

STUDIES ON MICROPLASTIC CONTAMINATION IN AFRICAN CATFISH (*CLARIAS GARIEPINUS*) AND TILAPIA (*OREOCHROMIS NILOTICUS*) MARKETED IN LOKOJA, KOGI STATE

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Abstract

Microplastic contamination has been documented in environments and organisms across the world, but the exposure arising from fish sold in Nigerian markets remains poorly characterised. This study analysed the occurrence of microplastics in two species widely marketed and consumed in Lokoja, Kogi State: *Clarias gariepinus* and *Oreochromis niloticus*. Ten specimens of each species were purchased from New Market, Lokoja, and their gastrointestinal tracts were subjected to wet peroxide oxidation followed by density separation in saturated sodium chloride, with a procedural blank run for every five samples. Recovered particles were classified microscopically as fibres, fragments or pellets. Microplastics were recovered from every specimen examined, giving a prevalence of 100 percent in both species. A total of 224 particles was recovered, 108 from *C. gariepinus* and 116 from *O. niloticus*, with burdens ranging from 7 to 15 particles per individual. Mean burden was 10.8 ± 2.30 particles per fish in *C. gariepinus* and 11.6 ± 1.90 in *O. niloticus*, and the difference between species was not statistically significant, $t(18) = 0.83$, $p = 0.418$. The distribution of morphotypes likewise did not differ significantly between species, $\chi^2(2) = 2.01$, $p = 0.367$. Morphotype did differ within each species. Pellets were the most abundant form in *C. gariepinus*, at 47.2 percent of its load, whereas fragments and pellets were equally abundant in *O. niloticus* at 37.9 percent each; fibres were least abundant in both, at 21.3 and 24.1 percent respectively. These differences among morphotypes were significant in both species, with $p = 0.004$ for *C. gariepinus* and $p = 0.002$ for *O. niloticus*. Because both species are commonly prepared with some viscera retained, the gastrointestinal burden reported here represents a direct route of human exposure.

Keywords: microplastics; fish; contamination; morphotype; pollution; Lokoja

1. Introduction

Microplastic pollution is a global environmental concern owing to the ubiquity of these particles across ecosystems (de Azadevo et al., 2024). Microplastics are plastic fragments below five millimetres in their largest dimension, arising either as manufactured particles or through the progressive breakdown of larger plastic items under mechanical, photolytic and oxidative weathering.

Microplastics enter water bodies, soils and the atmosphere and accumulate within ecosystems. Their accumulation in aquatic systems is of particular concern because particles in the size range concerned are readily ingested by organisms at many trophic levels, either directly or through prey. In fish the gastrointestinal tract is the principal site of accumulation, and particles retained there are available to any consumer who eats the viscera.

Humans ingest microplastics through contaminated seafood, among other routes. The consequences of chronic low level ingestion remain incompletely characterised, but the pathway itself is well established, and quantifying the burden in commonly marketed species is a precondition for any assessment of exposure (Imasha and Babel, 2021; McNeish et al., 2018).

In Lokoja, *Clarias gariepinus* and *Oreochromis niloticus* are among the most widely traded and consumed freshwater species, and both are frequently prepared by roasting or stewing with part of the viscera retained. No published assessment of microplastic burden in fish sold in the city exists. This study therefore determined the prevalence, abundance and morphotype composition of microplastics in the gastrointestinal tracts of these two species as marketed in Lokoja, and tested whether burden and composition differ between them. The two species were selected because they occupy different feeding guilds, *C. gariepinus* being a benthic opportunistic feeder and *O. niloticus* principally a grazer, so that any difference between them bears on the route by which particles are acquired.

2. Materials and Methods

2.1 Study Area

The study was conducted in Lokoja, Kogi State, Nigeria, which lies at the confluence of the River Niger and the River Benue at approximately 7°45' N to 7°51' N. Fish traded in the city are drawn principally from the adjoining reaches of the River Niger.

2.2 Sample Collection

Ten specimens of *Clarias gariepinus* and ten of *Oreochromis niloticus* were purchased at random from New Market, Lokoja. Samples were collected in precleaned buckets and transported immediately to the Environmental Biology Laboratory, Kogi State Polytechnic Lokoja, for analysis.

2.3 Microplastic Extraction

Extraction followed a two step procedure combining chemical digestion with density separation. Each specimen was placed dorsal side down and opened along the ventral midline from the anus to the gills, and the gastrointestinal tract was removed into a glass container. The tract was subjected to wet peroxide oxidation by addition of 30 percent hydrogen peroxide, and the mixture heated gently at 50 °C for 20 to 30 minutes until the tissue broke down.

The digested solution was transferred to a saturated sodium chloride solution, stirred and left to settle, so that microplastics floated while denser residues sank. The floating layer was filtered, rinsed with distilled water to remove salt, and examined microscopically. Particles were classified as fibres, fragments or pellets and counted.

To control for airborne contamination, one procedural blank was run for every five samples processed.

2.4 Data Analysis

Counts are reported as mean $\pm$ standard deviation. Differences in total burden between species were tested by independent samples *t* test. Differences among morphotypes within each species were tested by one way analysis of variance, and the joint effects of species and morphotype by two way analysis of variance. The distribution of morphotypes between species was tested by the chi square statistic on the two by three contingency table of pooled counts. Significance was assessed at $\alpha = 0.05$.

3. Results

3.1 Prevalence and Total Burden

Microplastics were recovered from every specimen of both species, giving a prevalence of 100 percent. A total of 224 particles was recovered, comprising 108 from *C. gariepinus* and 116 from *O. niloticus*. Individual burdens ranged from 7 to 15 particles in *C. gariepinus* and from 8 to 14 in *O. niloticus*. The per specimen counts are given in Tables 1 and 2.

Table 1: Microplastic counts by morphotype in individual *Clarias gariepinus* specimens

Specimen	Fragments	Pellets	Fibres	Total
C1	5	7	3	15

Specimen	Fragments	Pellets	Fibres	Total
C2	4	7	3	14
C3	2	10	0	12
C4	4	4	2	10
C5	3	3	3	9
C6	3	2	4	9
C7	5	4	2	11
C8	4	4	2	10
C9	4	5	2	11
C10	0	5	2	7
Total	34	51	23	108

Table 2: Microplastic counts by morphotype in individual *Oreochromis niloticus* specimens

Specimen	Fragments	Pellets	Fibres	Total
T1	5	5	2	12
T2	4	5	3	12
T3	4	5	3	12
T4	3	3	4	10
T5	6	5	2	13
T6	6	6	2	14
T7	5	4	5	14
T8	4	4	3	11
T9	3	3	2	8
T10	4	4	2	10
Total	44	44	28	116

Note. Counts are particles recovered from the gastrointestinal tract of each specimen. Source: authors' laboratory analysis.

3.2 Comparison Between Species

Mean total burden was 10.8 ± 2.30 particles per fish in *C. gariepinus* and 11.6 ± 1.90 in *O. niloticus*. The difference was not statistically significant, $t(18) = 0.83$, $p = 0.418$, and the direction of the small difference favours *O. niloticus* rather than *C. gariepinus*. The two way analysis of variance likewise returned no significant species effect (Table 5), and the species by morphotype interaction was not significant.

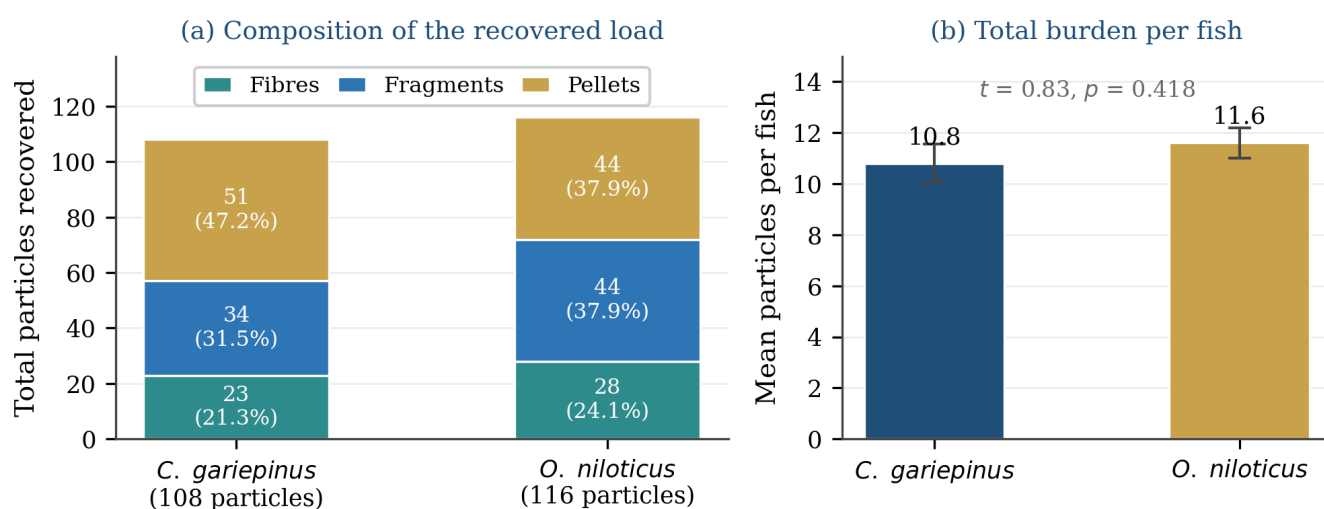


Figure 1: Microplastic burden by species. Panel (a) shows the composition of the total recovered load, with within species percentages; panel (b) the mean burden per fish with standard errors. The two species do not differ significantly in total burden.

3.3 Morphotype Composition Within Species

Morphotype composition differed significantly within each species. In *C. gariepinus*, pellets were the most abundant form at a mean of 5.10 ± 2.33 particles per fish, followed by fragments at 3.40 ± 1.50 and fibres at 2.30 ± 1.05 , and the differences

among morphotypes were significant, $p = 0.004$ (Table 3). In *O. niloticus*, fragments and pellets were equally abundant at 4.40 particles per fish, with fibres lowest at 2.80 ± 1.03 , and the differences were again significant, $p = 0.002$ (Table 4).

Table 3: Mean microplastic counts by morphotype in *Clarias gariepinus*

Species	Morphotype	Mean $\pm$ SD	p value
<i>C. gariepinus</i>	Fibres	2.30 ± 1.05^b	0.004
<i>C. gariepinus</i>	Fragments	3.40 ± 1.50^b	0.004
<i>C. gariepinus</i>	Pellets	5.10 ± 2.33^a	0.004

Table 4: Mean microplastic counts by morphotype in *Oreochromis niloticus*

Species	Morphotype	Mean $\pm$ SD	p value
<i>O. niloticus</i>	Fibres	2.80 ± 1.03^b	0.002
<i>O. niloticus</i>	Fragments	4.40 ± 1.07^a	0.002
<i>O. niloticus</i>	Pellets	4.40 ± 0.96^a	0.002

Note. $n = 10$ specimens per species. Within a species, means carrying different superscript letters differ significantly at $p < 0.05$. The p value is that of the one way analysis of variance across morphotypes.

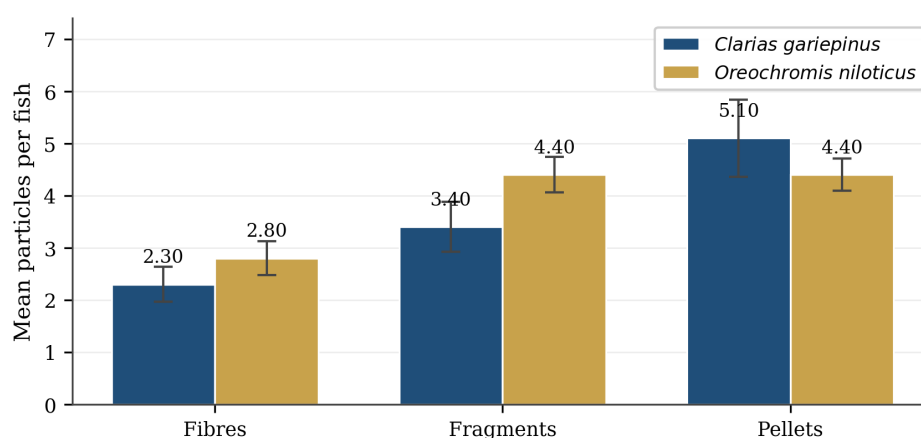


Figure 2: Mean microplastic counts by morphotype in the two species, with standard errors. Pellets dominate in *Clarias gariepinus*, whereas fragments and pellets are equally abundant in *Oreochromis niloticus*.

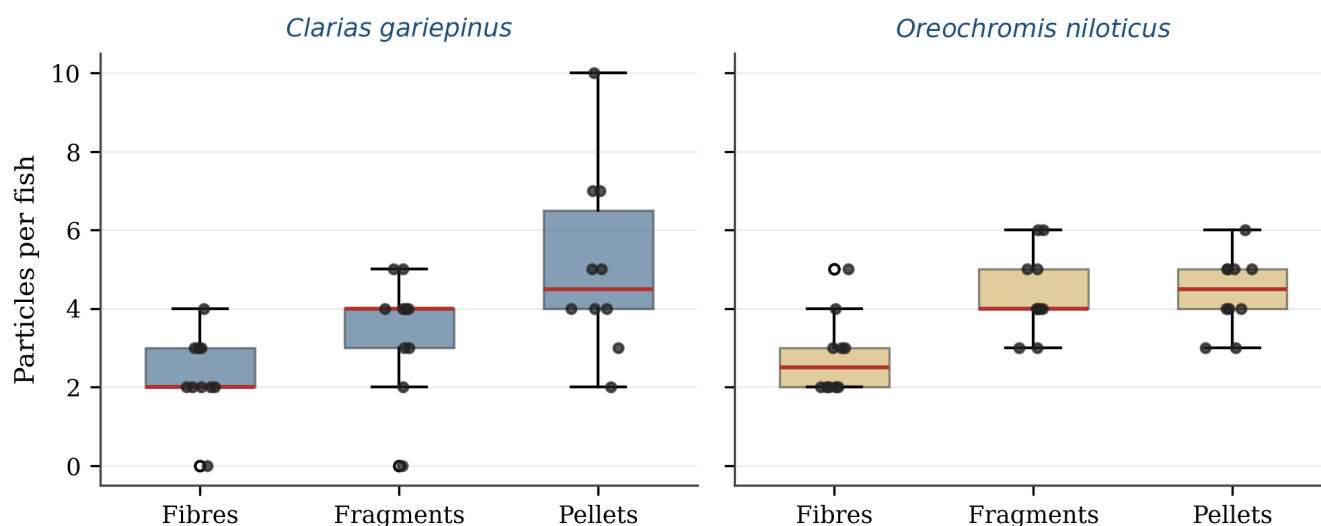


Figure 3: Distribution of microplastic counts by morphotype in each species. Boxes show the median and interquartile range, whiskers the range excluding outliers, and points the individual specimen counts. The wider spread of pellet counts in *C. gariepinus* is evident.

3.4 Joint Effects of Species and Morphotype

Table 5: Mean microplastic counts by species, morphotype and their interaction, with two way analysis of variance results

Factor	Level	Mean $\pm$ SD	p value
Species	<i>C. gariepinus</i>	3.60 ± 2.02	0.467
Species	<i>O. niloticus</i>	3.87 ± 1.25	0.467

Factor	Level	Mean $\pm$ SD	p value
Morphotype	Fibres	2.55 $\pm$ 1.05 ^b	< 0.001
Morphotype	Fragments	3.90 $\pm$ 1.37 ^a	< 0.001
Morphotype	Pellets	4.75 $\pm$ 1.77 ^a	< 0.001
Interaction	Species $\times$ morphotype	–	0.157

Note. Species means are averaged across morphotypes and therefore represent the mean count per morphotype rather than the total burden per fish.

Table 6: Comparison of microplastic morphotype distribution between species

Species	Fibres	Fragments	Pellets	Total	χ^2	p value
<i>C. gariepinus</i>	23 (21.3)	34 (31.5)	51 (47.2)	108	2.005	0.367
<i>O. niloticus</i>	28 (24.1)	44 (37.9)	44 (37.9)	116		
Total	51 (22.8)	78 (34.8)	95 (42.4)	224		

Note. Values in parentheses are percentages of the row total, not expected frequencies. The chi square statistic has two degrees of freedom and tests whether the distribution of morphotypes differs between species.

4. Discussion

4.1 Universal Prevalence as the Primary Finding

The most consequential result of this study is not any difference between species but the absence of a clean specimen. Microplastics were recovered from all twenty fish examined, a prevalence of 100 percent, and the lightest burden recorded was seven particles. Contamination of the marketed catch is therefore not an occasional occurrence to be managed by selection but a baseline condition of the supply.

This finding carries directly into human exposure because of how the fish are prepared. Both species are commonly roasted or stewed in Lokoja with part of the viscera retained rather than being eviscerated completely, and the gastrointestinal tract is precisely the compartment in which the particles reported here were found. A burden measured in the gut would be of limited dietary relevance for a consumer who discards it; it is of direct relevance where the tract is eaten.

4.2 No Difference Between Species, and Why That Is Informative

Neither the total burden nor the morphotype distribution differed significantly between the two species. The mean burden was 10.8 particles per fish in *C. gariepinus* against 11.6 in *O. niloticus*, a difference of less than one particle that is well within sampling variation, and the chi square on morphotype distribution returned 2.01 on two degrees of freedom.

A negative result of this kind is easily dismissed, but here it is informative. The two species occupy different feeding guilds: *C. gariepinus* is a benthic opportunistic feeder that takes prey and detritus from the river bed, while *O. niloticus* grazes algae and suspended material in the water column. Had particle acquisition been governed primarily by feeding mode, a difference between them would be expected, and studies in other systems have reported exactly such trait dependent differences (McNeish et al., 2018). That no difference emerged here suggests that microplastics in this reach are distributed across compartments sufficiently uniformly that feeding guild ceases to discriminate, which is itself a statement about the degree of contamination.

It should be noted that the present finding contrasts with reports of species dependent differences elsewhere, including the work of Sloommaekers et al. (2019) in a different freshwater setting. Whether the contrast reflects a genuinely different contamination regime or the limited statistical power of ten specimens per species cannot be resolved from these data, and the latter possibility is addressed in Section 4.4.

4.3 Morphotype Composition and Its Sources

Although species did not differ, morphotype did, strongly and in both species. Pellets and fragments together accounted for 78.7 percent of the load in *C. gariepinus* and 75.9 percent in *O. niloticus*, with fibres the least abundant form in both.

The composition is informative about source. Fibres derive predominantly from textile laundering and are the dominant morphotype in systems whose microplastic load is driven by domestic wastewater. Fragments arise from the breakdown of rigid plastic items, and pellets are either manufactured primary particles or heavily weathered secondary ones. The preponderance of pellets and fragments over fibres in this reach therefore points towards the degradation of solid plastic waste as the principal input rather than towards laundry effluent, which is consistent with the limited sewerage coverage and the visible accumulation of solid plastic waste along the waterway. That inference should be treated as a hypothesis generated by the composition data rather than as a demonstrated attribution, since source apportionment requires polymer identification.

The one distinction between species worth noting is the greater dominance of pellets in *C. gariepinus*, at 47.2 percent of its load against 37.9 percent in *O. niloticus*, together with the markedly wider spread of pellet counts in that species visible in Figure 3. This is consistent with benthic feeding, since denser weathered particles settle and accumulate in bed sediment. The

difference was not statistically significant and should be regarded as suggestive.

4.4 Limitations

Several limitations qualify these findings. The sample of ten specimens per species is small, which limits the power of the comparison between species and means that the absence of a significant difference cannot be taken as evidence of equivalence. Particles were classified by morphotype under the microscope without polymer identification by spectroscopic methods, so the chemical identity of the particles, and therefore their likely source and toxicological profile, is unknown. Visual identification alone is also subject to false positives from non plastic material, although the procedural blanks run for every five samples provide some control over airborne contamination. Specimens were purchased at market rather than collected from a defined reach, so the precise provenance of the fish, and hence the water body to which the burden should be attributed, is uncertain. Only the gastrointestinal tract was examined, so translocation into muscle tissue was not assessed. Finally, no size fractionation was performed, so the distribution of particle sizes within the microplastic range is unknown.

5. Conclusion and Recommendations

This study found microplastics in every specimen of *Clarias gariepinus* and *Oreochromis niloticus* examined from New Market, Lokoja, with 224 particles recovered from twenty fish and individual burdens between 7 and 15 particles. Burden did not differ significantly between species, but morphotype composition differed strongly within both, pellets and fragments predominating and fibres being least abundant.

The study concludes that microplastic contamination of these two commercially important species is universal rather than sporadic in the Lokoja market, and that because both are customarily prepared with viscera retained, the gastrointestinal burden constitutes a direct route of human exposure. The following recommendations follow.

1. **Identify polymer types in subsequent work.** Spectroscopic identification would confirm the visual classification and permit the source attribution suggested by the morphotype composition to be tested rather than inferred.
2. **Enlarge the sample and define provenance.** A larger sample collected from identified reaches rather than purchased at market would both raise statistical power and allow burden to be attributed to a specific water body.
3. **Examine muscle tissue as well as the gut.** Translocation from the gastrointestinal tract into edible muscle determines exposure for consumers who do eviscerate, and was not assessed here.
4. **Encourage complete evisceration in food preparation.** Since the burden documented here resides in the gut, public health messaging on removing the viscera before cooking offers an immediate and low cost reduction in exposure.
5. **Address solid plastic waste entering the waterway.** The dominance of pellets and fragments over fibres points to the degradation of solid plastic litter rather than to domestic effluent as the principal input, which identifies waste collection as the relevant intervention.

Conflict of Interest

The authors declare that there are no conflicts of interest in this research.

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Authors Contributions

Conceptualisation: S. U. Abdulazeer (lead). **Data curation:** I. O. Muhammed (lead), S. U. Abdulazeer, H. Salihu (supporting). **Formal analysis:** A. A. Salihu, K. A. Abdulmalik, M. Abdullahi. **Investigation:** A. A. Salihu, H. Yakubu, I. O. Muhammed. **Resources:** S. U. Abdulazeer, H. Salihu, H. Yakubu, M. Abdullahi. **Visualisation:** I. O. Muhammed and S. U. Abdulazeer (equal). **Writing of the original draft:** S. U. Abdulazeer (lead), I. O. Muhammed and H. Salihu (supporting).

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