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Occurrence of Microplastics in Commercial Fish Species in Nigeria: A Case Study of Lower Usuma Dam and Jabi Lake, Federal Capital Territory, Abuja, Nigeria

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ABSTRACT

The emergence of microplastics pollution poses a significant environmental and health concern on freshwater ecosystems as well as human health, due to its persistence and potential ecological impacts. Microplastics contamination remains greatly under reported across the Nigerian aquatic ecosystem and as such, only limited data exist for the occurrence of microplastics in the region. This present study was carried to investigate for the first time, the occurrence of microplastics in Lower Usuma Dam and Jabi Lake in the Federal Capital Territory of Nigeria. The gastrointestinal tract of common commercial fish species in the locations *Lates niloticus* (Nile Perch) and *Oreochromis niloticus* (Nile Tilapia) were analyzed, and microplastics were found in 60% and 80% of each fish species collected from the two sampling locations. Similarly, a total of 71 microplastics particles were also recovered from water samples collected from the two locations confirming the prevalence of microplastics. Polyethylene (PE), polypropylene (PP), and polystyrene (PS) were found in the surface water samples while Nylon (N), polyethylene terepthtalate (PET) were predominant in fishes collected. Generally, the shape distribution of microplastics particles were reported in the order fragment>foam>filament>film. Statistical analysis carried out showed no significant relationship between microplastics ingestion in different fish species and microplastics in the selected water bodies ($P > 0.05$). These findings highlight the need for further research in the region in other to identify and assess the full extent of microplastics pollution and how it affects the aquatic life as well as human health.

Keywords: Microplastics, *Oreochromis niloticus*, *Lates niloticus* Federal Capital Territory, Occurrence, Plastic Pollution

INTRODUCTION

Over the years, the plastic industry has experienced a staunch increase in production, such that, billions of tons of plastics produced since 1950 have ended up as waste (Attah et al., 2023). Microscopic plastic fragments measuring less than five millimetres are commonly referred to as microplastics (fragments < 5 mm) (Chidimma Adamma *et al*., 2024). The danger that microplastic pollution pose, has drawn growing attention in the world (Samuel *et al*., 2024). Due to the prevalent characteristics of microplastics, their presence in numerous environments such as rivers, oceans, sewages, sediments, and soil have been reported (Makhdoumi *et al*., 2023). Microplastics can be formed primarily from sizes less than (<) 5mm in diameter or originate from continuous breaking down of large plastic entities through environmental exposure and leaching (Fred-Ahmadu *et al*., 2020; Peixoto *et al*., 2019; Tanko *et al.,* 2026). These plastic fragments can be differentiated in terms of the way they are formed (Olarinmoye *et al*., 2020). There are two classifications of microplastics, namely primary and secondary. Plastic fragments that are microscopic and are found in cosmetics, food and abrasives are commonly referred to as Primary microplastics. Whereas, secondary microplastics are formed by fragmentation of plastic materials due to environmental factors like photo-oxidation and weathering (Ilechukwu *et al*., 2022; Terrazas-l *et al*., 2024).

Earlier studies have hinted that approximately 275 million metric tons of plastic materials are manufactured and widely used in 192 coastal countries since 2010. However, a predicted amount of about 4.8-12.7 million metric tons of plastic related waste reportedly potentially end up in the ocean (Aragaw, 2021). Many water bodies (both fresh water and the ocean) become vulnerable to contamination, when these plastic wastes are not properly discarded and subsequently undergo fragmentation to become microplastics and find their way into the waterbodies (Olarinmoye *et al*., 2020).

According to Browne (2015), there are several routes and sources through which microplastics might enter aquatic systems. These sources include sewage treatment plants (Ziajahromi *et al*., 2016), water (Sighicelli *et al*., 2018; Luo *et al*., 2019), and the manufacture of plastic materials (Fadare *et al*., 2020).

The existence, distribution, and possible impacts of pollution associated with waste plastics across many environments, particularly the marine environment in Africa especially Nigeria, are not well understood, despite the severity of its toxicity and health impacts. (Idowu *et al*., 2024; Yalwaji *et al*., 2022). Therefore, this study aims to provide for the first time, evidence of microplastics contamination in selected fish at lower usuma dam and Jabi lake in the Federal Capital Territory (FCT), Nigeria

MATERIALS AND METHODS

Study Area

The research was conducted in Jabi Lake and Lower Usuma Dam of the Federal Capital Territory (FCT) in Abuja, Nigeria. Jabi Lake is precisely 7°25'27" East and 9°3'45" North, respectively in the Municipal Area Council (AMAC) of the Federal Capital Territory. A recreational park and a shopping mall are located along the lake's bank, also fishing activities is carried out year-round within the lake. The selection of this site for the study was due to the potential contamination risk arising from recreational and other anthropogenic activities around the lake (Matouke & Abdullahi, 2020) .

Located near Abuja's Ushafa village in Bwari Area Council of the Federal Capital Territory (FCT), the Lower Usuma Dam spans a land area of $2.5x10^6$ sqm and is roughly positioned at latitude 7°25'16"E and longitude 9°01'12"N. Situated at an elevation of 570 meters, it is close to the highest point in the Nigerian Federal Capital Territory, some 15 kilometers northwest of Abuja. (Wuana et al.,2020). The Dam was constructed in 1987, and ever since it has served as a source of drinking water for the city and its environs. The main occupations of the locals are farming, fishing, and hunting. Ushafa Community, Kogo, Jigo, Pwambara, peyi and Usuma Dam Quarters are all in close proximity.

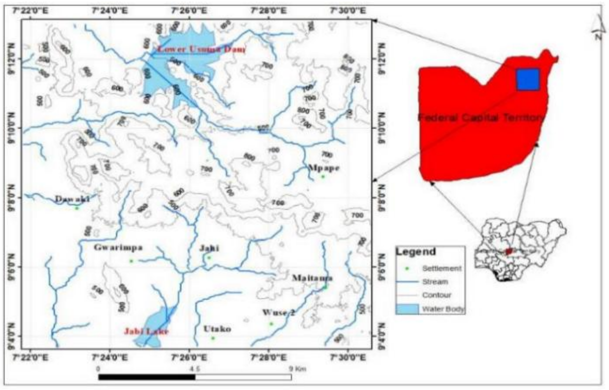


Figure 1: Map Showing Sample Retrieval Locations

Sample Collection

Collection of water and fish samples was carried out at the sampling locations in the month of September 2025 at the peak of the seasonal rainfall within the region. The points of sample collections in the sampling locations were carefully and systematically selected bearing in mind, the level of anthropogenic or human activities that take place.

Surface water sample was collected according to procedures described by Briggs *et al*., 2019; Kovač *et al*., 2016 at Jabi Lake and Lower Usuma Dam. Briefly, a plankton net with a mesh size of 50µm was mounted at least 1m away from a canoe. Samples were collected against the flow of water, and transferred into pre-cleaned 500ml glass sampling bottles labelled with the sample name and dates. The labelled bottles were then taken to the laboratory for further analysis.

Fish samples for microplastics analysis were freshly obtained from local fisher men at the sampling sites. 5 individual fish Oreochromis *niloticus* (Nile Tilapia) and Lates *niloticus* (Nile Perch) species were collected from each sampling stations and locations, thoroughly cleaned and stored at freezing temperature of 4^0C, before been transported to the laboratory for further analysis.

Extraction of Microplastics

Prior to microplastics identification, the samples obtained was subjected to pretreatment and subsequent extraction of suspected microplastic particles. The procedures involved in the pretreatment and extraction of microplastics in water was carried out in adherence to the National Oceanic and Atmospheric guidelines for water sample pretreatment and extraction (Masura *et al.,* 2015). The Wet Peroxide Oxidation (WPO) process was used for the digestion of organic matter present in the surface water samples collected. 20mL of aqueous 0.05M Fe (II) and 30% v/v Hydrogen peroxide (H_2O_2) was added to each beaker and was allowed to rest at room temperature loosely covered with aluminium foil paper. Density separation was carried out using 6g of NaCl (0.05M) solution to separate sand or settled minerals and effectively extract the suspected microplastics. The supernatant was filtered using an 8µm (0.008mm), 110mm Ø Whatman filter paper and the residue on the filter paper was collected and air dried in an oven loosely covered with aluminium foil for 24 hours, then stored in 4mL sample vials for microplastic identification.

Figure 2: Suspected Microplastics Separated During Density Separation

Fish exterior was thoroughly cleaned with di-ionized water before dissection for microplastic (MP) extraction. The methods described by Adeogun *et al*. (2020); Rahmawati *et al*. (2023); Merga *et al*. (2020), was used to accomplish stomach dissection for inspection.

Briefly, before dissection fish morphometrics such as fish length ($L_{(cm)}$), fish weight ($W_{(g)}$), were measured and recorded. The fish stomach was dissected horizontally and then the morphometrics were measured using a digital TS 200 weighing balance and then transferred into a 500-mL glass beaker, and dried at 100°C for 24 hours in an oven to remove water content. The dried samples were oxidized using the wet peroxide oxidation (WPO) method by adding 20mL of 20%v/v Hydrogen peroxide (H_2O_2) and heating at 75°C for 24 hours to achieve proper digestion of all organic matter present. To Separate the suspected microplastics, 50mL of 10% NaCl solution was added and stirred and allowed to stand for 24 hours until fully dissolved. The supernatants were then decanted into new 500 mL glass beakers and filtered using a 8 µm filter paper and was repeated two times so as to obtain a better extraction and a high microplastic recovery. The filter paper membranes were then collected dried in an oven for 24 hours and stored in glass petri dishes before examination for microplastics was carried out.

Microplastics Identification

After Pre-treatment and extraction of the microplastics samples (water and fish), the chemical and physical properties such as surface and shape structure, polymer type, functional groups present in the MPs samples were determined using procedures Aliyu *et al*. (2023); Adeogun *et al.* (2020) described. The surface morphology as well as confirmation of microplastics in the samples was determined with the aid of a scanning electron microscopy (ZEISS Sigma 300-VP Field Emission SEM). The qualitative analysis of microplastic composition was determined using Fourier transformed infrared spectroscopy (FTIR) equipped with an attenuated total reflectance (ATR) apparatus.

Statistical Analysis

The non-parametric statistical test was carried out. A Mann-Whitney U test was done to compare the abundance of microplastics in the water bodies and among the fish species. Spearman's rank correlation was conducted to ascertain the relationship between microplastics ingested by the fish species and their morphometrics. Thereafter, Kruskal-Wallis analysis was conducted to compare the abundance of microplastics across the water bodies and fish species. If there was any difference in the groups ($P < 0.05$), a post-hoc pairwise comparison was performed using the Dunn's test with Bonferroni pairwise adjustment to identify and minimize the possibility of false positives. All statistical analysis were carried out at 95% confidence interval ($\alpha = 0.05$) using Microsoft Excel, and R (R Studio 4.4.3).

RESULTS AND DISCUSSION

Microplastics in Water

A total of 71 microplastics particles were found across the two sampling locations in this study. At Usuma Dam, 29 microplastic particles were recorded at an abundance of 1.93 particles/L. while Jabi Lake recorded 42 microplastics particles at an abundance of 2.10 particles/L. The mean abundance of microplastics particles at the two sampling locations was 2.02 ± 0.12 particles/L indicating a low variability and uniform distribution among samples across the sampling site. Microplastics particles were recorded highest at Jabi Lake compared to Usuma Dam. No significant difference in microplastics abundance levels was observed across the water bodies ($p>0.05$).

According to studies carried out by Idowu et al., (2024) in Osun river, Nigeria, microplastics abundance of water samples were recorded at a maximum of 22,079 ± 134 particles/litre, these findings underlines a huge contrast with this research in terms values for the abundance of microplastics which is likely due to the high sample size analysed, compared to those in this study. However, it also reports for higher microplastics abundance in water samples in line with this study. Numerous human activities introduce microplastics into aquatic ecosystems, These include improper disposal of plastics, deliberate practice of introducing microscopic plastic particles into personal care products and various wide scale production activities across different industries (e.g., polyester fibers released during laundry), loss of plastic pellets during transport, discharge of microplastics through wastewater, presence of fishing equipment, discarded cigarette butts, abrasion from shipyard sandblasting, and transfer of waste plastics by air current or excess flow of water (Anyaegbu *et al*., 2024). The results presented on Figure 3**,** confirms the high level of urban and recreational as well as anthropogenic activities that take place at the sites (especially Jabi Lake). Also, Jabi Lake experiences limited water flow which makes it more likely for particles, including microplastics to accumulate in the system over time. Whereas, Usuma dam experiences faster water flows and controlled releases for water treatment purpose, thereby minimizing the retention of microplastics.

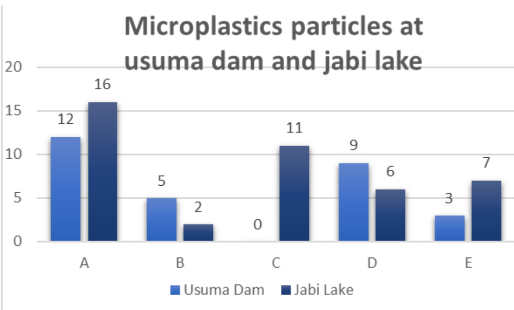


Figure 3: Chart Showing Microplastics Per Litre of Water Collected from Usuma Dam and Jabi Lake

Microplastics in Fish

Two distinct fish species, Oreochromis *niloticus* (Nile Tilapia) and Lates *niloticus* (Nile Perch) were carefully selected for this study based on their availability at the water bodies and also their characteristic feeding habit amongst other reasons. In this study, a total of 33 microplastic particles was recorded at a mean abundance of 1.65 ± 0.44 microplastics particles per fish across the fish species. At Lower Usuma Dam sampling station, the abundance of microplastics particles per fish was recorded as 1.8MP/fish for Oreochromis *niloticus* (Nile Tilapia) and 1.4MP/fish for Lates *niloticus* (Nile Perch), while at Jabi Lake, 2.2MP/fish was recorded for Oreochromis *niloticus*_(Nile Tilapia) and 1.2MP/fish was found for Lates *niloticus* (Nile Perch) with frequencies of occurrence at 60% and 80% respectively.

Studies carried out by Khan et al., 2020, reported 75.9% of microplastics abundance in Nile Tilapia from the Nile river in Cairo Egypt, accounting for 164 microplastic items from the fish species alone on an average of 7.5 ± 4.9 items per fish. These findings suggests that Nile Tilapia have a higher tendency to consume more microplastics particles as they occupy less deeper waters closer to the surface, making microplastics ingestion more likely than in Nile perch. Fish sampled from a water supply lake in southwestern Nigeria, also reported a high presence of 34% microplastics in Nile Tilapia and 5% in Nile Perch (Adeogun et al., 2020).

The high presence of microplastics detected in Nile Tilapia may be attributed to the fact that it occupies a low to intermediate position in the trophic system and exhibits an omnivorous feeding habit. Primarily it consumes phytoplankton, algae, detritus (dead, decomposing organic matter) and benthic materials. Hence, its non-selective feeding habit increases direct exposure to microplastics floating on water surface. However, Nile Perch on the other hand occupies a higher trophic position as a predator accounting for its strictly carnivorous nature, which makes it less likely to acquire microplastics directly through trophic transfer. Table 1 shows the morphometric properties of the fishes measured before microplastics extraction. As observed, no significant relationship between microplastics ingested and fish morphometrics across all the fish species in this study was recorded (P > 0.05).

Table 1: Morphology and Microplastics Count in Fish Species - Nile Tilapia and Nile Perch (*O. niloticus* and *L niloticus*), Collected from Usuma Dam and Jabi Lake

Fish Species/(Sampling Location)	Samples	Length (cm)	Weight (g)	GIT Weight (g)	Micropla- Stics Count (Items/fish)
Oreochromis Niloticus (Usuma Dam)	A	17.67±0.58^a	130.77±1.22^a	3.93±0.13^a	2
	B	16.47±2.63^a	102.30±1.13a	2.94±1.07^a	4
	C	15.97±1.50^a	59.40±1.44^a	3.08±0.36^a	0
	D	14.23±1.50^a	60.67±0.93^a	2.13±0.41^a	3
	E	13.50±0.50^a	44.67±1.04^a	1.17±0.31^a	0
Lates Niloticus (Usuma Dam)	A	20.60±0.53^a	110.03±0.91^a	3.40±0.20^a	2
	B	21.63±0.55^a	113.20±0.26^a	4.36±0.17^a	1
	C	18.10±0.46^a	59.53±0.23^a	2.56±0.80^a	3
	D	15.13±0.32^a	38.63±0.55^a	1.41±0.54^a	0
	E	17.50±0.50^a	49.33±1.53^a	2.63±0.93^a	1
Oreochromis Niloticus (Jabi Lake)	A	17.80±0.26^a	104.40±0.36^a	2.70±0.82^a	4
	B	18.23±0.25^a	114.33±0.42^a	2.95±0.64^a	2
	C	17.93±0.12^a	109.87±0.23^a	2.53±0.91^a	1
	D	19.17±0.29^a	113.90±0.10^a	2.98±0.77^a	3
	E	16.57±0.40^a	87.53±0.35^a	2.00±0.86^a	1
Lates Niloticus (Jabi Lake)	A	23.23±0.25^a	110.63±0.12^a	3.20±0.26^a	4
	B	25.03±0.06^a	113.17±0.21^a	3.95±0.05^a	2
	C	17.50±0.50^a	59.30±0.26^a	2.37±0.45^a	0
	D	15.83±0.76^a	39.00±0.95^a	0.87±0.35^a	0
	E	14.83±1.44^a	49.33±0.29^a	1.06±0.41^a	0

The Same Superscripts on the Same Column Means Values are not Significantly Different

Shape Distribution

Microplastics collected from surface water and fish at the two sampling stations (Usuma Dam and Jabi Lake) in this research were classified into fragments, filament, films, foams, and fibres, with fragments the most predominant microplastic shape. Generally, the shape distribution of microplastics particles across the sampling stations is in the order fragment > foam > filament > film. Awewomom *et al*., (2024), reported only fibres and fragments of different sizes, likely coming from the improper waste management systems in Ghana. Also, Samuel *et al.*, (2024) in their study discovered that gastrointestinal tracts of two fish species contained microplastics primarily in the form of fragments, fibers, pellets, and films. However, Based on findings by Rahmawati *et al*., (2023) Transparent fragments made up close to 64% the overall microplastics type present in every species of fishes investigated in their study aligning with this present study.

The presence of these shape types provides cogent proof on the use of secondary microplastics sources such as plastic bags, packaging materials, synthetic fibres etc. across these locations resulting from the heavy fishing and anthropogenic activities that take place especially at Jabi Lake. Microplastics are introduced into the water bodies by the breakdown of larger plastic particles over time, and can cause severe physical and internal injuries as well as digestive and immune system impairment to the aquatic fauna when ingested, due to their asymmetrical shape (uneven shape) as shown on figure 4 presenting the different shapes of microplastics found in this present study and their resemblance to natural prey (Płuciennik *et al*., 2024; Selvam *et al*., 2021; Subaramaniyam *et al*., 2023).

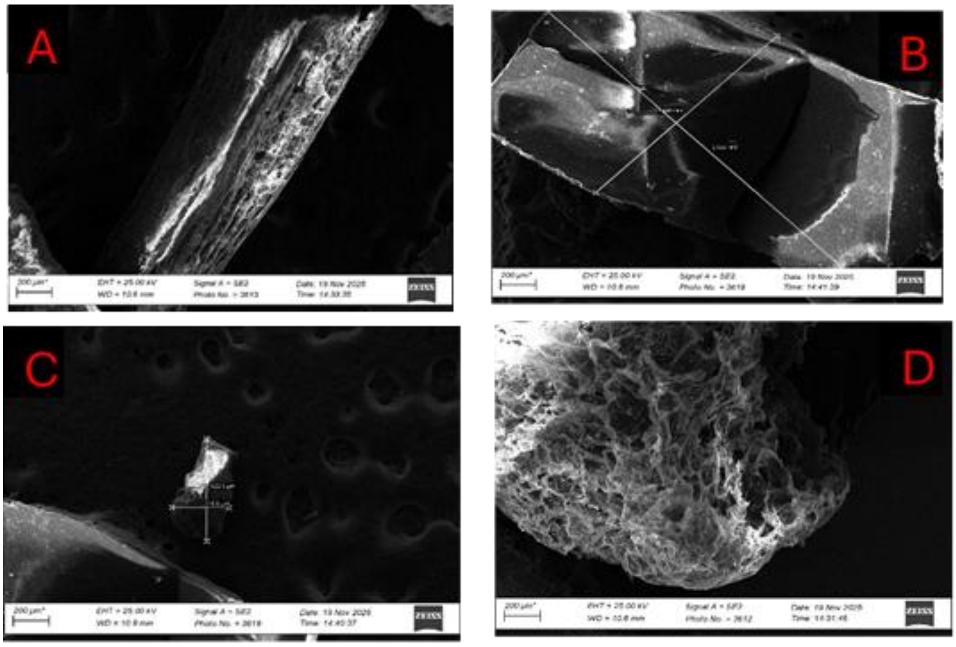


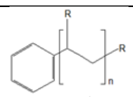
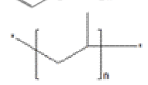
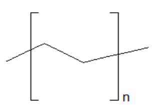
Figure 4: Different Shapes of Microplastics Analyzed in this Study. Key A= Filament, B= Film, C=Fragment, D=Foam

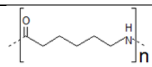
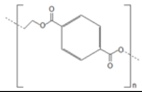
Polymer Distribution

Five (5) plastic polymer type were identified across the samples collected from surface water and fishes. Surface water samples comprised of polystyrene (PS), polypropylene (PP), polyethylene, and Polyethylene Terephthalate (PET), with polypropylene (PP) the most predominant plastic polymer at Usuma Dam accounting for 60% of the plastic polymers detected, followed by Polystyrene (PS) with 30%, then Polyethylene (PE) which had a 10% abundance. Also, at Jabi Lake Polypropylene (PP) was also dominant with similar abundance of 60%, followed by Polystyrene (PS) with an abundance of 20% and Polyethylene Terephthalate (PET) covering 20% of plastic polymers detected at Jabi Lake.

At Usman Dam and Jabi Lake, the most dominant polymer discovered in Nile Tilapia (Oreochromis *niloticus*) was Polyethylene Terephthalate (PET). In all the samples collected of Nile Tilapia (Oreochromis *niloticus* from) these two locations (Usuma Dam and Jabi Lake), PET was observed to be present in all of them with an abundance rate of 100%. Nylon (Nylon 6) on the other hand was the most abundant polymer type in Nile Perch (Lates *niloticus*), as analysed from the two sampling locations. The polymer types found in this research, are similar to those reported by Eberemu *et al*., (2024) who in their study, reported the presence of polystyrene (PS), polypropylene (PP), polyethylene, and Polyethylene Terephthalate (PET), polypropylene (PP)**.** Aliyu *et* al., (2023) also described the presence of similar polymer types in their research. The presence of these polymer types suggests that when plastics materials are littered in or around this water bodies (Jabi Lake and Usuma Dam), they take a longer time before they are eventually cleaned thus, creating the time needed for these larger plastic materials to fragment/breakdown into smaller plastic materials which in turn cause harm to the aquatic biota and its immediate consumers (humans). Table 2 shows the polymer types found in this study as well as the different absorbance peaks that were used to identify the polymer types and also the probable sources of these polymers from our daily lives. Nonetheless, pollution may likely arise from poor management of waste which also includes these sources as highlighted on Table 2, urban run-off, and other anthropogenic activities from residents near these locations

Table 2: Polymer Types Found in This Study and Their Functional Groups, Showing Key Absorbance Peaks from which Polymers Were Identified as Well as the Sources of These Polymers. Key: C=Carbon, H=Hydrogen, N= Nitrogen, O=Oxygen

Polymer type	Key Peaks	Functional Groups	Structure	Sources
Polystyrene	3024 (aromatic C-H),2918,1647/1601 (aromatic C=C), 1559 (aromatic), 1492, 1452, 1003, (in plane bend variant), 910, 749, 695	C-H aromatic, C=C aromatic		Disposable cups
Polypropylene	2950, 2917, 2867, 2838, 1452, 1376, 1166, 1101 (weak C-C), 1035/997 (shoulder), 841	Weak C-C (Alkane)		Food containers, texile materials
Polyethylene	2950 (weak CH3), 2915(CH2 asymetric stretch), 2848 (CH2 symetric stretch), 1462 (CH2 bend), 1376 (CH3 bend), 1166/1032/999 (minor, possible PP impurity), 913, 841, (weak, possible impurity), 718 (CH2 rocking, diagnostic for PE)	-CH2, -CH3 Stretching and bending		Food packaging containers, bottles, packaging materials

Nylon	3273 (N-H), 2922 (C-H), 1621 (amide I), 1528 (amide II), 1454/1383 (C-H bend), 1220 (C-N)	Amide(N-H), C-N, C-H		Ropes, fishing nets, toothbrush, threads
Polyethylene Terephthalate	1737/1713 (C=O ester), 2923/2853 (C-H), 1180/1082/1143 (C-O), 1003,912,750/688 (aromatic C-H out of plane)	Carbonyl (C=O), C-H, C-O		Plastics bottles, ropes,textile

The occurrence of microplastic in both water (Usuma Dam and Jabi Lake) and the selected fish species (Nile Perch and Nile Tilapia) confirms that microplastics contamination is pervasive within the aquatic environment, as a result of the continuous pollution arising from different sources such as domestic waste, surface runoff, wastewater discharge, fishing activities and plastic degradation. The absence of a statistically significant difference in microplastic abundance between the selected water bodies $p > 0.05$, suggest that microplastic pollution is not localized, instead it is regionally distributed and that, these waters maybe similar experiencing similar anthropogenic pressures. Ecologically, microplastics occurrence in the selected fish species indicates that ingestion is non selective and may occur irrespective of feeding habits or ecological niche. Also, no significant relationship between microplastic ingestion and fish morphometrics (Spearman's correlation, $p > 0.05$) implies that fish, regardless of their sizes are equally vulnerable to microplastics exposure. The Kruskal-Wallis analysis where significant differences were observed ($P < 0.05$) among certain groups as presented on Figure 5, suggest that ecological factors such as feeding behaviour may influence microplastics exposure. Further highlighting the role of specific fish species in determining microplastics ingestion relative to the environment.

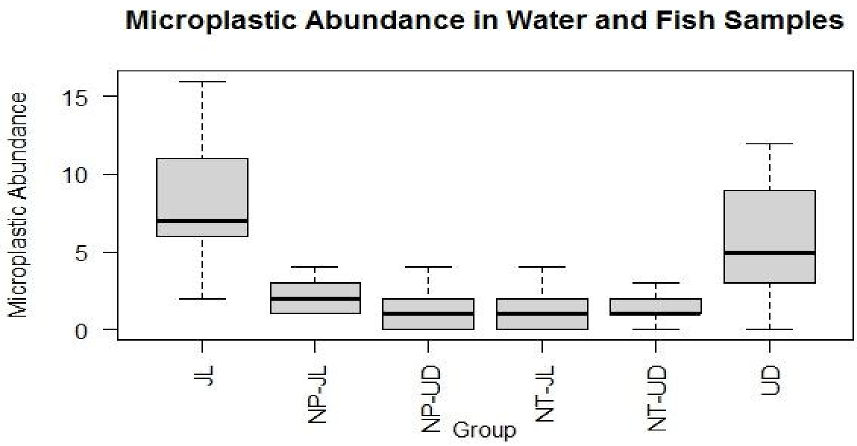


Figure 5: Kruskal Wallis Test Showing Relationship of Microplastic Abundance Across the water Bodies and Fish Species are Significantly Different (NP = Nile Perch, NT = Nile Tilapia, UD = Usuma Dam, JL = Jabi Lake)

CONCLUSION

This research provides baseline data for the studies of microplastics contamination or pollution in the Federal Capital Territory Nigeria, from the selected water bodies and aquatic fauna. This study confirms the occurrence of microplastics (different shapes and polymer types) in varying abundance in the selected fish species and their aquatic environment. With exposure occurring irrespective of the fish size or water body, which raises concerns of the widespread prevalence of microplastics in the selected aquatic environment. These findings highlight the need for a sustainable approach to environmental monitoring, and an improved plastic waste management practice to help eliminate the prevalence of microplastics in the environment.

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