

DETERMINATION OF MICROPLASTIC POLLUTANTS IN *Chrysichthys nigrodigitatus* IN IKPOBA RIVER, BENIN CITY

BY

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BENIN CITY**

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SUBMITTED TO

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DEDICATION

This report is dedicated to God Almighty for His grace, mercies, guidance and protection throughout this program and because he has made me to come this far in my academic journey. I also dedicate it to my lovely mother Mrs Iguisi and sister Favour Iguisi for their constant support, encouragement and prayers.

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ABSTRACT

Microplastic (MP) contamination of freshwater ecosystems is a significant environmental and public health concern globally. The paucity of data on MP contamination in *Chrysichthys nigrodigitatus* from the Ikpoba River, Benin City, Nigeria, warranted this investigation. This study determined the levels, types, and estimated daily intake (EDI) of microplastics in *C. nigrodigitatus* from three stations along the river over three months (July-September), using visual identification and Fourier Transform Infrared (FTIR) Spectroscopy for polymer confirmation. The mean levels of MPs in fish ranged from 0.0113 in August at Station 3 to 0.0163 in September at Station 2, with no significant difference ($p > 0.05$) between months at each station. The plastic load (particles/fish) ranged from 0.00103 in September at Station 1 to 0.00136 in September at Station 2, showing significant temporal variation ($p < 0.05$) at Station 1. The frequency of occurrence (FO) of MPs ranged from 0.33 in July at Station 1 to 1.00 in September at Stations 1 and 3. Physical classification revealed that fragments were the most dominant MP type (39.29%). FTIR analysis confirmed the presence of polyethylene, identified by characteristic absorbance wave numbers at 2925 cm^{-1} , 2850 cm^{-1} , 1430 cm^{-1} , and 710 cm^{-1} . The estimated daily intake (EDI) of MPs for humans through the consumption of *C. nigrodigitatus* was calculated to be low. The findings confirm the prevalence of microplastics in Ikpoba River and their ingestion by a commercially important fish species. It is recommended that continuous monitoring, effective waste management policies, and public enlightenment campaigns be implemented to mitigate plastic pollution and protect the river's ecosystem and associated public health.

CHAPTER ONE

1.0. INTRODUCTION

Microplastics are emerging contaminants in the marine biota, which cause many harmful effects on aquatic organisms, especially fish (Adika *et al.*, 2020). Fish is a staple and affordable food source, rich in animal protein, along with various vitamins, essential amino acids, and minerals. Exposure of fish to microplastics induces oxidative stress, inflammation, immunotoxicity, genotoxicity, and DNA damage and alters gut microbiota, thus reducing the growth and quality of fish (Alsaqfi *et al.*, 2021). Changes in fish behavioral patterns, swimming, and feeding habits have been observed under exposure to microplastics (Asma Al Shuraiqi *et al.*, 2024). Effects of microplastics were found to modulate many antioxidant enzymes, including superoxide dismutase, catalase, and glutathione system.

Recent studies estimate that about 5–13 million tons of plastic enter the oceans annually (Narra *et al.*, 2022). Because of their small size, aquatic organisms like bivalves, fish, zooplankton, shrimp, and whales ingest microplastics (Strungaru *et al.*, 2019). Microplastics have been found in 728 fish species worldwide (Hossain and Olden, 2022). After ingestion, microplastics accumulate in the gastrointestinal tract (GI) and block digestive system of fish, including the stomach and intestine, which reduces their feeding ability (Wright and Kelly, 2017). Microplastics adhere to fish skin, translocate to tissues like gills, muscles, and liver, and enter the circulatory or lymphatic system, causing nutritional and growth disorders (Lusher *et al.*, 2017). Microplastic exposure induces fish behavioral changes, including altered feeding, swimming, weakened predatory performance, foraging, and ventilation (Liang *et al.*, 2023). Microplastic ingestion affects immunity, growth, reproduction, survival, metabolism, and other toxicity

responses (e.g., oxidative stress) in fish. On consumption of fish, microplastics can enter the human diet (Smith *et al.*, 2018).

MPs have been found in edible fish, according to various research, and as a result of biomagnifications, MPs penetrate human systems (Alfaro-Núñez *et al.*, 2021). MP-induced impairments in species ranged from minimal biological systems disturbance to substantial unfavorable consequences that resulted in mortality (Mallik *et al.*, 2021). Physiological harm as a result of MPs accumulating within the digestive system; disruption of organisms' energy flow as a result of MPs expelling as pseudofeces; and inner body tissue exposed to MPs after transfer within the body were all designated as harmful by Ma *et al.* (2020). They also serve as a pathway for organic contaminants and trace metals to reach aquatic habitats (Gholizadeh and Patimar, 2018). MPs can affect predatory behavior in fish and cause misunderstanding between MPs and genuine prey (de Sá *et al.*, 2015), leading to malnutrition and MP storage in key organs such the gills, gut, and stomach (Lu K. *et al.*, 2018). MPs were also found in fish muscle/meat, which is mainly consumed by humans (Thiele *et al.*, 2021). Growth retardation, hormone disruption, metabolic perturbation, oxidative stress, immunological and neurotoxicity malfunction, and genotoxicity behavioural alterations are all caused by a buildup of MPs (Choi *et al.*, 2018)

1.1. Justification of the study

Microplastics, have become widespread in water environments due to increasing plastic production, population growth, and poor waste management (Li *et al.*, 2018). These particles persist in nature for long periods, breaking down slowly in water and soil. They are considered harmful pollutants because they attract toxic substances such as pesticides and heavy metals (Rochman *et al.*, 2019). Once microplastics enter freshwater systems, they accumulate in the bodies of aquatic animals and remain there for extended periods (Andrady, 2017).

Studying microplastic pollution is crucial because it threatens aquatic life, biodiversity, and human health. These tiny particles settle in water bodies, sediments, and living organisms, disrupting ecosystems and contaminating the food chain (Garcés-Ordóñez *et al.*, 2022). Many aquatic species, including *Chrysichthys nigrodigitatus*, mistakenly consume microplastics, leading to their buildup in tissues (Rochman *et al.*, 2015). When these tiny particles settle in water bodies, sediments, and living organisms, disrupting ecosystems, smaller organisms ingest microplastics, they pass them up the food chain, ultimately reaching humans (Smith *et al.*, 2018). Since microplastics carry harmful chemicals, they may cause digestive issues, hormonal imbalances, or even increase the risk of diseases like cancer (Wright and Kelly, 2017).

Urban rivers like the Ikpoba River, which support fisheries and aquaculture, are particularly vulnerable to microplastic pollution. Given these concerns, investigating microplastic pollution in *Chrysichthys nigrodigitatus* from the Ikpoba River, Benin City, Nigeria, will provide important insights into contamination levels and potential risks to fisheries and public health.

Chrysichthys nigrodigitatus, commonly known as the silver catfish, is a freshwater and brackish water fish belonging to the Clariidae family. It is widely found in West African rivers, lakes, and estuaries, including the Ikpoba River. This species is valuable in local fisheries and aquaculture due to its high economic importance as a source of protein and livelihood for fishing communities.

As a bottom-dwelling omnivore, *C. nigrodigitatus* feeds on detritus, insects, crustaceans, mollusks, and plant material. Its feeding habits make it more likely to ingest microplastics, which accumulate in riverbed sediments and organic matter. Since this fish is a common food source, microplastic contamination could pose risks to fisheries, aquaculture, and public health.

The Ikpoba River, like many urban water bodies, faces serious pollution from plastic waste due to poor waste management, industrial activities, and domestic waste disposal. The presence of microplastics in this river raises concerns about contamination in *C. nigrodigitatus* and its potential effects on the environment and human health.

1.2. Aim and objectives of the study

The aim of the study is to determine microplastic pollutants in *Chrysichthys nigrodigitatus* from Ikpoba river, Benin city, Edo state, Nigeria.

The specific objectives of the study was to;

1. determine the levels of microplastics(mp/fish) in *C. nigrodigitatus* from Ikpoba river.
2. identify the types of microplastics based on physical and chemical composition found in *C. nigrodigitatus* from Ikpoba river.
3. determine the estimated daily intake (EDI) of microplastic via the potential consumption of *C. nigrodigitatus*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Plastic Production

Plastic pollution has emerged as a major environmental crisis in recent years, posing serious threats to ecosystems, human health, and the global economy. Over 400 million tonnes of plastic were produced in 2022, with only about 9.5% of it made from recycled materials (The Guardian, 2025). This staggering production rate, coupled with inefficient recycling practices, suggests that plastic generation could double by 2050 if no major interventions are implemented. The COVID-19 pandemic further worsened the situation by increasing the global use of single-use plastics such as masks, gloves, and packaging materials, leading to additional pressure on waste management systems (Patrício Silva *et al.*, 2021).

Environmental contamination by plastics is now a concern across marine, freshwater, and terrestrial ecosystems. Marine environments, in particular, have seen a dramatic rise in plastic accumulation. Recent studies have shown that the North Pacific Garbage Patch has experienced a tenfold increase in microplastic concentration between 2015 and 2022, reaching up to 10 million microparticles per square kilometer (Le Monde, 2024). This massive influx of plastic debris has severe implications for marine species, many of which suffer from ingestion, entanglement, and habitat disruption. Meanwhile, terrestrial ecosystems are also not spared; microplastics in soil have been found to significantly alter soil microbial communities and disrupt nutrient cycles, which in turn affects plant growth and agricultural productivity (Kibria and Ali, 2024).

Developing nations face a disproportionate burden of plastic pollution, mainly due to inadequate waste management infrastructure. A study focusing on Nigeria highlighted the presence of

plastics in river sediments, wetlands, and urban waterways, although there remains a dearth of research on the presence of plastics in soil and the atmosphere (Ogunola *et al.*, 2022). Furthermore, in island nations such as Fiji, residents often resort to burning plastic waste in open-air conditions, a practice that releases harmful toxins and microplastics into the environment, exacerbating public health risks (Time, 2025).

Recognizing the global nature of the problem, the United Nations initiated the negotiation of a legally binding international treaty on plastic pollution in 2022. This treaty aims to cover the entire life cycle of plastics, from production and consumption to waste management and recycling (Wikipedia, 2024). However, progress remains slow due to political resistance from countries heavily invested in fossil fuel industries. Regionally, some policy measures have shown promise; for example, the European Union banned oxo-degradable plastics in 2021 to prevent the accelerated generation of microplastics (Wikipedia, 2024).

2.2 Sources of Plastic in Nigeria

In Nigeria, the sources of plastic pollution are diverse and closely linked to the country's rapid urbanization, industrialization, and lifestyle changes. One of the major contributors is the packaging industry, where plastics are heavily used for food, beverages, pharmaceuticals, and personal care products. It is estimated that sachet water commonly known as "pure water" accounts for a significant portion of Nigeria's plastic waste, with millions of small polyethylene bags discarded daily across urban and rural areas (Ogunola *et al.*, 2022). Similarly, plastic bottles from the booming soft drink and bottled water sectors add heavily to the volume of non-biodegradable waste generated in cities like Lagos, Abuja, and Port Harcourt.

Another significant source is the widespread use of single-use plastic products, such as shopping bags, disposable cutlery, and food containers. The availability of cheap, lightweight plastics makes them the preferred choice for businesses and consumers, but they are often improperly disposed of due to limited waste collection infrastructure (Akindele *et al.*, 2020). In many Nigerian cities, open dumping and illegal waste disposal practices are common, leading to plastics clogging drainage systems and contributing to severe urban flooding during the rainy season (Olufemi and Adewuyi, 2021).

The manufacturing and industrial sectors also play a notable role in Nigeria's plastic pollution problem. Industries producing household items, automotive parts, construction materials, and packaging materials generate significant amounts of plastic waste during production processes (Ajibade and Akinbobola, 2023). Many of these industries operate with minimal environmental oversight, resulting in the release of plastic scraps into surrounding land and water bodies. Additionally, agricultural practices have introduced plastics into rural environments through the use of plastic mulch films, pesticide containers, and irrigation equipment, all of which contribute to microplastic contamination over time (Kibria and Ali, 2024).

The importation of second-hand goods such as electronics and vehicles into Nigeria introduces additional plastic waste, as many of these products contain substantial amounts of plastic components that are eventually discarded when they reach the end of their usable life (Onianwa *et al.*, 2023). The informal recycling sector, though vibrant, focuses mainly on economically valuable plastics such as PET bottles, leaving less valuable or contaminated plastics to accumulate in the environment.

In coastal regions of Nigeria, particularly along the Atlantic coastline, marine plastic pollution is exacerbated by fishing activities and tourism. Discarded fishing nets, ropes, and other plastic

gear from artisanal fisheries are common sources of marine debris (Okafor-Yarwood *et al.*, 2022). Additionally, beachside leisure activities generate plastic litter, which often ends up in the ocean due to poor waste management practices. Rivers like the Ogun, Benue, and Niger serve as important conduits for transporting inland plastic waste to the coastal areas, further worsening marine pollution (Akindele *et al.*, 2020).

2.3 Sources of Microplastics in the Ikpoba River

The Ikpoba River, like many urban rivers, is subjected to diverse anthropogenic pressures that contribute to its microplastic pollution load. Major sources of microplastics in the river include domestic waste discharges, industrial effluents, agricultural runoff, and improper plastic waste management practices prevalent within the surrounding urban areas (Igbinosa *et al.*, 2012).

Unregulated dumping of household waste along riverbanks leads to the direct introduction of plastic debris into the river system, which, through degradation processes such as photolysis and mechanical abrasion, generates secondary microplastics (Akindele *et al.*, 2019). Industrial activities, particularly those related to manufacturing, construction, and automobile services, contribute to microplastic inputs through the release of raw plastic materials, paint residues, and tire wear particles (Akindele *et al.*, 2020).

Agricultural practices within the river's watershed also play a role in microplastic contamination, primarily through the application of plastic mulches, fertilizers packaged in plastic materials, and pesticide containers that eventually break down into microplastics and enter watercourses via surface runoff during rainfall events (Adeogun *et al.*, 2020). Furthermore, informal recycling activities and inadequate waste disposal infrastructure exacerbate the accumulation and dispersion of plastics within the riverine environment.

Given the multiple and overlapping sources, the Ikpoba River represents a complex matrix of microplastic pollution, emphasizing the need for comprehensive management approaches targeted at source reduction, improved waste handling practices, and public awareness initiatives to mitigate the impacts of microplastics on the river ecosystem.

2.4 Formation of Microplastics

Microplastics, defined as plastic particles less than 5 millimeters in diameter, are formed through several pathways, most of which are linked to the breakdown of larger plastic materials already present in the environment. One of the primary mechanisms of microplastic formation is the physical degradation of plastic debris under environmental conditions such as sunlight, temperature fluctuations, wind, and wave action. This process, known as photodegradation, causes plastics to become brittle and fragment over time, producing smaller and smaller particles (Patrício Silva *et al.*, 2021). In Nigeria, where open-air dumping of plastic waste is common and environmental exposure is intense, photodegradation significantly accelerates the formation of microplastics in both terrestrial and aquatic ecosystems (Ogunola *et al.*, 2022).

Mechanical forces also play an important role in the formation of microplastics. In urban centers, the constant abrasion of plastic items through human activity, transportation, and construction processes leads to the shedding of tiny plastic fragments. Tires, for example, release microplastic particles as they wear down on Nigerian roads, contributing significantly to atmospheric and surface water microplastic pollution (Akindele *et al.*, 2020). Similarly, the improper disposal and frequent reuse of plastic bags and packaging cause them to weaken and disintegrate, creating microplastic residues in markets, homes, and drainage systems.

Chemical degradation is another pathway through which microplastics are formed. Plastics exposed to environmental chemicals, oxidative agents, or certain microbial activities can undergo chemical reactions that weaken their polymer structure, leading to fragmentation. Studies have shown that agricultural soils treated with fertilizers and pesticides may experience faster plastic degradation due to chemical interactions, especially where plastic mulching films are used (Kibria and Ali, 2024). In Nigeria's agricultural zones, where plastic use in farming is increasingly common, chemical degradation contributes to the presence of microplastics in rural soil ecosystems.

Marine and freshwater environments serve as secondary sites for microplastic formation. Plastic debris that enters rivers like the Ogun, Benue, and Niger is subjected to constant abrasion by sediments and organic matter, leading to gradual fragmentation into microplastics (Okafor-Yarwood *et al.*, 2022). Fishing equipment, such as nets and ropes made from synthetic fibers, also degrade over time, releasing microplastic fibers into the water bodies, which can be ingested by aquatic organisms and enter the food chain.

2.5 Types of Microplastics

Microplastics are generally classified into two major types based on their origin: primary microplastics and secondary microplastics. Both types are significant contributors to environmental pollution in Nigeria and globally, although they differ in how they are formed and introduced into ecosystems (Patrício Silva *et al.*, 2021).

2.5.1 Classification Based on Origin

2.5.1.1 Primary Microplastics

Primary microplastics are manufactured to be microscopic in size from the beginning. They are intentionally produced for use in a variety of products such as cosmetics, toothpaste, industrial abrasives, and cleaning agents (Ajibade and Akinbobola, 2023). These microplastics include microbeads, plastic pellets (also called nurdles), and fibers from synthetic textiles. In Nigeria, the use of microbead-containing products remains common due to lax regulatory policies, allowing these tiny plastics to enter waterways directly through household wastewater (Ogunola *et al.*, 2022). Textile industries and everyday washing of synthetic clothes also release large quantities of primary microplastic fibers into the environment, further worsening the pollution load in rivers and urban drainage systems (Kibria and Ali, 2024).

2.5.1.2 Secondary Microplastics

Secondary microplastics are formed from the breakdown of larger plastic debris after exposure to environmental factors such as sunlight, heat, mechanical abrasion, and chemical reactions (Akindele *et al.*, 2020). Items like plastic bags, bottles, fishing nets, and packaging materials gradually fragment into smaller particles when abandoned in landfills, rivers, or coastal environments. In Nigeria, poorly managed landfills, open dumping sites, and plastic waste accumulation in urban areas are major sources of secondary microplastic generation (Okafor-Yarwood *et al.*, 2022). Secondary microplastics are often more irregular in shape compared to primary microplastics and are widespread across soil, freshwater, and marine ecosystems.

2.5.2. Classification Based on Morphology

Table 1: Classification of plastic based on Morphology

Morphology Type	Description	Examples
Fragments	Irregularly shaped pieces resulting from the breakdown of larger plastic items	Broken pieces of bottles, containers and packaging materials
Fibers	Long, thin strands shed from synthetic textiles or fishing gear	Fibers from polyester clothes, nylon and fishing net
Films	Thin, flat, sheet like plastics usually resulting from degraded plastic bags or wrappers	Torn parts of plastic bags and agricultural mulch films
Foams	Lightweight, porous plastics often used for insulation and packaging	Pieces from styrofoam, cups, plates and packaging forms
Pellets (Nurdles)	Small rounded plastic beads used as raw material in plastic manufacturing	Industrial plastic nurdles spilled during transportation
Beads	Microscopic spherical plastics used in cosmetic and cleaning products	Micro beads from facial scrubs and toothpaste

Source: Akindele *et al.* (2020).

2.5.3. Classification Based on Polymer

Table 2: Classification of plastic based on Polymer composition

Polymer type	Common uses	Properties
Polyethylene (PE)	Plastic bags, bottles, packaging films	Light, flexible, low density
Polypropylene (PP)	Food containers, straws, bottle caps	Durable, heat resistant, lightweight
Polystyrene (PS)	Disposable cups, packaging foams	Brittle, low melting point
Polyvinyl chloride (PVC)	Pipes, cables, medical equipment	Dense, rigid, chemical resistant
Polyethylene terephthalate (PET)	Beverage bottles, textiles (polyester)	Strong, high clarity, good barrier properties
Polymide (Nylon)	Fishing nets, textiles, ropes	Strong, flexible, abrasion resistant
Polycarbonate (PC)	Eyewear lenses, electronics, water bottles	Tough, transparent, impact resistant
Polymethyl methacrylate (PMMA)	Acrylic glass, signage lenses	Clear, uv resistant, lightweight

Source: Silva *et al.*, (2021)

2.6 Deposition and Transportation of Plastic/Microplastic in River/Ocean System

The deposition and transportation of plastic and microplastic particles within river and ocean systems are complex processes influenced by various physical, chemical, and biological factors. Rivers act as major conduits, transporting significant amounts of plastic waste from terrestrial environments into marine systems. It is estimated that rivers contribute up to 80% of plastic debris found in the world's oceans, with larger rivers, particularly in heavily populated regions, serving as critical pathways for plastic pollution (Patrício Silva *et al.*, 2021). In Nigeria, rivers such as the Ogun, Benue, and Niger are heavily impacted by anthropogenic activities, leading to the widespread transportation of plastic waste from urban centers to aquatic ecosystems (Akindele *et al.*, 2020).

The transportation of plastics begins with surface runoff during rainfall events, carrying improperly managed waste from land into river systems. Once in the river, the movement of plastic and microplastic particles is largely controlled by the flow dynamics of the water body. Larger plastic debris tends to remain buoyant and travels on the water surface, moving rapidly downstream under the influence of currents and tides. However, factors such as biofouling — the colonization of plastics by microorganisms — can increase the density of plastic particles, causing them to sink and become deposited in riverbeds or estuarine sediments (Ogunola *et al.*, 2022).

Microplastics, due to their small size, exhibit more complex behaviors. They can remain suspended in the water column, transported horizontally by surface flows or vertically through turbulent mixing. Fine particles may settle temporarily in low-energy environments such as river bends, backwaters, and estuarine mudflats but can be resuspended during flood events or strong tidal movements (Kibria and Ali, 2024). In Nigerian river systems, seasonal variations in rainfall

and flow regimes significantly affect the deposition and remobilization of plastics. During the dry season, lower water velocities may allow for greater deposition of microplastics, while the onset of heavy rains and flooding can lead to widespread redistribution and flushing of accumulated debris into the ocean.

Upon reaching estuaries and coastal zones, plastics and microplastics undergo further sorting and dispersion driven by oceanographic processes. Currents, wind action, and wave energy determine whether particles are deposited in coastal sediments, returned to the open sea, or washed back onto beaches. Heavier and biofouled microplastics are more likely to accumulate in seabed sediments, forming long-term pollution sinks, while lighter, buoyant plastics can travel across vast distances, contributing to the formation of massive garbage patches such as the North Atlantic and South Pacific gyres (Patrício Silva *et al.*, 2021).

The chemical and physical properties of the plastics themselves, such as polymer type, shape, and size, also influence their transport behavior. For instance, polyethylene and polypropylene, which are less dense than seawater, tend to remain afloat, while denser materials like polyvinyl chloride (PVC) are more prone to sinking (Ajibade and Akinbobola, 2023). Additionally, the fragmentation of larger plastics into secondary microplastics during transportation further complicates their fate, increasing the overall abundance of microplastics in aquatic environments.

In Nigeria, insufficient waste management infrastructure exacerbates the problem, as large volumes of uncollected plastics are readily available for riverine transport. Combined with rapid urbanization and weak environmental regulations, rivers have become saturated with plastic debris, resulting in adverse ecological impacts and threatening the livelihoods of communities dependent on fishing and clean water sources (Ogunola *et al.*, 2022). Understanding the patterns of deposition and transport is crucial for developing targeted mitigation strategies, such as river

clean-up initiatives, improved waste collection systems, and public education campaigns aimed at reducing plastic leakage into freshwater and marine environments.

2.7 Microplastic Ingestion

2.7.1 Microplastic Uptake

An expanding body of evidence supports the ingestion of microplastics by freshwater fish species (Akindele *et al.*, 2020). Fish may uptake microplastics passively, such as through direct exposure to contaminated water columns. For example, benthic species may unintentionally ingest microplastics while foraging in sediment or through filtration mechanisms during gill respiration (Adeogun *et al.*, 2020). Alternatively, active ingestion may occur when fish mistake microplastics for prey items, driven by visual or chemical cues (D'Souza *et al.*, 2021), or when they consume prey organisms already contaminated with microplastics (Adam *et al.*, 2021).

Microplastic contamination, propelled by wind action, heavy precipitation, and tidal currents, has been reported to reach even remote environments (Li, Zhang *et al.*, 2020). Their presence has been documented in remote rivers (Blettler *et al.*, 2021), estuarine ecosystems (Karbalaie *et al.*, 2021), seas (Sun *et al.*, 2021), oceans (Pan *et al.*, 2021), and even sea ice environments (Cai *et al.*, 2021). Owing to their diminutive size and low density, microplastics exhibit the capacity for long-range transport and global distribution (He *et al.*, 2022), enabling them to traverse extensive distances across aquatic systems via wind and currents (Chen *et al.*, 2021). Improperly disposed plastic waste, therefore, can be transported by pluvial flows into aquatic environments (Li *et al.*, 2020).

The pathways by which primary microplastics enter the environment are largely dictated by their intended applications. Cosmetic product particles typically enter water bodies via wastewater

streams, while microplastics generated by abrasive blasting activities disperse through both atmospheric and wastewater routes. Raw plastic materials used in manufacturing may find their way into the environment through accidental spills during transportation or through runoff from production sites. In instances where wastewater treatment plants are unable to capture these small particles, they may flow directly into rivers and oceans, exacerbating marine pollution (Li *et al.*, 2020).

Secondary microplastics are introduced into the environment through multiple mechanisms. These include the release of fibers from textiles into wastewater during washing or drying (Zhou *et al.*, 2020); the weathering of plastics utilized in agriculture, leading to runoff contamination; the mechanical abrasion of vehicle tires, dispersing microplastics via both atmospheric deposition and runoff (Kole *et al.*, 2021); and the degradation of plastic waste in landfills, producing airborne or waterborne microplastics that may enter aquatic systems. Additionally, the breakdown of plastic litter in coastal environments can result in microplastic accumulation within sediments or transport offshore. Environmental factors such as ultraviolet (UV) radiation, thermal degradation, and mechanical abrasion significantly influence the formation of secondary microplastics (He *et al.*, 2022).

2.7.2 Factors Affecting Microplastic Ingestion

2.7.2.1 Physical Properties

The physical characteristics of microplastics, such as size, shape, color, and density, play a crucial role in their ingestion by organisms. Smaller particles are more likely to be ingested simply because they can be easily confused with food items by a wide range of species (Akindele *et al.*, 2020). Similarly, certain shapes like fibers and fragments may mimic natural prey such as

plankton or aquatic plants, increasing the chances of accidental ingestion. Color is another important factor; brightly colored microplastics are more attractive to fish and seabirds, which often mistake them for edible materials (Ogunola *et al.*, 2022). In freshwater bodies like the Ogun and Benue Rivers, diverse microplastic shapes and colors have been found within the gastrointestinal tracts of fish species, illustrating the influence of physical properties on ingestion patterns.

2.7.2.2 Presence of Biofilms

Microplastics in the environment often develop biofilms thin layers of microorganisms such as bacteria, algae, and fungi that colonize their surfaces. The presence of these biofilms can significantly alter the chemical and biological identity of microplastics, making them more likely to be ingested by aquatic animals (Kibria and Ali, 2024). Biofilm-coated microplastics can emit odors similar to those of natural food sources, misleading organisms into perceiving them as edible (Okafor-Yarwood *et al.*, 2022). In Nigerian water systems where organic pollution is common, biofilm formation on microplastics occurs rapidly, further enhancing the ingestion risks for species such as catfish, tilapia, and invertebrates.

2.7.2.3 Physiological Traits

The feeding habits, sensory capabilities, and digestive physiology of organisms also significantly affect their likelihood of microplastic ingestion. Filter feeders such as mussels, clams, and some fish species indiscriminately take in particles from their surrounding water, making them highly vulnerable to microplastic ingestion (Ajibade and Akinbobola, 2023). Visual feeders, on the other hand, are influenced by how plastics look or move in the water. Moreover, species with poor discrimination between food and non-food particles, or those that feed at the surface or near

sediment layers where microplastics accumulate, are at higher risk (Akindele *et al.*, 2020). In Nigeria's coastal and inland water bodies, many commercially important fish exhibit feeding behaviors that expose them to high levels of microplastics, posing a threat to food safety and human health.

2.8 Microplastic Effects on Fish

Microplastics have profound and multifaceted effects on fish, impacting their physiology, behavior, reproduction, and overall health. As fish are exposed to microplastics primarily through ingestion and, to a lesser extent, through their gills, the consequences can vary depending on the species, environmental conditions, and the characteristics of the plastic particles. Several studies have documented these impacts across different aquatic environments, including those found in Nigeria, such as the Lagos Lagoon and the Ogun River (Ogunola *et al.*, 2022).

One of the primary effects of microplastic ingestion is physical blockage and damage to the digestive tract. Fish that consume microplastics often suffer from intestinal abrasions, inflammation, and reduced gut function, leading to impaired nutrient absorption and decreased energy reserves (Patrício Silva *et al.*, 2021). The presence of indigestible plastic particles can create a false sense of satiation, causing fish to reduce their feeding activity. Consequently, this can lead to malnutrition, stunted growth, and weakened immune responses, making fish more susceptible to diseases and environmental stressors (Ajibade and Akinbobola, 2023).

Microplastics act as vectors for a wide range of harmful chemical pollutants. Due to their high surface area and hydrophobic nature, microplastics readily adsorb persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), heavy metals, and pesticides from the

surrounding water (Kibria and Ali, 2024). When ingested by fish, these contaminants can leach into tissues, causing toxic effects including oxidative stress, hepatotoxicity, neurotoxicity, and endocrine disruption. Oxidative stress induced by microplastics often results in the overproduction of reactive oxygen species (ROS), leading to lipid peroxidation, DNA damage, and cellular apoptosis in fish (Okafor-Yarwood *et al.*, 2022).

Behavioral alterations have also been observed in fish exposed to microplastics. Changes such as reduced swimming performance, impaired predator avoidance, and altered feeding behaviors compromise survival and fitness. Juvenile fish exposed to high concentrations of microplastics have been shown to exhibit decreased exploratory behavior and increased vulnerability to predation, which can ultimately affect population dynamics in natural ecosystems (Patrício Silva *et al.*, 2021). In the context of Nigeria's inland fisheries, such behavioral impairments can threaten species like *Chrysichthys nigrodigitatus*, which are vital for both ecological balance and local economies.

Reproductive toxicity is another critical concern associated with microplastic exposure. Laboratory studies and field observations have revealed that chronic ingestion of microplastics can lead to reduced reproductive output, altered sex hormone levels, and histopathological changes in gonadal tissues (Akindele *et al.*, 2020). Female fish may produce fewer eggs, and sperm motility in males can decline, resulting in decreased fertilization success. These reproductive challenges, if persistent across generations, could lead to population declines, especially in already vulnerable fish populations subjected to additional pressures such as overfishing and habitat degradation in Niger

The presence of microplastics in fish tissues poses significant food safety concerns. Fish are an essential source of protein for millions of Nigerians, and the consumption of contaminated fish

could expose humans to plastics and associated toxic chemicals (Ogunola *et al.*, 2022). While the gastrointestinal tracts, where most microplastics are located, are often discarded during fish processing, the potential for particle translocation to edible tissues such as muscle cannot be completely ruled out, especially for small microplastics.

2.9 Bioavailability of microplastics

The bioavailability of microplastics refers to the extent to which these particles are accessible to living organisms for ingestion, absorption, or interaction within different environmental compartments. Several factors determine the bioavailability of microplastics, including their size, density, chemical composition, and environmental behavior. In aquatic systems, microplastics are particularly bioavailable to a wide range of organisms, from plankton to large fish species, because they are suspended in the water column, float on the surface, or settle into sediments where many organisms feed (Patrício Silva *et al.*, 2021). In Nigeria's inland water bodies such as the Ikpoba and Ogun Rivers, studies have shown that microplastics are abundant in both surface waters and benthic zones, increasing their accessibility to multiple trophic levels (Akindele *et al.*, 2020).

The small size of microplastics enhances their bioavailability because many aquatic organisms are incapable of distinguishing them from natural food particles. Zooplankton, for instance, readily ingest microplastics that are within the same size range as their prey, thereby introducing plastics into the lower levels of the food chain (Ogunola *et al.*, 2022). Furthermore, low-density plastics such as polyethylene and polypropylene tend to float and remain bioavailable to surface-feeding organisms like juvenile fish and seabirds, while denser plastics such as polyvinyl chloride (PVC) settle to the bottom, making them available to benthic feeders like catfish and shrimps (Kibria and Ali, 2024).

Environmental conditions also influence microplastic bioavailability. The formation of biofilms on microplastic surfaces alters their buoyancy and chemical properties, sometimes causing initially floating plastics to sink or making them more attractive as pseudo-food sources (Okafor-Yarwood *et al.*, 2022). Additionally, the adsorption of pollutants such as heavy metals and persistent organic pollutants (POPs) onto microplastic surfaces can increase their toxicity and ecological impact when ingested, making bioavailable microplastics potential vectors of secondary contamination (Ajibade and Akinbobola, 2023).

Terrestrial ecosystems are not exempt from the issue of microplastic bioavailability. In agricultural fields, microplastics present in soils can be taken up by soil invertebrates like earthworms, which are key to nutrient cycling. The ingestion of microplastics by such organisms can influence soil structure and fertility, with potential consequences for crop production in Nigeria's farming regions (Kibria and Ali, 2024). Moreover, atmospheric fallout of microplastic particles adds another layer of exposure, as microplastics can be inhaled by animals and even humans living near polluted areas.

2.10 Trophic Transfer of Microplastics

Trophic transfer of microplastics refers to the movement of plastic particles through different levels of the food web as organisms consume one another. Once microplastics are ingested by lower-trophic-level organisms such as zooplankton, benthic invertebrates, or small fish, they can be passed on to predators through feeding interactions (Patrício Silva *et al.*, 2021). In aquatic ecosystems of Nigeria, including the Lagos Lagoon and Niger River, studies have demonstrated the presence of microplastics in both prey and predator species, providing clear evidence that trophic transfer is an important pathway for the spread of microplastics across the food chain (Akindele *et al.*, 2020).

At the base of the food web, filter feeders such as mollusks and zooplankton ingest microplastics while feeding on suspended particles. These organisms are, in turn, consumed by fish species like tilapia and catfish, common in Nigerian rivers and lakes (Ogunola *et al.*, 2022). As larger fish prey upon smaller fish or invertebrates, the microplastics are transferred upward, sometimes accumulating in higher concentrations at higher trophic levels, a phenomenon known as biomagnification. Birds and mammals that feed on contaminated fish are also at risk, potentially introducing microplastics into terrestrial food webs and even human diets.

Several factors influence the efficiency and extent of trophic transfer. The size, shape, and retention time of microplastics within the digestive system of prey organisms determine whether plastics are available for transfer to predators. For instance, microplastics that are small enough to move beyond the gut lining into tissues are more likely to persist through digestion and be passed to the next trophic level (Kibria and Ali, 2024). In Nigeria, where fish such as *Chrysichthys nigrodigitatus* are important for both local consumption and commerce, trophic transfer of microplastics poses a direct threat to food safety and public health (Okafor-Yarwood *et al.*, 2022).

The adsorption of toxic chemicals onto microplastic surfaces can exacerbate the risks associated with trophic transfer. As microplastics move through the food chain, they can serve as carriers of pollutants such as heavy metals and persistent organic pollutants (POPs), leading to chemical exposure in addition to physical hazards (Ajibade and Akinbobola, 2023). This dual threat is particularly concerning in regions with high environmental pollution, as is the case in several industrial zones of Nigeria.

2.11 Biomagnification of Microplastics in Humans

2.11.1 Microplastics in Human Diet and Nutrition

The entry of microplastics into the human diet has become a growing concern in recent years, as studies have increasingly reported the presence of these particles in a wide range of food products and drinking water sources. Humans are exposed to microplastics primarily through the consumption of contaminated seafood, drinking water (both bottled and tap), salt, honey, and even fresh produce (Ogunola *et al.*, 2022). In Nigeria, where fish constitutes a major component of dietary protein, the ingestion of microplastics through seafood such as tilapia, catfish, and shrimps is particularly significant (Akindele *et al.*, 2020). Investigations have found that fish sold in Nigerian markets often contain microplastics in their gastrointestinal tracts and, potentially, in their muscle tissues, especially when the particles are sufficiently small to translocate across biological membranes (Patrício Silva *et al.*, 2021).

Beyond seafood, microplastics have also been detected in table salt, a staple in the Nigerian diet, as well as in bottled water, which is widely consumed due to concerns over the quality of municipal supplies (Kibria and Ali, 2024). Vegetables irrigated with contaminated water sources have shown microplastic contamination as well, suggesting that terrestrial food chains are not immune (Ajibade and Akinbobola, 2023). The cumulative ingestion of microplastics from multiple dietary sources raises concerns about potential health impacts, particularly in vulnerable populations such as children, pregnant women, and individuals with pre-existing health conditions.

2.11.2 Biomagnification of Microplastics in Humans

Biomagnification of microplastics in humans is an emerging area of concern, highlighting the cumulative exposure to plastics and associated toxins through dietary and environmental pathways. Unlike traditional chemical pollutants that biomagnify strictly through lipid accumulation, microplastics can persist mechanically across trophic levels, adhering to or becoming embedded within biological tissues (Patrício Silva *et al.*, 2021). In aquatic food chains, fish and shellfish act as intermediate carriers, ingesting microplastics from water, sediments, and prey. When humans consume these contaminated organisms, particularly when internal organs are eaten or when the microplastics have translocated into muscle tissues, the risk of internal exposure increases (Akindele *et al.*, 2020).

The phenomenon is intensified by the ability of microplastics to serve as vectors for hazardous substances. Studies have shown that microplastics sorb environmental contaminants like polychlorinated biphenyls (PCBs), heavy metals such as lead and mercury, and endocrine-disrupting chemicals like bisphenol A (BPA) (Kibria and Ali, 2024). When these contaminated particles are ingested, they can release the adsorbed toxins in the human gastrointestinal tract, leading to bioavailability of harmful compounds that might otherwise be less accessible. This means that not only the physical presence of plastics but also their chemical payloads contribute to biomagnification effects in humans (Ogunola *et al.*, 2022).

Evidence supporting this concern is growing. Microplastics have been detected in various human biological samples, including stool, blood, placenta, and even lung tissue, indicating the capacity of these particles to cross biological barriers and persist within the body (Ajibade and Akinbobola, 2023). Although the precise health effects are still being unraveled, current hypotheses suggest that chronic exposure to microplastics may induce low-grade inflammation, immune system dysregulation, oxidative stress, and possibly contribute to metabolic disorders

and cancer development (Patrício Silva *et al.*, 2021). The size, shape, chemical composition, and surface characteristics of microplastics all influence their biological interactions and potential toxicity.

Particularly concerning is the vulnerability of certain groups such as children, whose developing organs and immune systems may be more sensitive to environmental pollutants. Pregnant women are another high-risk group, as studies have reported microplastics in placental tissues, raising questions about possible impacts on fetal development (Ajibade and Akinbobola, 2023). Furthermore, the cumulative exposure over a lifetime through continuous consumption of contaminated food and water could potentially lead to health effects that only manifest decades later.

In Nigeria, where environmental plastic pollution is widespread and where dependence on local seafood is high, the potential for biomagnification is a serious public health issue. In addition to seafood, exposure pathways also include drinking water (both bottled and tap), agricultural produce irrigated with contaminated water, and even airborne microplastic inhalation in urban areas (Ogunola *et al.*, 2022). With limited regulatory frameworks and waste management challenges, biomagnification of microplastics in the human population could worsen if proactive measures are not implemented. Comprehensive national studies and public health interventions are urgently needed to assess exposure levels and mitigate risks.

2.12 Effects of Microplastics in Humans

The effects of microplastics on human health are an area of increasing scientific scrutiny, driven by growing evidence of the widespread presence of microplastics in the environment and within the human body. Humans are exposed to microplastics primarily through ingestion of

contaminated food and water, inhalation of airborne particles, and dermal contact in certain occupational settings (Ogunola *et al.*, 2022). Once inside the body, microplastics can exert a range of biological effects, depending on factors such as particle size, shape, chemical composition, and associated pollutants.

One of the most immediate concerns is the potential for microplastics to cause physical damage and inflammation. Studies have shown that microplastics can penetrate biological barriers, such as the gastrointestinal lining, and trigger localized inflammatory responses. The body's immune system may recognize these particles as foreign invaders, leading to chronic low-grade inflammation, which is a known contributor to various non-communicable diseases, including cardiovascular diseases, diabetes, and cancer (Patrício Silva *et al.*, 2021). Microplastics that translocate into systemic circulation may accumulate in organs such as the liver, kidneys, and lungs, compounding their potential to cause tissue damage over time.

In addition to physical harm, microplastics are known to carry a host of chemical contaminants. Due to their large surface area and hydrophobic nature, microplastics readily adsorb toxic chemicals such as persistent organic pollutants (POPs), heavy metals, and endocrine-disrupting compounds (Kibria and Ali, 2024). When ingested or inhaled, these substances can be released within the human body, contributing to toxicological effects. For example, heavy metals like lead and cadmium are associated with neurotoxicity and renal impairment, while endocrine disruptors such as bisphenol A (BPA) can interfere with hormonal regulation, potentially affecting reproductive health and increasing the risk of hormone-related cancers (Ajibade and Akinbobola, 2023).

Microplastics may disrupt the gut microbiota, an essential component of human health. The gut microbiome plays a critical role in digestion, immunity, and even mental health through the gut-

brain axis. Experimental studies have suggested that exposure to microplastics can alter the composition and function of gut microbial communities, leading to dysbiosis—a condition associated with inflammatory bowel disease, obesity, and metabolic syndrome (Patrício Silva *et al.*, 2021). Changes in the microbiome may also impair the gut's barrier function, making the body more susceptible to infections and systemic inflammation.

The long-term implications of chronic microplastic exposure remain largely unknown but are a significant cause for concern. Microplastics have been detected in human placentas, suggesting potential impacts on fetal development and pregnancy outcomes (Ajibade and Akinbobola, 2023). Research has also hinted at possible connections between microplastic exposure and increased oxidative stress, genotoxicity (DNA damage), and neurotoxicity, though more longitudinal studies are needed to fully establish causal links. Inhaled microplastics, particularly from indoor air and occupational environments, may deposit deep within the lungs, potentially leading to respiratory conditions such as asthma, fibrosis, or even contributing to the development of lung cancer (Kibria and Ali, 2024).

In Nigeria, where urbanization and plastic pollution are on the rise, these health risks are especially pressing. Poor waste management practices, combined with high dependency on plastic-packaged water and food, heighten the exposure of the Nigerian population to microplastics. Without adequate awareness, regulatory policies, and mitigation strategies, the burden of microplastic-associated diseases could add a significant strain to public health systems already grappling with other environmental and infectious diseases (Ogunola *et al.*, 2022).

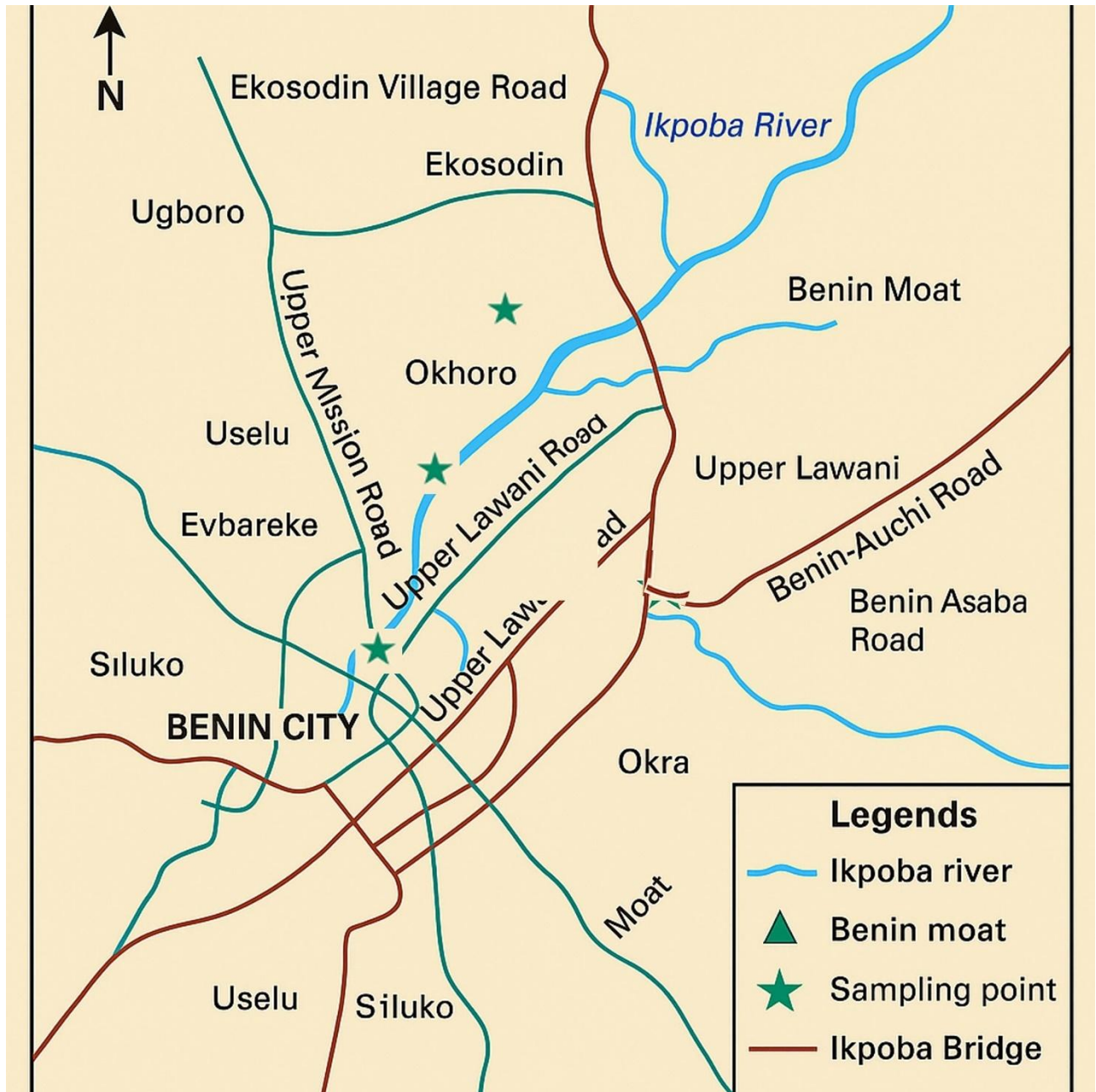
CHAPTER THREE

3.0 Materials and Methods

3.1 Study Area

Ikpoba River lies within the coordinates of Latitude 6° 19' 12"N and Longitude 5° 24' 0" E to Latitude 6° 22' 48"N and Longitude 5° 51' 7.2" E in Benin City, Edo State, Nigeria. The river flows in a south-westerly direction, traversing a sharply incised valley and sandy terrain, before coursing through Benin City and eventually merging with the Ossiomo River (Odigie, 2021). The river exhibits a dendritic pattern in its upper reaches and originates from the Ishan Plateau, which stands 230 meters above sea level in the eastern coastal plain, northeast of Benin City (Odigie, 2021).

Communities along the riverbanks benefit from various resources, such as fishery and water for domestic use. The riparian zone is primarily dominated by *Bambusa vulgaris* (bamboo), which is the main native plant species in the study area. However, extensive deforestation driven by agricultural activities has led to a significant reduction in the natural vegetation. The fertile alluvial soils in the region contribute to its agricultural viability



Source: Odigie, (2021)

Plate 1: Map of Benin city showing sampling stations along Ikpoba River

3.2 Experimental Design

The study was a factorial experiment within a Completely Randomized Design (CRD) with 3 stations, 3 months, 4 microplastic types and 3 replications.

3.3 Stations

3.3.1 Okhoro Reservoir (Station 1)

Situated at Latitude 6°22'37" N and Longitude 5°38'23" E, Okhoro Reservoir is a relatively enclosed water body. Local economic activities around this station include retail trading, tailoring, sawmills, carpentry, boutiques, salons, and tyre repair services, which may contribute plastic pollutants to the environment.

3.3.2 Upper Lawani (Station 2)

Located at Latitude 6°22'32" N and Longitude 5°38'45" E, the Upper Lawani station includes a waterfront utilized for fishing and religious ceremonies. Commercial ventures here also include salons, retail shops, and sawmills. The presence of plastic waste along the shorelines is evident.

3.3.3 Ikpoba Bridge (Station 3)

This station lies at Latitude 6°21'5" N and Longitude 5°38'49" E. It serves the local communities by providing water, fish, and aquatic vegetation. Dominant activities around this site include car and rug washing, along with animal slaughtering, which potentially contribute contaminants to the river.

3.4 Collection of Samples

Sampling of fish was done between 7:00 am and 10:00 am using fishing nets and a dugout canoe operated with help from local fishers. Upon collection, specimens was stored in labelled zip-lock bags and transported to the laboratory in an icebox within a 24-hour period.

3.5 Sample Preparation for Analysis

3.5.1 Cleaning the Samples

Fish specimens was thoroughly rinsed under running water to eliminate external debris attached to the fish (Davidson and Dudas, 2021).

3.5.2 Preparation of Digesting Solution

A 10% potassium hydroxide (KOH) solution was prepared by adding the appropriate volume of distilled water into a beaker, followed by the addition of KOH equal to 10% of the final solution volume. The solution was gently mixed to ensure uniformity (Karami *et al.*, 2021).

3.5.3 Digestion Process

The fish was dissected along the side to extract muscle tissue, which will be rinsed under running water. The cleaned sample was immersed in 10% KOH solution in a beaker, sealed, and incubated overnight at 60°C in an oven. This digestion technique is recognized as highly effective for isolating microplastics (Thiele *et al.*, 2022).

3.5.4 Purification of Digested Samples

To eliminate any remaining organic material, the digested samples was further treated with a 30% hydrogen peroxide (H₂O₂) solution (GESAMP, 2021).

3.5.5 Filtration of Digested Samples

The resulting liquid digested was filtered using 5 µm cellulose nitrate filters to capture even the smallest microplastic particles. The filters was rinsed into glass Petri dishes with distilled water (De Witte *et al.*, 2020).

3.6 Identification of Microplastics

The Petri dishes was oven-dried at 100°C for 12 hours. The dried contents was transferred onto microscope slides for visual inspection and identification, categorizing each microplastic by type: fibre, foam, fragment, or film (Roch *et al.*, 2020).

3.7 Confirmation of Microplastic Polymers

Given the limitations of visual identification which can result in misclassification even by expert further analysis of the suspected microplastics was undertaken. The tagging method was chosen for its cost-efficiency and satisfactory accuracy.

3.7.2 Hot Needle Test

To support visual identification, a hot needle was applied to the suspected microplastic particles. Melting upon contact indicated synthetic polymer material (Bellas *et al.*, 2020).

3.7.3 Microplastic Characterization

The identified particles was analyzed based on polymer type using Fourier Transform Infrared (FTIR) Spectroscopy at Splendidstan Research Laboratory, Benin City, Edo State. Samples was loaded into the FTIR spectrometer, which was pre-calibrated to capture spectra. Background readings was taken prior to each sample, and the ATR crystal was cleaned with acetone between runs to ensure accuracy in polymer identification.

3.8 Microplastic Metrics Assessed

Two key metrics will be evaluated in this study:

1. Plastic Load (PL)
2. Frequency of Microplastic Ingestion (FO)

3.8.1 Plastic Load (PL)

This metric denotes the average count of microplastic particles per fish, including those with no microplastic ingestion. Consequently, the PL value may be less than one (Avio *et al.*, 2021).

$PL = \text{Total number of microplastic particles} / \text{Total number of fish sampled}$ (Wootton *et al.* 2021)

3.8.2 Frequency of Occurrence (FO)

FO represents the proportion of sampled fish containing at least one microplastic particle.

$FO = \text{Number of fish with at least one microplastic} / \text{Total number of fish sampled}$ (Markic *et al.* 2020)

3.9 Contamination Prevention

To avoid cross-contamination, all lab surfaces, tools, and containers was cleaned with 70% ethanol prior to use and between samples. Rigorous contamination control procedures was followed throughout all stages of sample processing and analysis (Hermsen *et al.*, 2021). The work area was also cleaned thoroughly before processing each fish (Karami *et al.*, 2021).

3.10 Statistical Analysis

Data analysis was performed using GenStat software (Version 12.1). One-way Analysis of Variance (ANOVA) was used to identify significant differences in microplastic concentrations at a 5% significance level. Observed differences was separated using the New Duncan's Multiple Range Test.

CHAPTER FOUR

4.0 RESULT

The results of microplastic pollutants in *C. nigrodigitatus* harvested from ikpoba river, Benin city, Edo state, Nigeria is presented in this chapter

4.1 Mean level of Microplastics

The mean level of microplastics in silver catfish is presented in Table 1. The values ranged from 0.0113 in August at station three to 0.0163 in September at station two. There was no significant difference ($p>0.05$) in the mean levels between all stations in the months of July and August. However, in September, a significant difference ($p<0.05$) was observed across all stations. Vertically, there was no significant difference ($p>0.05$) between the months for station one.

Table 3: mean level of micropoplastics from *C. nigrodigitatus* according to stations and months

Location		July	August	September
Station one	(okhoro)	0.0143a	0.0133a	0.0123a
Station two	(upper lawani)	0.0143a	0.0153a	0.0163a
Station three	(ikpoba bridge)	0.0133a	0.0113a	0.0133a
Mean		0.014	0.0133	0.014

4.2 Plastic Load

The plastic load, defined as the number of plastic particles per fish, is shown in Table 2. The load ranged from 0.00103 in September at station one to 0.00136 in September at station two. Analysis of variance showed no significant difference ($p>0.05$) in plastic load between all stations in July. A significant difference ($p<0.05$) was observed between station two and the other stations in August and across all stations in September.

Table 4: Plastic load of *C. nigrodigitatus* according to stations and months

Location	July	August	September
Station one (okhoro)	0.00119	0.00111	0.00103
Station two (upper lawani)	0.0119	0.00128	0.00136
Station three (ikpoba bridge)	0.00111	0.00111	0.00111

4.3 Frequency of Occurrence

The frequency of occurrence (FO) of microplastics in silver catfish is presented in Table 3. The FO ranged from 0.33 in July at station one to 1.00 in September at stations one and three. There was a significant difference ($p < 0.05$) in FO across all months for each station. In the month of July, there was no significant difference ($p > 0.05$) between station one and three, but a significant difference ($p < 0.05$) was found with station two. A similar pattern was observed in the months of August and September.

Table 5: frequency of occurrence of Microplastics according to stations and months

Location	July	August	September
Station one (okhoro)	0.33	0.67	1
Station two (upper lawani)	0.67	0.33	0.67
Station three (ikpoba bridge)	0.33	0.67	1

Table 6: physical classification of microplastic particles in *C. nigrodigitatus* according to stations and months

	July			August			September		
	Okhoro	Upper Lawani	Ikpoba Bridge	Okhoro	Upper Lawani	Ikpoba Bridge	Okhoro	Upper Lawani	Ikpoba Bridge
R1	E	C	E	C	B,C	D	B	B	A
R2	B	C	C	A	D	C	E	A	C
E3	C	A	C	B	C	A	C	A	F

Note: R= Replication, A= No plastic, B= Filament, C= Fragment, D= Foam, E= Pellet, F= Fibre

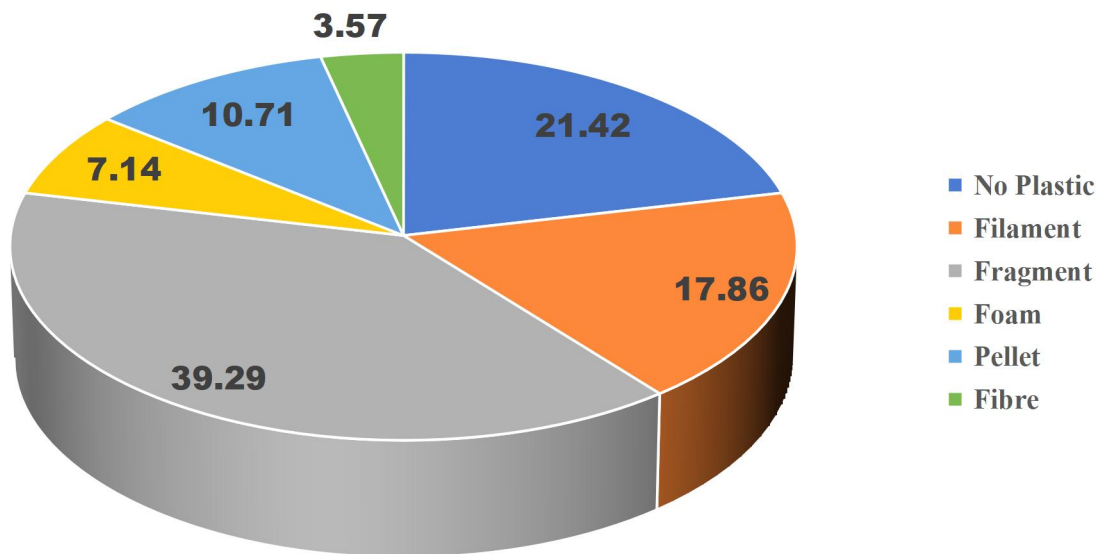


Figure 1: Percent (%) Quota of occurrence of microplastic particles

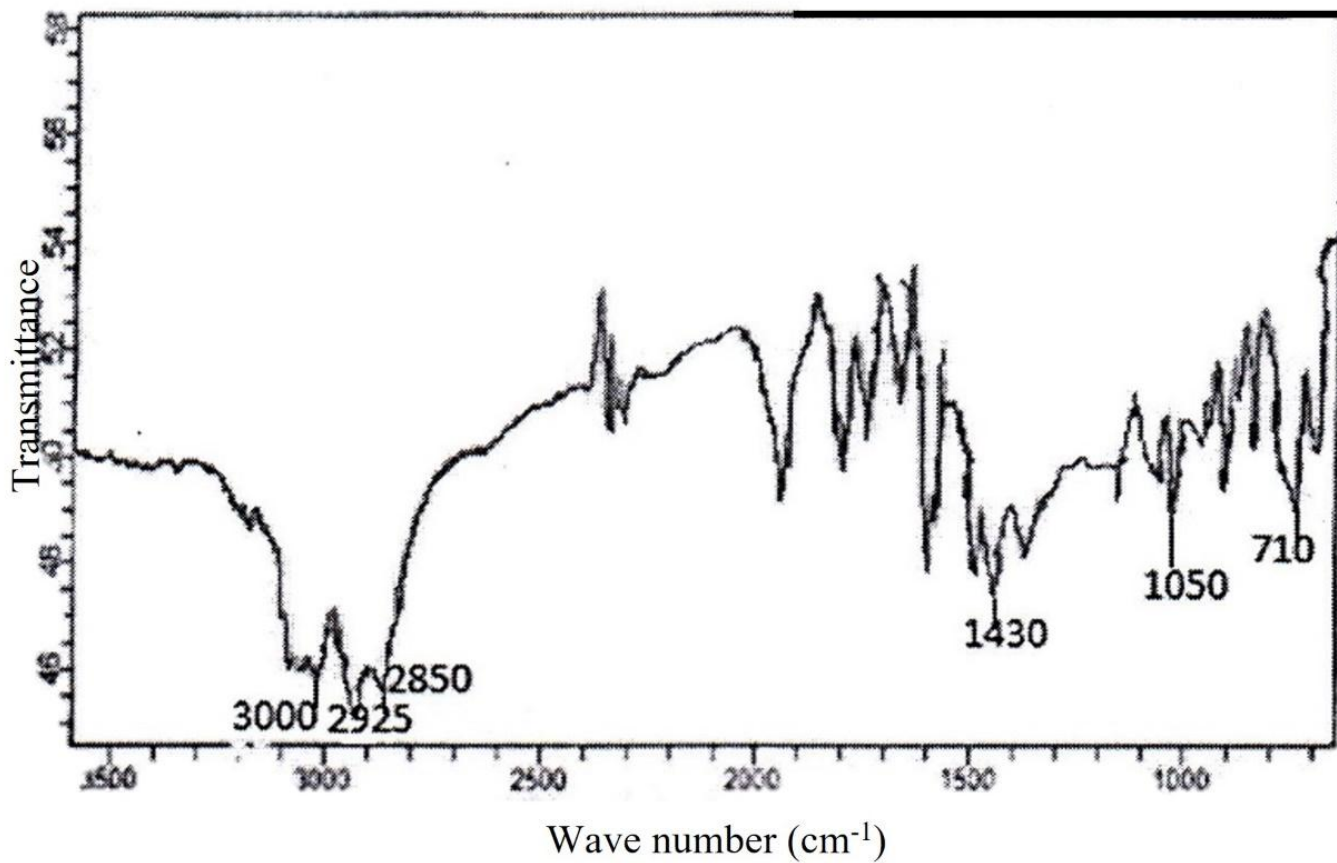


Figure 2: A typical FTIR spectrum for microplastic particles

The FTIR spectrum show absorbance band at different wave number.

There is a peak at 2925cm^{-1} is attributed to absorption of asymmetric CH_2 stretching

There is also a peak at 2850cm^{-1} which is attributed to symmetric Stretching.

A peak at 1430cm^{-1} is attributed to CH_2 scissoring.

There is a peak at 710cm^{-1} is attributed to CH_2 rocking.

The peaks at 2925cm^{-1} , 1430cm^{-1} and 710cm^{-1} are absorbance wave numbers range used to identify polyethylene (PE) compound in FTIR spectrum. Therefore, microplastic of polyethylene was confirmed with these absorption wave numbers

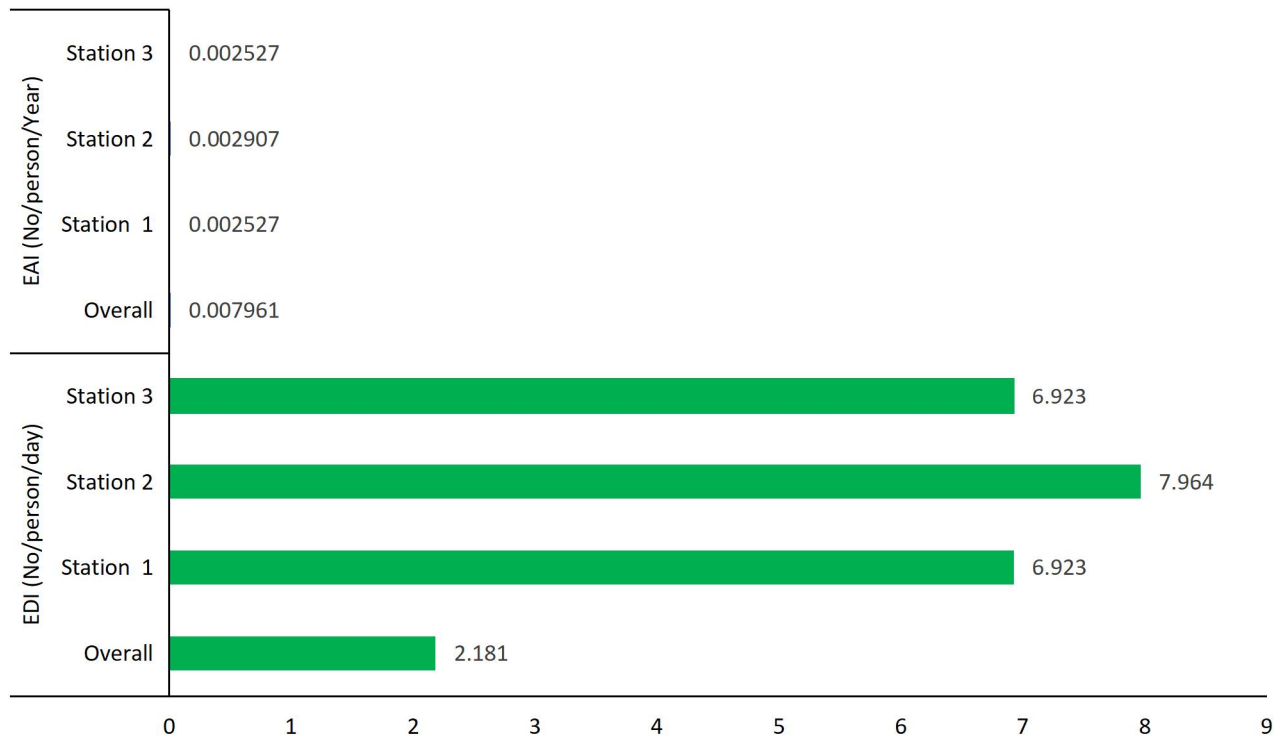


Figure 3: Estimated annual intake (EAI) and estimated daily intake (EDI) values for microplastics

CHAPTER FIVE

DISCUSSION

5.1 Level of Microplastics in *Chrysichthys nigrodigitatus*

Microplastics (MPs) were detected in *Chrysichthys nigrodigitatus* from Ikpoba River, confirming that the species is exposed to plastic contamination in its environment. The mean level of MPs was highest at Station 1, followed by Station 2, and lowest at Station 3. Statistical analysis revealed no significant difference ($p > 0.05$) in the mean levels of MPs between months at each station, indicating a continuous inflow of MPs into the river throughout the sampling period.

The higher concentration of MPs at Station 1 may be linked to its proximity to residential and commercial areas where domestic and market wastes are regularly discharged. In contrast, Station 3, which recorded the lowest MP concentration, is relatively less disturbed by human activity. This pattern supports the findings of Do Amparo et al. (2023), who reported that freshwater systems close to urban settlements tend to have higher microplastic loads due to direct waste inflow and surface runoff.

5.2 Plastic Load (PL)

The plastic load, which represents the total number of microplastic particles found in each fish, was also highest at Station 1, moderate at Station 2, and lowest at Station 3. A significant difference ($p < 0.05$) was recorded between months at Station 1, suggesting temporal variation in microplastic input, possibly influenced by seasonal rainfall or fluctuations in human activities around the river.

The consistently high load at Station 1 indicates that this location receives greater quantities of plastic waste. This may be due to effluents from domestic drains and commercial waste entering the river channel. Similar observations were made by Han et al. (2024), who noted that microplastic concentrations in river systems tend to fluctuate seasonally with rainfall and flooding events that transport land-based debris into aquatic environments.

5.3 Frequency of Occurrence (FO)

The frequency of occurrence (FO) of microplastics in *C. nigrodigitatus* varied among stations, with the highest values recorded at Station 1, followed by Station 3, while Station 2 had the lowest FO. The significant variation ($p < 0.05$) between months at Station 2 suggests that the presence of microplastics there might depend on periodic waste discharges or river flow dynamics.

Generally, the high FO across all stations indicates that microplastic pollution is widespread within Ikpoba River. Abbasi et al. (2024) similarly reported that the presence of MPs in freshwater fishes is becoming increasingly common globally, emphasizing the widespread distribution of plastic contamination even in inland aquatic systems.

5.4 Physical Classification of Microplastics

The physical examination of microplastics revealed five major types: fragments, filaments, fibres, pellets, and foams. Among these, fragments were the most dominant, accounting for nearly half (48.15%) of the total observed particles. The high occurrence of fragments can be attributed to the breakdown of larger plastic materials such as bottles, packaging films, and polyethylene bags due to sunlight and physical abrasion. This finding is consistent with Uchida et al. (2016) and

Kooi et al. (2017), who both explained that fragmentation is one of the main pathways through which macroplastics degrade into smaller, more persistent particles.

The variation in colors, sizes, and shapes of MPs also indicates multiple sources of pollution. The predominance of transparent and colored fragments suggests domestic packaging materials, while the presence of filaments may originate from textile fibres and fishing gear used along the river.

5.5 Polymer Identification Using FTIR

Fourier Transform Infrared (FTIR) analysis confirmed polyethylene (PE) as the most common polymer type found in the samples. The absorption bands corresponded to standard PE spectra, as earlier reported by Unimaya et al. (2023). The dominance of polyethylene is not surprising, as it is one of the most commonly used plastic materials globally, particularly in packaging, disposable containers, and agricultural films (FAO, 2017).

Other polymers such as polypropylene (PP) and polystyrene (PS) were also detected in smaller amounts. These materials are often used in consumer products, food packaging, and fishing equipment. The variation in polymer types supports findings by Abisha et al. (2024), who reported that freshwater fish can accumulate diverse microplastic types depending on local waste composition and hydrological conditions.

5.6 Sources and Distribution of Microplastics

The pattern of MP distribution observed across the three stations suggests that human activity plays a central role in determining contamination levels. The higher values at Station 1 can be attributed to poor waste disposal, open dumping, and stormwater runoff that carries plastic litter into the river. This agrees with Xiong et al. (2023), who noted that rivers near urban areas are

often hotspots for microplastic accumulation due to their role as drainage pathways for solid waste.

The dominance of polyethylene fragments further implies that single-use plastics, such as bags and wrappers, are the major contributors. Hydrological processes like flow velocity and seasonal flooding might also redistribute MPs, resulting in the observed variations between stations.

5.7 Ecological and Human Health Implications

The ingestion of microplastics by *C. nigrodigitatus* may have several ecological and physiological effects. MPs can cause internal abrasions, reduce feeding efficiency, and lead to false satiation in fish, thereby affecting growth and reproduction (Li *et al.*, 2024). In addition, the adsorption of toxic substances such as polychlorinated biphenyls (PCBs) and heavy metals onto microplastic surfaces increases the potential for bioaccumulation in aquatic organisms.

For humans, consuming contaminated fish may result in the indirect ingestion of MPs and their associated toxins through the food chain. Zhu *et al.* (2023) reported that exposure to polyethylene microplastics impaired gonadal development in carp, while Saikumar *et al.* (2024) highlighted the potential health risks posed by continuous exposure to MPs through diet. As a result, the findings from this study point to an emerging health concern, particularly for communities relying on Ikpoba River fish as a protein source.

5.8 Comparison with Other Studies

When compared with results from other regions, the microplastic levels observed in this study fall within the range reported for freshwater systems affected by moderate urban pollution.

Ahmad et al. (2023) found higher concentrations of MPs in fish from Indonesian markets, indicating more severe contamination in regions with intense industrial and municipal waste discharge.

Although the MP concentration in Ikpoba River is relatively lower than that of heavily industrialized rivers, its consistent presence still raises environmental concerns. The similarity of polymer types (mainly polyethylene and polypropylene) across different global studies suggests that single-use plastics are the dominant sources of MP contamination everywhere (FAO, 2021).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

This study was conducted to determine the presence and characteristics of microplastic pollutants in the silver catfish (*Chrysichthys nigrodigitatus*) from the Ikpoba River in Benin City, Nigeria. The research was driven by the growing global concern over microplastic pollution and its potential impacts on aquatic ecosystems and human health, particularly in urban water bodies like the Ikpoba River which are exposed to significant anthropogenic pressure.

The study achieved its three specific objectives:

1. The mean level of microplastics in *C. nigrodigitatus* was determined, with values ranging from 0.0113 to 0.0163 items per gram of fish tissue. The highest concentrations were consistently found at Station 1 (Okhoro Reservoir), indicating a spatial variation in pollution levels linked to proximity to human activities.
2. Physical identification revealed five types of microplastics: fragments, filaments, fibres, pellets, and foams. Fragments were the most dominant (48.15%), suggesting the breakdown of larger plastic items is a primary source. Fourier Transform Infrared (FTIR) spectroscopy confirmed that the predominant polymer type was polyethylene (PE).

3. The frequency of occurrence (FO) of microplastics was high across all stations, reaching 100% at some locations and months, confirming the widespread nature of contamination. The plastic load (PL), or the average number of particles per fish, also varied significantly, with the highest load observed at Station 2 (Upper Lawani) in September.

The findings confirm that *C. nigrodigitatus* in the Ikpoba River is a bio-indicator of microplastic pollution, ingesting these particles likely through its bottom-feeding behaviour. The variation in contamination levels across stations and months underscores the role of local waste disposal practices, surface runoff, and seasonal factors in polluting the river.

6.2 Conclusion

Based on the findings of this study, the following conclusions are drawn:

1. Microplastic Contamination is Widespread: The silver catfish (*Chrysichthys nigrodigitatus*) from the Ikpoba River is contaminated with microplastics. The high frequency of occurrence confirms that ingestion of microplastics is a common phenomenon for this species in this environment.

2. Human Activity is the Primary Driver: The spatial variation in microplastic levels, with the highest concentrations at stations near dense commercial and residential areas (Okhoro Reservoir and Upper Lawani), directly links the pollution to anthropogenic sources such as improper waste disposal and urban runoff.

3. Fragments and Polyethylene Dominate: The dominance of fragments points to the degradation of larger plastic items like bags and packaging as the main pathway of microplastic formation in the river. The prevalence of polyethylene, a polymer commonly used in single-use plastics, further supports this.

4. A Potential Public Health Concern Exists: The confirmed presence of microplastics in an economically important food fish raises concerns about potential human exposure through consumption. This represents a potential pathway for microplastics and associated adsorbed toxins to enter the human food chain.

In essence, the Ikpoba River is a sink for microplastic pollution, and the resident *C. nigrodigitatus* population is actively ingesting these pollutants, thereby posing a potential risk to both the aquatic ecosystem and public health.

6.3 Recommendations

To address the issue of microplastic pollution in the Ikpoba River and mitigate its impacts, the following recommendations are proposed:

1. For Policy and Waste Management:

- The local and state government should strengthen and enforce regulations against improper plastic waste disposal and open dumping, particularly along riverbanks.
- Public awareness campaigns on the dangers of plastic pollution and the importance of proper waste segregation should be initiated within communities bordering the river.
- Investment in improved waste collection infrastructure and the establishment of functional recycling facilities are urgently needed to reduce the amount of plastic waste entering the environment.

2. For Future Research:

- This study should be expanded to include other commercially important fish species in the Ikpoba River to gain a broader understanding of the ecosystem's contamination level.

- Further research is needed to quantify the Estimated Daily Intake (EDI) of microplastics by humans through the consumption of contaminated fish, using local data on consumption rates.
- Investigation into the specific toxicological effects of the ingested microplastics (e.g., heavy metals, persistent organic pollutants) on *C. nigrodigitatus* is recommended.
- A long-term monitoring program should be established to track seasonal and annual trends in microplastic pollution in the Ikpoba River.

3. For Public Health and Community Action:

- Fishermen and communities that depend on the Ikpoba River for food and livelihood should be educated on the findings of this study.
- As a precautionary measure, consumers should be advised to properly eviscerate and clean fish (removing the gut where microplastics predominantly accumulate) before consumption, even though the risk of translocation to muscle tissue requires further investigation.

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