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Characterisation of Ingested Microplastic Particles and Textile Microfibres in the Gastrointestinal Tract of Demersal Fish from a Peri-Urban Open Access Lagoon in Lagos Nigeria

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ABSTRACT

Background and Objective: Information about microplastic (MP) prevalence in fishes' resident in West African waters is still patchy at best. This study was initiated to study the presence, abundance and species distribution of microplastics (MP) and fibres (MF) in fish caught from a lagoon bordering the mega city of Lagos in Southwestern Nigeria, intending to fill the knowledge gap as concerns their presence and species prevalence in Nigerian waters. This study aimed to describe MP and MF numbers and, types in the gastrointestinal tracts (GITs) of fish from Lagos. **Materials and Methods:** The gastro- intestinal tracts of sixty-eight individuals from six genera were analysed. Evidence of microplastic ingestion, retention and abundance. physical characteristics and types were also determined. Primary MP Identification and physical characterisation was done visually using microscopes with camera attachments. Suspect MP were physically categorized according to colour, size and debris type. Polymer identification was done using the micro-FTIR protocol. **Results:** A total of 62 suspect microplastics were recovered in total. The mean number of MPs ingested per individual was 2.4 and mean MP length was >1 μm (816 μm). Twenty particles were successfully analysed by micro-FTIR, with Micro fibres being the predominant forms detected, composed mainly of cotton (31%), natural (5%), cellulose (23%), rayon (26%), polypropylene (3%), (PET (5%), polyacrylate (3%), nylon (3%) and wool (5%). Fibres with a preponderance of blue fibres (53%) followed by black fibres (26%), red fibres (8%), clear/white/grey fibres (8%) purple and brown 2% each. **Conclusion:** Omnivorous/carnivorous and mixed-mode feeder species consumed/retained the highest number of microplastics. Potential sources of microfibre/plastic inputs into the local catchment are suggested.

KEYWORDS

Microplastics, microfibres, Lagos, Nigeria, fish, Fourier Transform Infra-Red (FTIR) spectrometry

INTRODUCTION

Microplastics (MP), defined as plastic particles <5 mm in size have been described in water bodies globally and are regarded as a major constituent fraction of global marine litter. Their small size, weight and buoyancy makes them readily dispersible over great distances by wind-assisted water currents[1]. The

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presence of microplastics has been reported by scientific investigators in virtually all studied water bodies worldwide. In oceans, seas, lakes, estuaries, rivers, etc. even the most remote[2,3]. Their locational ubiquity, inherent and real-time persistence, bioavailability and resistance to normal environmental attritive processes have raised concerns about their effects on aquatic animals which are constantly in habitual contact with and ingesting often chemical-tainted MPs[4]. Recently, studies into the microplastic loads of fresh waters have come to the fore following the discovery of their importance as contributors to aquatic microplastic loading. With increasing knowledge about the land-water interphase and, the roles of these coupled matrices on microplastic leaching into water and, the hydro-alluvial dynamics involved in these land-water transfer processes becoming increasingly important[5]. Studies into the presence of microplastics in fish and, other aquatic fauna which inhabit fresh waters, which incidentally ingest MP and their roles in the trophic transfer of MP have become more pertinent from the perspective of consumer food safety[6]. Information from Africa especially West Africa is still a bit patchy at best and nonexistent for the commercially important city of Lagos, at this time. Lagos is a West African "low-resource[7]" megacity[8] and the commercial capital of Nigeria, Lagos has a large and increasing population the exact numbers of which are largely unknown but estimated to be about 17 million people[9]. Only a few studies[10-13] exist which document MP presence in feral fish from Nigeria and this study was initiated to study the presence and species distribution of microplastics in artisanal fish catch from the megacity of Lagos, Southwestern Nigeria intending to fill the knowledge gap as to the Nigeria/West African situation referencing a high plastic generation location.

MATERIALS AND METHODS

Study area: Ologe Lagoon 6°27'N and 6°30'N; 3°02'E and 3°07'E is an open access freshwater lagoon and one of several lagoons bordering the city of Lagos in Southwestern Nigeria. River Owo is the major inlet of fresh water and sediments and detritus into the Lagoon, which receives industrial waste and effluents from the neighbouring Agbara Industrial Estate[14].

Collection of fish specimens and transport: Sixty-eight individuals from six genera were analysed. All fish were purchased from fishermen as parts of single landed fish catch between April and June 2022 at the Agbara fish landing site in Lagos. Bought fish were placed in freezer bags (Ziploc®), kept on ice and transported to the laboratory for processing. Specimens were subsequently stored at -20°C until used.

Digestion protocol: The KOH solutions were prepared fresh by adding 100 g KOH to 1,000 mL of water in a beaker and mixing gently by swirling. Before the commencement of digestion, the resulting solution were allowed to cool for 15 min and filtered, to exclude occult MPs from KOH pellets or glassware. Filtered solutions were decanted into conical flasks stoppered with aluminum foil. Specimens were removed from storage and allowed time to thaw on covered glass Petri dishes. Clean scalpel blades were used to cut up large gut segments carefully, ensuring that no pieces were lost in the process of cutting and transfer of specimens into KOH solutions previously decanted into beakers already placed in a fume chamber and left for 96 hrs, after which dissolution was incomplete. Flasks with incompletely digested specimens were heated at 60°C for 12 hrs[6]. Following which dissolution was complete and filtration commenced. Solutions were filtered through Whatman Number 5 filter papers (product Catalog number: 1005-055). Filters were placed in clean labelled glass Petri dishes and allowed to dry[15].

Quality control

Airborne contamination prevention: Concerted efforts were taken to reduce and eliminate airborne contamination during laboratory screening for MPs. Before starting, all glassware items were washed with mild detergent and thoroughly rinsed in running borehole water. Washed bottles and flasks were then autoclaved, clad in aluminium foil and stored in cupboards. All work surfaces were wiped down with 70% ethanol solution before the start of procedures. Specimen dissection, organ removals, decanting of KOH

aliquots for digestion etc. were done in fume chambers with vacuum suction pumps. All persons involved wore cotton lab coats and latex (rubber) disposable gloves, Laboratory doors and windows were also shut, to reduce wind-borne contamination.

Blanks: Uncovered Petri dishes with filter paper discs were left on the work areas to serve as blanks for determining the incidence of airborne MP contamination. Plastic fragments and MPs from the blanks were analysed and debris, where found, were characterised according to their physical characteristics and colour.

Visual inspections: Filters were visually examined under a Leica MZ10F with a GXCAM-U3PRO-20 camera attachment microscope and suspected plastics were imaged in Capture-T software (Version ×64). Suspected microlitter items suspected to be of plastic origin were identified for further identity confirmation and polymer identification.

FTIR polymer identification and validation: Suspected microlitter items were identified for confirmation and polymer typing. A LUMOS II FTIR Imaging Microscope (Bruker, UK) was used for definitive identification of suspect MP. Using a micro-ATR objective coupled with a liquid nitrogen-cooled MCT (Mercury-Cadmium-Telluride) IR infrared detector. For micro-ATR FT-IR, spectra were collected in reflectance mode in the range 4000-500 cm^{-1} at a resolution of 4 cm^{-1}. For particles that couldn't be analysed using micro-ATR FT-IR, transmission mode was used. For transmission mode, particles of interest were transferred to 25 mm Anodiscs filters (0.2 m porosity, Whatman, VWR, UK). Spectra were collected in transmission mode in the range 4000-1250 cm^{-1} at a resolution of 4 cm^{-1}. For all cases, polymer identification was verified based on the percentage match against provided polymer libraries e.g.: Bruker Optics ATR-Polymer Library; IR-Spectra of Polymers, Diamond-ATR, IR-Spectra of Polymers, etc. Only matches above 60% were selected for positive microplastic validation and polymer identification.

Ethical consideration: All subjects used in this study were not alive at the time of collection and, were not specifically killed for use in this research.

RESULTS

Visual ID

Fragments/suspect MPs: About 19 filters with potential MPs, all fibrous in nature, present visually were studied and 62 potential MPs were visually identified and classified by colour (Table 1).

Fibres

Abundance size and colour: About 62 fibres of various material types were visually identified. Suspect particles were detected through microscope-aided visual perusal of filters. The primary colour, blue was most frequently detected (53%), followed by the neutral, black (26%). A mix of primary and neutral colours ranging from red to purple accounted for the remainder of the colours seen.

Table 1: Potential MP visually identified and classified by colour

Fibres	Value	Percentage
Blue fibres	33	46
Black fibres	26	36
Red fibres (1 tangled)	5	7
Clear/white fibres	3	4
Grey fibres	2	3
Red fragment	1	1.4
Brown fibre	1	1.4
Purple fibre	1	1.4
Mean length of potential MPs (µm)	815.9	
SD of mean length (µm)	1205.8	

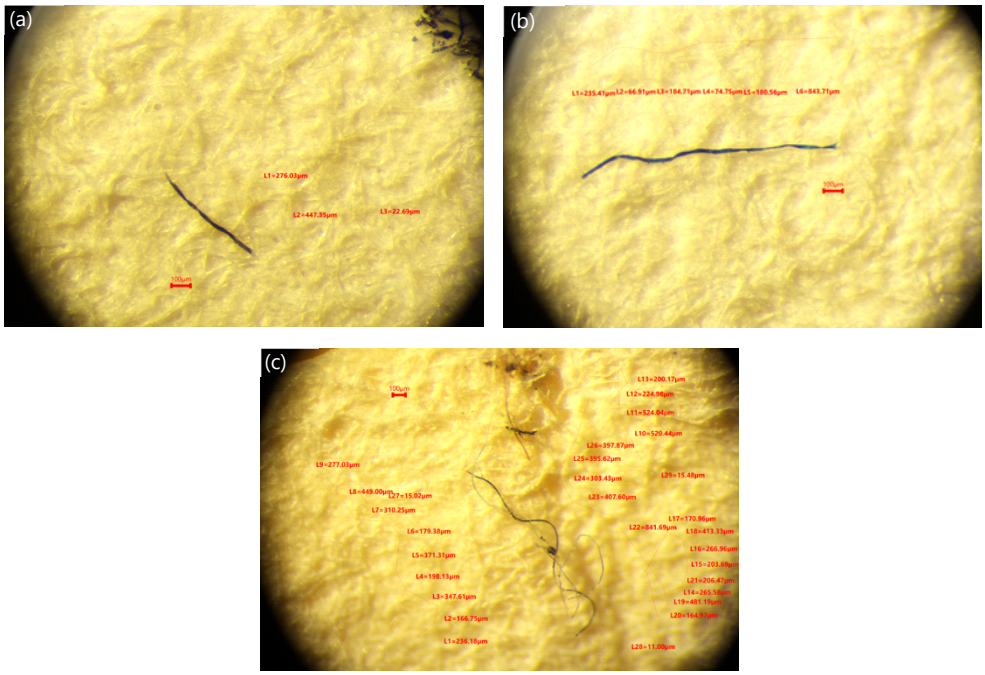

Fig. 1(a-c): Micrographs of typed microplastic, (a) Black fibre, (b) Blue fibre and (c) Tangled black fibres

FTIR analysis: About 19 suspect particles were successfully analysed by FTIR. The majority were cotton fibres (65%). Two distinct MP types, Rayon and PET occurred as (5%) each of the total number of particles Fig. 1 depicted that a specimen micrographs of FTIR typed MP. Frame A depicting a black fibre; B, a blue fibre and, C, tangled skein of black fibres.

DISCUSSION

Current findings from this study have established the basic premise of bioavailable MP presence in the studied location and ingestion by resident fish of several genera. The results also suggested a distinct preference for certain MP colour types, probably those most closely mimicking the coloration of desired prey types. At present, there is still limited knowledge about microplastic levels in semi-enclosed systems such as coastal lagoons in comparison to the larger marine (sea) environment[16,17]. This, despite the importance of terrestrial waste, impacted freshwaters as important catchments for the sequestration and ingress of plastic litter into the marine environment[18,19]. Ologe Lagoon is proximal to several medium-sized peri-urban communities with strong utilisation influences on the water body. Most significantly in this case, risks from pollution from the surrounding human communities to which it provides significant ecological services, including, largely unrestricted fishery resource exploitation, agricultural inundation, transport, sand dredging and other commercial opportunities related to the fishery[20]. About 62 fibres of various material types were visually identified. Suspect particles were detected through microscope-aided visual perusal of filters. The primary colour, blue was most frequently detected (53%), followed by the neutral, black (26%). A mix of primary and neutral colours ranging from red to purple accounted for the remainder of the colours seen. The ingestion colour desirability gradation ranged from darkest (black) to clear with the majority of detected fibres, (blue fibres) occurring closest to black in the colour spectrum. Rochman *et al.*[21,22] also suggested some colour related predilection for fragment uptake. The predominance of cotton fibres despite their inherent biodegradability in comparison to other, more environmentally durable and persistent fibre types, including polypropylene, rayon and polyester can be explained by the predominant choice of clothing material used in the locality under study. The latter preference for blue fibres is also attributable to the sheer numbers (density) of blue fibres available to foraging fish. Since fibres can be considered as secondary fragmentation contaminants, originating from

the breakdown of larger items usually during laundering[23]. This large proportion of cotton and cellulosic fragments reported in this study could be partly accounted for by the use of the lagoon as a laundry site by surrounding communities and transients, who frequently wash by hand washing and beating clothes on rock formations surrounding and within the waters, the mechanical nature of these modes of laundering could account for the loosening and dislodgement of cotton fibres from clothing. Laundering methods have been implicated in the numbers and quantities of clothing fibres shed during laundering[24,25]. Cotton is the most affordable garment material available, its suitability for the tropical climate of Nigeria and its widespread use for making cheap cotton prints, widely used for frequent communal gatherings and events, coupled with, the dumping of laundry wash waters from significantly populated communities around the lagoon could be contributory. These factors alongside the broad popularity of blue as a colour choice for clothing could account for the preponderance of blue cotton microfibres detected in this location, relative to other colours. Microfibres are among the most common microparticle pollutants detected along populated shorelines[26] and fibres from clothes laundering are suggested as the main sources of primary microplastics in oceans and open waters[27-29].

Positively identified MP numbers were lower in comparison to other micro fragment counts. This agrees with the discovery by Yahaya *et al*.[30]. In a global oceanic survey of microfibre presences, reporting synthetic fibre occurrences as the minority in comparison to fibres of natural or animal origin. In this study, microfibres are reported alongside microplastics with semi-synthetic and natural items excluded from current analysis. This could be partly responsible for the low "MP" numbers reported. The MP numbers were few in comparison to other analysed debris types. Occurring at less than one particle per individual fish, bottom-dwelling, carnivorous and omnivorous species had the highest group gut resident MP numbers, (69%) with fish of the genus *Chrysichthys* accounting for the highest individual and aggregate MP numbers. The latter could be partly due to individual species feeding voracity and active benthic foraging behaviour[31]. However, there were no significant associations found between the size of fish in terms of length, weight and number of ingested microplastics.

CONCLUSION

In the light of the sheer abundance of other natural, semi-synthetic and hybrid fragments in this study, which were detected relatively easily. The low numbers of microplastics cannot be attributed to fish, prey discernment or choice, but to other factors including their lower relative absolute numbers in the study location, small sample size cum catch speciation spectrum/width. With this, being a preliminary, "snapshot" study, it is recommended that further studies of wider scope be carried out addressing these limitations, for a better picture of MP presences in fish from similar, but demographically different locations in Lagos State with different usage, waste generation and land-water litter exchange profiles. The low numbers of microplastics found however, should not inform a reduction in efforts to monitor and reduce plastic ingress into these largely unregulated and monitored water bodies which play a very important part in the provision of ecological services to surrounding communities in Lagos State, Nigeria.

SIGNIFICANCE STATEMENT

This study was done to provide information lacking about the presence, types and numbers of microplastics in local fish species resident in the anthropogenically impacted waters surrounding, Lagos, Nigeria, a major urban population center in West Africa. Evidence of microplastic (MP) ingestion evidenced by MP presence in the GI of assayed fish subjects, establishes the bioavailability of MP to resident fish at different levels of the water column. It is recommended that further studies of wider scope be carried out on biota and water in tandem, for a better picture of MP presences in similar, but demographically different locations in Lagos State with different usage, waste generation and land-water-litter exchange profiles.

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