and their contiguity to brackish and freshwater ecosystems make it a contributing factor to the increase. Thus, this observation aligns with the previous studies identifying an increase in fiber positively correlated with human settlement[29,30].

Fragments (Fig. 2b), were scarce for most months, with two distinct spikes in April, 2022 and January, 2023. This suggests episodic events, such as plastic litter breakdown following waves or localized disposal activities. While fragments could be attributed to high use of styrofoam's for parties supporting the claim by Cesa *et al*.[31] that they are products of weathered plastics. Figure 2c revealed a marked peak in December, 2022, coinciding with potential artisanal activities, such as the use of plastic mulch or increased packaging waste. Figure 2d, filaments displayed periodic increases, with peaks in April, May, July, August, and December, 2022. These trends suggest the influence of industrial and fishing-related activities, as filaments are commonly associated with fishing lines and nets.

Foam (Fig. 2e), concentrations were minimal throughout the year, with a notable spike in February, 2023. This abrupt increase could be linked to specific events, such as the improper disposal of polystyrene materials during seasonal festivities or construction activities. The consistent timing of filament peaks may suggest that there are repeated activities or continuous input from maritime sources[19]. Likewise, foam's limited presence during other months may indicate lower degradation rates or reduced inputs relative to other microplastic types.

Thus, the low concentration of microplastics could also be ingestion by aquatic life like fishes, sequestered in the vegetation and binding to ghost Cacaban or buried in the sediment. The present study supports the reports by Wang *et al*.[26] opined the breakdown of plastics into smaller fragments through fragmentation/degradation of large plastic items through weathering by abiotic factors such as the age of plastic, ultraviolet light, water temperature, as well as wave and wind action.

However, the lower Forcados River was considered to be subjected to various sources of contamination, including rural and building activities, fishing activities, and boat building, which might cause an excessive influx of plastic materials. Consequently, the water current might aid plastic waste of high densities traveled all the way from the upper Forcados River through the lower Forcados River and empty into the Atlantic Ocean. The study further concurred with the findings by Yang *et al*.[30] documented that decreased levels of microplastics from upstream imply potential sequestration within the creek or a loss of microplastics from the waterway. According to Auta *et al*.[25], who noted that agricultural practices and human activities may contribute to the presence of plastic waste and other pollutants in the river. However, the study opined that the busy fishing activities of the river may also be an important reason for the substantial microplastic contamination. The distribution pattern of microplastic abundance may indicate variations in microplastic load across the different selected sites. In the study, microplastic abundance in the river of the lower Forcados was highest during the dry season, and this could account for the influence of river water velocity, wind, and river width. It could be observed that plastics age in the environment and that physicochemical parameters such as temperature immensely contributed to plastics fragmentation in the study. The present study further tied with the finding by Yang *et al*.[30], who pointed the extent to which plastic tend to disintegrate into subunits is a function of multiple factors, including the type and age of the plastic polymer as well as the environmental conditions of use and weathering, such as temperature, irradiation, pH, etc.

CONCLUSION

The study highlights significant spatial variability in the distribution of microplastic types across the four stations. Fibers were the most dominant microplastic type overall, followed by filaments, films, fragments, and foam. Station 3 exhibited the highest total microplastic concentration, a hotspot for microplastic contamination, potentially due to multiple converging anthropogenic sources and hydrodynamic factors concentrating pollutants in this area, suggesting a need for targeted pollution mitigation strategies in this area. Understanding the sources and distribution patterns of microplastics is critical for developing effective management policies to reduce their environmental impact.

SIGNIFICANCE STATEMENT

This study provides important information about water safety for the residents around the river and the public by assessing the microplastic contamination of the surface water of the lower Forcados River in Delta State, Nigeria. The findings unveil that watercraft, fishing gear, nets, line, and improvised plastic cork used for floatation of nets and coastal garbage sites need to be improved for the sake of aquatic life and the receiving river ecosystem. To guarantee a safe, accommodating, less contaminated river ecology, protecting biota and the public. The study also emphasizes the significance of developing risk mitigation and raising awareness campaigns for all.

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