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Microplastics Contaminated Mullet (*Mugil cephalus*) (Linnaeus, 1758) from the Lower Forcados River, Burutu, Delta State, Nigeria

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Abstract

The increasing contamination of the environment by microplastics (MP) in various forms is a consequence of modern lifestyle advancements and has emerged as a significant environmental hazard. The digestive tracts of 36 specimens of the economic mullet (Mugil cephalus) were investigated between March 2022 and March 2023 from the lower Forcados River, Burutu, Delta State, Nigeria. A total of 96 MP particles were extracted from 18 fish out of the total samples. Among the examined species, three types of microplastics were identified in Mugil cephalus: microfibres (76, 79.16%), microfragments (6, 6.25%), and pellets (14, 14.58%). Distribution across the digestive tract revealed 16 microplastics (16.67%) in the oesophagus, 30 (31.25%) in the gills, and 50 (52.08%) in the stomach. The highest concentration of ingested microplastics was found in the form of microfibres (4.17 ± 0.71) recovered from the stomach, while the least were micro pellets (0.00 ± 0.00) retrieved from the oesophagus. These differences were statistically significant ($p < 0.05$). The findings demonstrate that, compared to other sections, the stomach of Mugil cephalus had the highest concentration of fiber-ingested microplastic pollutants. Due to concerns about potential harm to fish well-being and the risk of biomagnification, the widespread prevalence of microfiber contamination in mullet underscores the need for biomonitoring of microplastics in both inland and coastal waters, regardless of the accumulation pathway. This study serves as a benchmark for future research.

Keywords: Aquatic wastes, Delta State, diet, Forcados river, microplastics, mullet

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INTRODUCTION

Microplastics are minuscule, frequently encountered plastic particles that are less than five millimeters (5 mm) [1]. Residential and commercial sewer systems, along with wastewater treatment amenities, are the main entry points for microplastics into the marine ecosystem [2]. According to Alomar *et al.* [3], opined that the aquatic environment may become contaminated with microplastics contamination as a result of bulkier plastic particles from dumps of trash disintegrating into smaller pieces. The intricate movement of microplastics is caused by an assortment of aspect, such as wave action, local and large-scale currents, buoyancy, biofouling, polymer type, size, and form [4]. The existence of microplastics, which affect all water-related life forms, is mostly due to human interference, they are found in the atmosphere, biosphere, and hydrosphere. According to Gallagher *et al.* [5], Microplastics can be seen floating in surface waters and resting on mud and sandy shorelines, seabed sediments, wastewater effluents, and even frozen ice [6].

The mullet (*Mugil celphalus*) belongs to the Mugilidae family, which has 72–81 species and 17–18 genera worldwide [7]. The *M. cephalus* is one of the commercially essential fish species with high market acceptance in Nigeria but not yet culture in Nigeria, due to funding and fewer information on the genetic manipulation of the fish. It occupies fresh, brackish and marine habitats in a depth ranging between 0 and 120 meters and with temperatures between 8 and 28°C. the flathead grey mullet are primarily a diurnal coastal species that are catadromous and euryhaline found in shallow depths near shore, around the mouths of streams and rivers inlets, and brackish with sandy or muddy sediment.

Due to lack of protection of human waste, aquatic debris contaminates any flowing water body either tidal, subtidal or stagnant water [8], this could be world's oceans, rivers and lakes [9–10], and this waste is found floating at the sea surface or on the seafloor [11].

Microplastics is ingested by filter feeder species, the suspension of detritus trigger feeders living in the water column, surface water and bottom sediments mistakenly consider it for diet and has been found in the guts of invertebrates, fish, turtles and other larger animals, including species edible for human consumption. *Mugil celphalus* species are omnivorous feeders, preying on algae and debris. Mohamoud *et al.* [12], found stomach content diet of diatoms, green algae, crustaceans, foraminifera in *Mugil cephalus*. Mullet from Durban Harbor showed a high incidence of microplastics ingestion, with fibres being the primary microplastics type [13]. Microplastics may have an extensive spectrum of negative consequences on humans as well as animals [1]. Microplastics ingestion of aquatic insect larvae of two Gulf of Guinea tributaries in Lagos Nigeria was documented by [14]. Some fish species from Eleyele lake Ibadan was also reported by [15], but little or no report on microplastics contamination in mullet (*Mugil cephalus*). It is within this context my research was established to bridge the gap in knowledge on microplastic contaminated mullet from the lower Forcados river, Delta State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in the lower reaches of the Forcados River Burutu Local Government Delta State, Nigeria. The Forcados river is a major fishing and navigation channel in the Niger Delta, southern Nigeria. The river drain into the Atlantic Ocean and the area is characterized by extensive inter-connection of creek and other rivers, all in the same parallel long stretches of rivers. The coordinates of the region lie between latitudes 5.43160° N, and longitudes 5.45839° E (Figure 1).

Sample Collection

Mullets fish samples was purchase from artisanal fishers in field during voyage and the total weight and total length of each fish sample was measured to the nearest 0.1 g and 0.1 cm, respectively [16]. The fish samples were preserved with ten percent (10%) formalin and were taken to the laboratory for additional analysis.

Microplastics Extraction in Mullet *Mugil cephalus*

The microplastics in the fish was extracted based on the method described by Li *et al*. [17]. The gut (gastrointestinal tracts), stomachs and the gill were removed from the fish samples by ventrally dissecting each fish sample and tissues were transferred directly to covered glass petri dishes and weigh (to the nearest 0.001 g) with a digital electronic weight scale (Model Yieyi 8028) made in China. Thus, tissues were emptied into 250 mL separate glass beakers with warm water and 40 mL neat Nitric acid (HNO_3) was added to the organs for 24 hours, stirred and supernatant was filtered through stainless sieve of 5 mm, 0.3 mm, and 50 µm meshes [18], after which the filtrate was washed into 500 ml beaker, 60 mL each of 0.05 M ferrous sulfate solution and 30% H_2O_2 was added stir to degrade the organic matter and heated on a hot plate between 5 and 10 min as it was about to boil was removed.

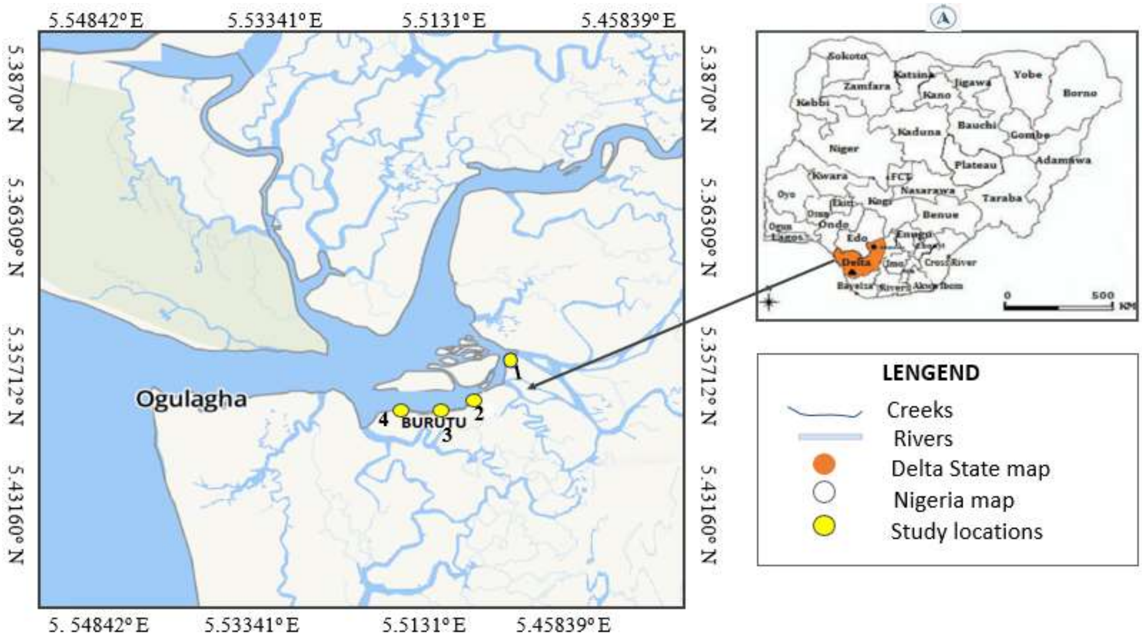

Figure 1. Map of the lower Forcados river (LFR).

The digestion of organic matter was allowed to stand for 5 min at room temperature, then incubated for 20 min at 65°C to degrade any remaining organic matter. After digestion, 300 ml of NaCl was added to the digested solution (6.0 g per 20 mL) for the flotation of the microplastic debris. The supernatant was filtered using 0.45 μm Whatman Membrane Filters paper was used for filtration by means of a suction pump. Afterward, a spatula was used to carry the filter paper containing the residue into a petri dish and allowed to dry inside a glass dissector for 24 hours at room temperature. Some measures described by [19] was taken to prevent background microplastic contamination. Clean laboratory coat, hand gloves and nitrile gloves were used during all laboratory stages. All work surfaces and dissection materials were cleaned with 70% ethanol before and after was use, to avoid individual and samples cross-contamination.

Observation, identification and classification of microplastics

Subsequently, the microplastics on the filter papers were identified under a digital microscope with camera (Model Elikliv EDM 11S). The microplastics particles were counted, and their physical characteristics, including the types were determined as described by [19–22]. Methods to classify microplastics were adopted by [23, 24]

RESULTS

Microplastics contamination in mullet (*Mugil cephalus*) from the lower Forcados River, Delta State, Nigeria

Eighteen (18) individual fishes were found present of microplastics ingestion out of the total 36 mullets, a total of 96 microplastics were implicated for *Mugil cephalus* gastrointestinal tract contamination. The microplastics were categorized into six (6) polymers to make easier identification, only three (3) microplastics polymers were found in *Mugil cephalus* (Figure 2).

The microplastic recorded in the were microfibres 76 (79.16%), micro fragments 6 (6.25%) and pellets 14 (14.58%) (Table 1). Sixteen (16) microplastics 16.67% (Oesophagus), 30 microplastics 31.25% (gills) and 50 microplastics 52.08% (stomach) were obtained in the study. The minimum and maximum concentrations of microfibres ranged from mean value (2.17±0.41 item/g) in the gills to a mean of (4.17±0.71 item/g) in the stomach while microfragments were lowest of (0.00±0.00 item/g) in the gills and higher (0.50±0.12 item/g) in the Oesophagus while least (0.00±0.00 item/g) in the stomach

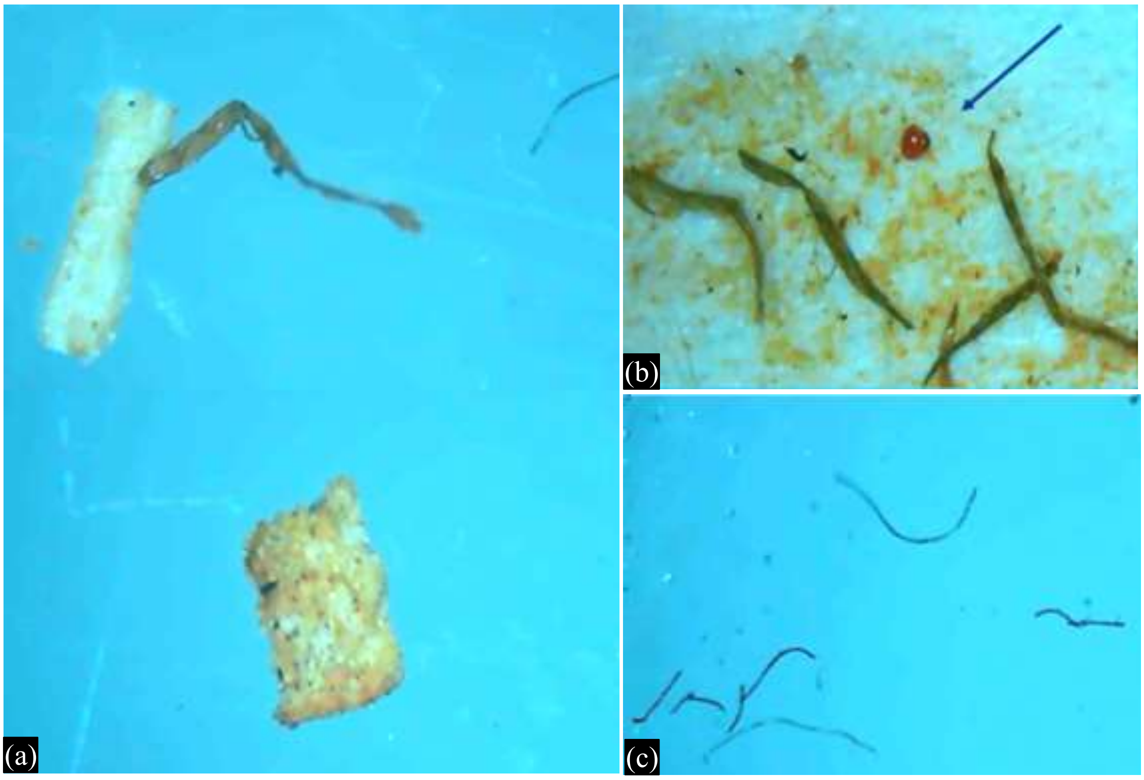

Figure 2. Microplastics extracted from the stomach of *M. cephalus* present in the lower Forcados River, Burutu, Delta State, Nigeria (a) fragment, (b) pellet and (c) fibre.

Table 1. Occurrence of microplastics in the gastrointestinal tract of *Mugil cephalus* of the lower Forcados river, Delta State, Nigeria

Microplastics type (item/g)	Gastrointestinal tract			Overall mean
	Gills (n = 30) (31.25%)	*Oesophagus (n = 16) (16.67%)*	*Stomach (n =50) (52.08%)*	
Fibre	2.17±0.41^{b}	0.00±0.00^{c}	4.17±0.71^{a}	2.11±0.31
Fragments	0.00±0.00^{b}	0.50±0.12^{a}	0.00±0.00^{b}	0.17±0.05
Pellet	0.33±0.18^{b}	0.83±0.22^{a}	0.00±0.00^{b}	0.39±0.10
Total	*2.50±0.59*	*1.33±0.34*	*4.17±0.71*	*2.67±0.46*

Means within the rows with different superscripts are not significant at p<0.05

and highest value (0.83±0.22 item/g) were also noted for micro pellets in the gastrointestinal tract. However, the highest ingested microplastics were established to microfibres recovered from the stomach and the least were micro pellets retrieved from the Oesophagus. There were significant differences ($p<0.05$) between the *Mugil cephalus* in the gastrointestinal tract (Table 1).

Monthly Mean Variation of Microplastics in *Mugil cephalus* from the Lower Forcados River, Delta State, Nigeria

The monthly pattern of microplastics ingestion by the fish *Mugil cephalus* are displayed in Figures 3–5. A peak was observed in microfibres from the estuary in December 2022 and least in May 2022. The variation of the microfibres differed slightly throughout the months ranging from (4.33 item/g)

December 2022 to (1.00 item/g) February 2023 (Figure 3). Micro fragments recorded parallel low distribution trend from (0.00 item/g) May 2022 to (0.00 item/g) September 2022. Though, between November 2022 and January 2023, micro fragments showed symmetry higher value of (0.67 items/g) in both months (Figure 4). Consequently, between April 2022 ((0.00 item/g) and September 2022 (0.00 item/g) micro fragments maintained similar trend that were not significantly different from each other

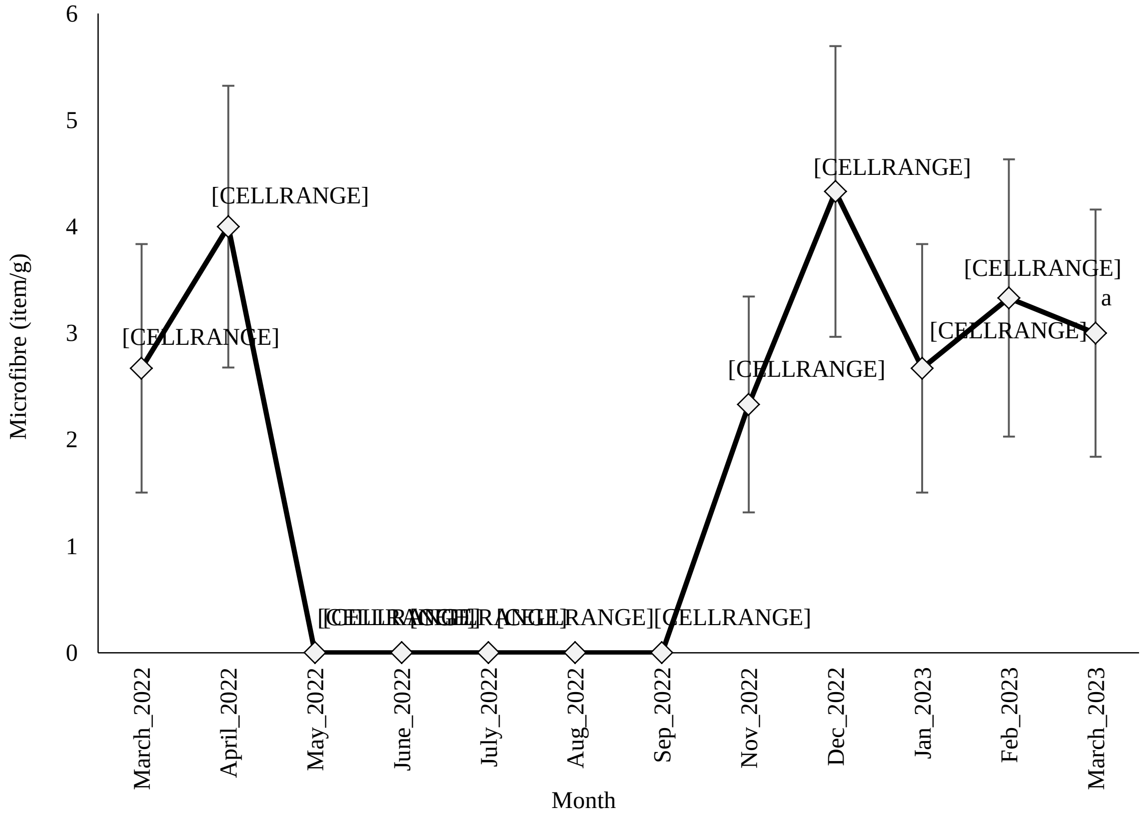

Figure 3. Monthly microfibre in *Mugil celphalus* of the lower Forcados river, Delta State, Nigeria.

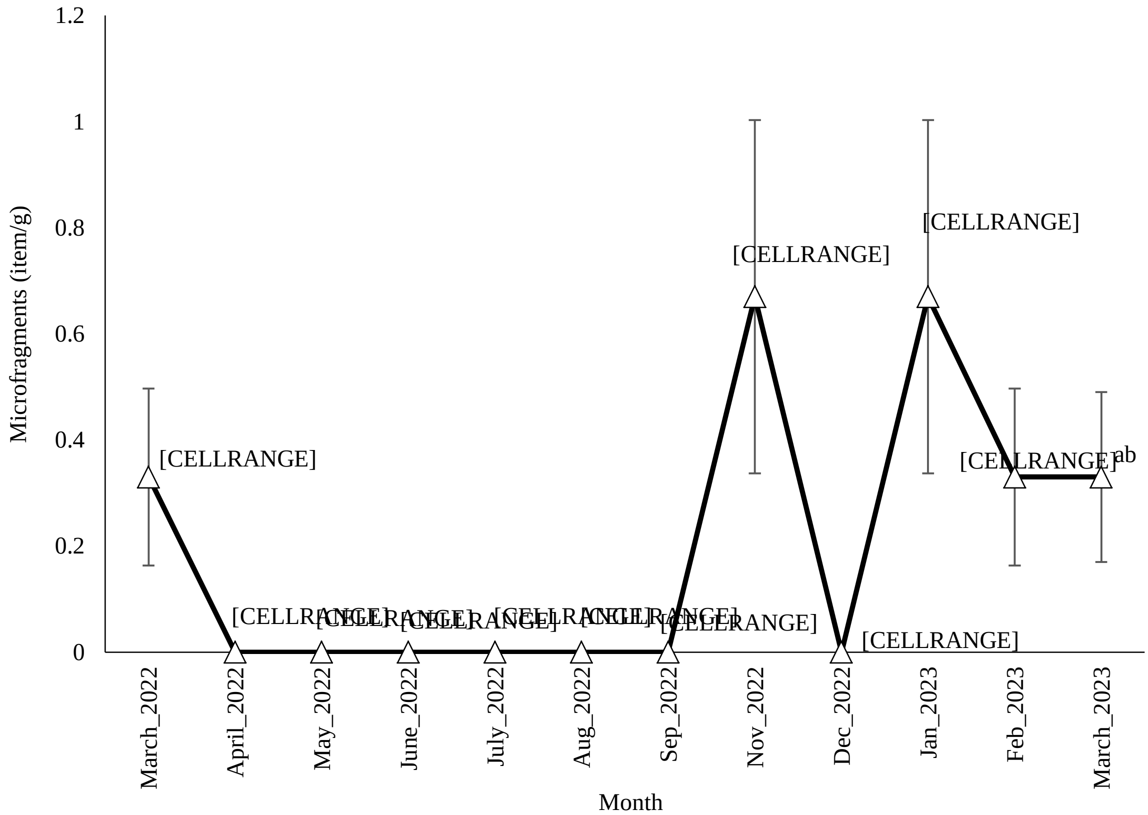

Figure 4. Monthly microfragments in *Mugil celphalus* of the lower Forcados river, Delta State, Nigeria.

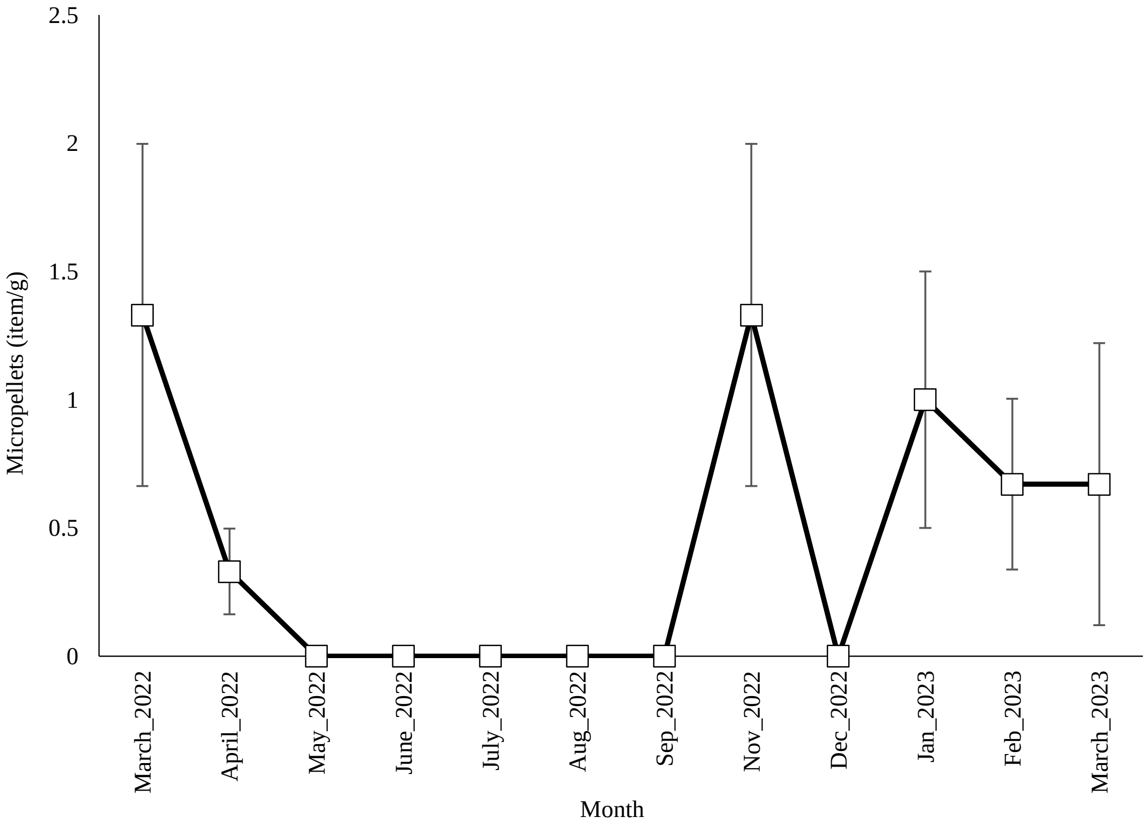

Figure 5. Monthly micropellets in *Mugil cephalus* of the lower Forcados river, Delta State, Nigeria

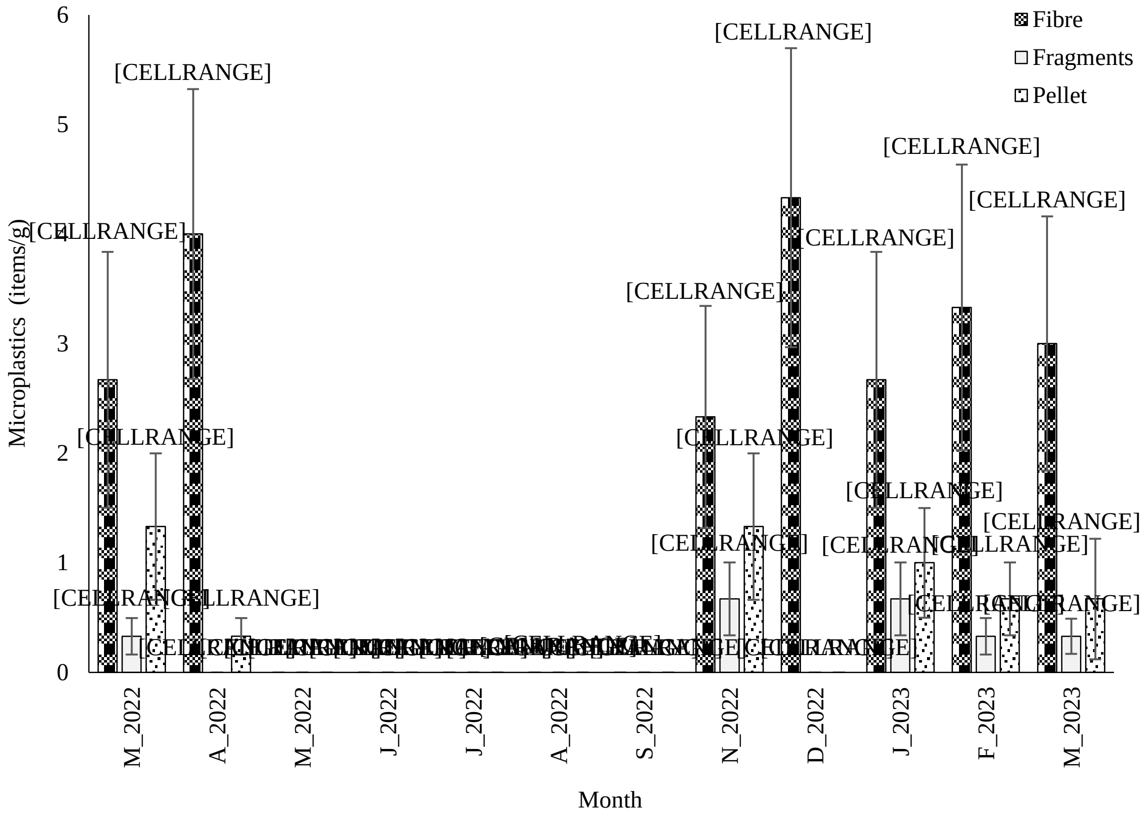

Figure 6. Compartative microplastics variation in *M. cephalus* from lower Forcados River, Nigeria.
Note*: Monthly alphabet starts with letter M- March- 2023 and end with M- March -2023*

indicating a pronounced decreased blueprint from March 2022 to September 2022 (Figure 4). Micro pellets therefore, increased in November 2022 with a value 1.33 item/g and dropped considerably in the month of December 2022 with a value 0.00 item/g (Figure 5) ($p<0.05$).

The monthly distribution of microfiber was found highest (4.33 item/g) December 2022 and microfragment detected lowest (0.33 item/g) February and March 2023 respectively (Figure 6). Thus, microfiber showed a better monthly distribution compared to microfragment and pellet. Comparatively, the microplastics type were not significant ($p>0.05$) statistically from one another. Though, microfiber seizes the lead in all sampled months (Figure 6).

DISCUSSIONS

The abundance of microplastics in the gastrointestinal tracts (GIT) of fish might be closely related to their habitats [25]. Lower observations were recorded in red mullet (*Mullus barbatus barbatus*) (1.1 items/g), (0.6 items/g) for sand steenbras (*Lithognathus mormyrus*) and 0.4 items/g for surmullet (*Mullus surmuletus*) along Turkish coast [26]. In this study, *Mugil cephalus* exhibited highest concentration of microplastics abundance from the lower Forcados river with emphasis on the fish stomach possibly because of their feeding habit to detritus and algae related feeding pattern close to the sandy and muddy shore habitat.

Fareza and Sembiring [27], reported higher concentration in the gut and gills of milkfish, Browne *et al*. [28 - 29], reported high occurrence of microplastics in another tissue than stomach contents of the marine organism mussel. The most dominant microplastics in the fish *Mugil cephalus* were fibres and this was similar to the previous findings by [14], who reported fibres as the most dominant microplastics in the gastropod from Osun River, Nigeria. Additionally, the lower Forcados river is known for long term boating and incur ideal fishing ground history. It was a route for cargo vessels as cabotage. Fishing nets and rope are mostly made from polyethylene and polyamide fibres. Thus, the source of these microplastics could be from fishing nets and rope from all the communities within and around the lower Forcados river as it is the basic source of livelihood.

Thus, most of the microplastics found in gut contents of the fish were classified as fibres. The present study demonstrated that, due to microplastics buoyancy and durability, these items can be attached to plankton as a result of garbage's from the shorelines or direct and indirect sources of wastes disposal are transported through a long distance by the mercies of the wind and tide, thus highly concentrated as food for pelagic fishes. More so, the water currents contributed significantly in the spread of microplastics in the ecosystem for uptake by aquatic organism. The study connived with the report by [30], that the growth of phytoplankton and zooplankton are attracted by small pelagic fish as a result of plastic debris coming from land base input.

CONCLUSION AND RECOMMENDATIONS

Microplastics were recognized in the stomach and other digestive tracts of the fish, the consequence of these microplastics in the mullet is a subject that requires further and more detailed study. However, the entry of microplastics into the food chain means that it can interfere with the fish health and also become more concentrated at higher trophic levels, posing ecological risks to both aquatic creatures and mortal being. The study will serve as baseline for further studies.

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