ASSESSMENT OF MICROPLASTIC CONTAMINATION IN ELEPHANT SNOUT FISH (*Mormyrus rume*) FROM IKPOBA RIVER, BENIN CITY, NIGERIA

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UNIVERSITY OF BENIN

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AN UNDERGRADUATE PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.SC.) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY.

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CERTIFICATION

This is to certify that this research titled "**ASSESSMENT OF MICROPLASTIC CONTAMINATION IN ELEPHANT SNOUT FISH (*Mormyrus rume*) FROM IKPOBA RIVER, BENIN CITY, NIGERIA**" was carried out by **"JEROMA JOY OHIAFI"** with matriculation number **"LSC2006950"** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City; in partial fulfillment of the requirements for the award of Bachelor of Science (B.Sc.) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of a Bachelor of Science degree in Environmental Management and Toxicology.

Dr. (Mrs.) I. E. Iyorah-Elliot **Date**

Project Supervisor

Prof. E. T. Aisien **Date**

Head of Department

DECLARATION

I **“JEROMA JOY OHIAFI” declare that “ASSESSMENT OF MICROPLASTIC CONTAMINATION IN ELEPHANT SNOUT FISH (*Mormyrus rume*) FROM IKPOBA RIVER, BENIN CITY, NIGERIA”** is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other university.

______________________ ____________________

Jeroma Joy Ohiafi **Date**

DEDICATION

This project is dedicated to God almighty, and to my wonderful parents Dr. And Mrs. Ohiafi, who I could not have done this journey without.

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ABSTRACT

This study investigates the presence and abundance of microplastic contamination in a commercially important fish species, *Mormyrus rume* from Ikpoba River Benin City. A total of sixteen samples of *Mormyrus rume* (n=16) were collected from three designated stations along the river with the help of artisanal fishermen. The fish samples were then dissected for Gastrointestinal Tract (GIT) removal. The Gastrointestinal Tract was digested for microplastic extraction and density gradient techniques were used to isolate microplastic. The polymer composition of microplastic was confirmed using Attenuated Total Reflectance- Fourier Transform infrared (ATR-FTIR) spectroscopy. The result showed that samples from station 3 had the highest microplastic contamination, with an abundance of 40.53% while samples from station 1 had the least with an abundance of 26.63%. A total of eight plastic polymers were identified, polyethylene terephthalate (PET), polyethylene (PE), polyamide (PA), polyurethane (PU), polypropylene (PP), polystyrene (PS), polycarbonate (PC), and polyvinyl chloride (PVC). The polymer count was recorded in an increasing order of PET>PP>PA>PE>PS>PU>PC>PVC across all the stations. This study confirms the presence and abundance of microplastics in fish samples and indicate that fish from the river may pose human health risks to consumers due to bioaccumulation and biomagnification. The findings emphasize the need for better waste management practices, public awareness and improved urban drainage systems.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Recent years have seen the rise of microplastic pollution in aquatic systems as a serious and perturbing environmental issue (Aunurohim *et al*., 2024). Microplastics have a particularly negative effect on freshwater ecosystems, which are essential to human life and biodiversity on Earth because they supply drinking water, irrigation, maintain ecological balance, and allow for the survival and reproduction of innumerable species. Compared to marine ecosystems, studies on microplastics in freshwater environments started relatively recently, yet, it has been demonstrated that microplastics are common in freshwater rivers and lakes across the globe (Horton *et al*., 2017; Adeogun *et al*., 2020; Shi *et al*., 2024). Microplastic can be defined as artificial polymers and plastics with a diameter smaller than 5mm (Prusty *et al*., 2023). They are categorized into primary microplastics, which are purposefully made from microbeads for industrial uses, and secondary microplastics, which originate from the gradual breakdown of larger plastics under different physical and chemical conditions in the environment (Joalosho *et al*., 2025). Microplastics can be divided into five main categories based on their shape and industrial manufacturing, these include films, pellets, fragments, fibers, and foams.(Anderson *et al*., 2017). Films are thin plastic sheet commonly derived from plastic bags and packaging materials, pellets are small spherical particles often used as raw materials in plastic production, fragments originate from the the breakdown of larger plastic items, fibers are mainly released from synthetic textiles and fishing materials, while foams are lightweight porous particles produced from materials such as polystyrene. (Prabhu *et al*.,2022; Hu *et al*.,2022).

Microplastics greater propensity for bioaccumulation and biomagnification, exacerbates the problem posed to the environment and living organisms. Their significantly small size, buoyancy, and long-term environmental durability enable them to accumulate in environmental matrices such as sediments, water columns, and living organisms, leading to their widespread global dispersion (Horton *et al.*, 2017; Ashrafy *et al.*, 2023). Microplastics can be dangerous to consumers because they are easily consumed, bioaccumulate, and spread throughout the food chain. The life cycle of aquatic species may be disrupted in freshwater ecosystems by the trophic transfer of microplastics from primary producers to herbivores (Mariani *et al.*, 2023). In addition to serving as transporters for chemicals or viruses and inflicting direct physical harm through plastic shards, microplastics can leach harmful chemical components (Shi *et al.*, 2024). Microplastics bioaccumulate in aquatic animals when consumed, causing physical issues such gastrointestinal obstructions, decreased mobility, and tissue abrasions that diminish feeding efficiency and stunt growth (Bhuyan, 2022). Furthermore, the buildup of microplastics on appendages like furca, antennae, and swimming legs further limits movement and causes major behavioral abnormalities (Bhuyan, 2022).

There are three main ways that microplastics can enter and build up in the human body: ingestion (from eating seafood), inhalation (from air entering the lungs), and dermal (from coming into contact with the skin). Of these, ingestion is the most common and significant (Sharma and Chatterjee, 2017). Hormonal imbalances, cognitive and reproductive difficulties, developmental issues, and possibly an elevated risk of some types of cancer in exposed populations are some of the possible health hazards associated with this (Oehlmann *et al.*, 2009). In addition, exposure to microplastics can cause oxidative stress, in which cells and tissues are damaged by reactive oxygen species (ROS), metabolic disorders, which can interfere with normal bodily functions, immunological responses, which can cause inflammation, neurotoxicity, which affects the nervous system and brain function, reproductive problems. and developmental toxicity, especially in offspring (Bhuyan, 2022).

Given their closer proximity to human habitation than the ocean, freshwater and terrestrial ecosystems are unquestionably more susceptible to high amounts of plastic litter (Tang *et al.*, 2021). This is especially troubling because plastics, particularly microplastics, are widely introduced into marine ecosystems through both freshwater and terrestrial habitats (Horton *et al*., 2017).

Current global evidence shows that microplastics enter freshwater ecosystems through multiple pathways, including stormwater runoff, industrial effluents, fishing activities, wastewater discharges, and the degradation of larger plastic materials (Talvitie *et al.,* 2015; Horton *et al.,* 2017; Tibbetts *et al.,* 2018; Guo *et al.,* 2024). Once introduced into aquatic environments, microplastics undergo several processes such as fragmentation, biofouling, aggregation, and sedimentation, which influence their transport, distribution, and environmental fate. Heavier particles and aggregated microplastics often settle into sediments, where they may persist for long periods and become resuspended during flooding or storm events. In contrast, lighter and more buoyant polymers can remain suspended in the water column and disperse over wider areas (Zhu *et al.,* 2024). These processes increase the availability of microplastics across different aquatic habitats, including both benthic sediments and pelagic zones, thereby enhancing their potential for uptake by aquatic organisms.

Freshwater fishes form one of the critical bioindicators of the microplastic pollution among aquatic organisms since they serve as an essential component of food webs and comprise numerous trophic positions (De Araujo *et al*., 2025). Fish consume microplastics on a large scale, according to numerous studies; the most common forms found are fibers and pieces, which are frequently connected to textile laundry and packaging materials (Wang *et al*., 2020; Dalu *et al*., 2024; Horton *et al*., 2024; Munno et al., 2024). Since freshwater fish are a staple diet for millions of people worldwide, especially in underdeveloped countries, the presence of microplastics in them poses environmental and public health problems (De Araujo *et al*., 2025). Developing countries like Nigeria have limited data on the presence, types, and concentration of microplastics in freshwater and marine fish species. This data gap makes it difficult to develop national policies and mitigation strategies. Establishing baseline data in cities like Benin City help assess pollution levels, identify sources and track changes over time. Therefore, investigating the prevalence of microplastics in freshwater fish is very vital as it helps assess pollution levels and potential risks to human health

1.2 Aim and Objectives of the study

The aim of the study is to determine the occurrence of microplastic contamination in Elephant Snout Fish (*Mormyrus rume*) from Ikpoba River, Benin City.

The objectives are to:

1. To determine the differences in microplastic contamination at different sites along the river
2. To identify the types of microplastic polymers present in fish samples.
3. To determine the concentration of microplastic contamination in the fish species

1.3 Justification of the study

Developing countries like Nigeria face greater risks of microplastics pollution due to the poor waste management practices, indiscriminate disposal of plastics and limited environmental monitoring programs. The Ikpoba River, a key source of water, food and livelihood to people in Benin City, is exposed to constant supply of domestic, industrial, and municipal waste, rendering it very vulnerable to microplastic contamination. The Elephant Snout fish (*Mormyrus Rume*) is an economically important fresh water fish commonly consumed by residents of Benin City. Studying the presence and concentration of microplastics in this species is crucial for understanding the level of contamination in the local aquatic food web and assessing potential risk to human consumers. There is currently limited data on microplastic pollution in fish species from Ikpoba River, this study provides data on the occurrence, types, and distribution of microplastic in fish from Ikpoba River.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Microplastics mainly originate from land-based sources (e.g., personal care products, cosmetics, synthetic clothing, tourism, and industrial activities) and sea-based sources (e.g., transportation, fishing, and shipping) (Browne *et al*., 2010; Foo *et al*., 2022). They are highly persistent and have gradually contaminated every facet of aquatic ecosystems, including the food chain and biota, across multiple trophic levels, such as crustaceans (Zhang *et al*., 2019), fish, and mammals (Lusher *et al.*, 2015; Nelms *et al*., 2018). The ingestion of Microplastics by fish poses risks, causing physical harm and internal blockages and altering feeding behavior, reproduction, and growth patterns in organisms (Gall and Thompson, 2015; Guzzetti *et al.*, 2018). Studying microplastic contamination in fresh water fish species like *Mormyrus rume is* important for assessing environmental health, protecting public health, understanding ecological impact and strengthening scientific knowledge and pollution control measures in fresh water systems.

2.1 Biology of the Elephant Snout Fish (*Mormyrus rume*)

The Elephant snout fish (*mormyrus rume*) commonly called 'long mouth fish' is a tropical fresh water fish and it is among the important commercial fishes found in Ikpoba River, Benin city, Nigeria. It belongs to the family Mormyridae commonly known as elephant fishes due to their elongated snouts and electrosensory capabilities, from the order Osteoglossiformes and are found in freshwaters of tropical Africa (Greenwood *et a*l., 1966). It has two subspecies *Mormyrus rume rume* which is distributed in the west African Chad system and *Mormyrus rume proboscirostris* which is distributed in the middle and upper Congo River

2.1.1 Morphology of the Elephant Snout Fish (*Mormyrus rume)*

One of the largest species in its genus, *Mormyrus rume* can reach standard lengths of 90–100 cm and weights of over 5 kg. In the wild, they typically reach adult sizes of 60–80 cm standard length (Nicole *et al.,* 2019; Froese and Pauly, 2024). Its fusiform appearance and elongated laterally compressed body facilitate effective mobility in riverine habitats (Hopkins *et al*., 2007). The eyes are comparatively small and positioned laterally on the smoothly curved head. The fish uses its electric organ in the caudal peduncle, which produces weak electric fields for navigation, communication, and prey detection, rather than vision as its primary sense (Moller *et al*., 2004). One of its most distinguishing characteristics is its small yet thick snout, which resembles a truncated tube and gets more noticeable as the fish gets older. The sub-terminal (inferior) mouth is comparatively small and situated beneath the snout on the bottom of the skull. This characteristic is an adaptation for benthic invertebrate bottom feeding (Froese and Pauly, 2024).

The anal fin has 16–21 soft rays, but the dorsal fin is long and has 72–95 soft rays (Hopkins *et al*., 2007). The caudal fin is forked and well developed enabling fast and agile swimming. The anal fin is notable for being longer in base length than the dorsal fin which distinguishes it from other *Mormyrus* species. In adult males the anal fin may show modifications such as indentation or thickening at the base, used in reproductive behaviour (Moller *et al*., 2004). The body is covered in small smooth scales along the lateral line. There are 20-26 scales around the caudal peduncle. The colour of the dorsal side is usually olive-brown or greyish fading to a lighter silvery or whitish ventral surface. The two subspecies of *Mormyrus rume* are often recognized based on location found and appearance. *Mormyrus rume rume* is common in West Africa basins, it has a shorter snout and slightly darker body coloration while *mormyrus rume proboscirostris* is found mainly in Congo basins and is distinguished by a longer more tabular snout resembling a proboscis (Hopkins *et al*., 2007; Scharpf and Lazara, 2025)

2.1.2 Physiology of the Elephant Snout Fish (*Mormyrus rume)*

The elephant snout fish's special electroreceptive sense helps it survive in murky, turbid freshwaters with a high organic content (Worm *et al.*, 2017). In local fisheries, it is frequently one of the most prevalent species of mormyrids (Olopade, 2013; Souleymane *et al*., 2024). Although the species is active and catchable all year round, its abundance may vary seasonally. It has been found that it is more active in the rainy season as it falls in line with seasonal floods, which provide the perfect environment in which the larvae develop and spawn (Alhassan, 2014; Fadekemi, 2018). In adults, the sex ratio is skewed towards the female gender where the ratios are about 1:2-1:3 males to females. The females are also rather fruitful, and the mature fish bears an average of 4,000 to 30,000 eggs (Fadekemi, 2018). *Mormyrus rume* is a benthic omnivore, which feeds primarily on detritus, insect larvae, and small aquatic invertebrates (Odedeyi and Fagbero, 2010). It possesses a small ventrally located mouth which is best adapted to bottom feeding, and uniquely adapted to benthic foraging. It also has a little longer trunk that it uses to search for prey in the silt (Krischbaum, 2000). It makes use of electric organ discharges (EODs) for electrolocation and electrocommunication. It produces weak electrical pulses from an organ located in the caudal penduncle. These pulses form an electric field that enables the fish detect nearby objects and preys (Carlson and Hopkins, 2004). The skin has electroreceptors to determine this change even in total darkness (Worm *et al.*, 2017). The fish is primarily nocturnal and uses its electric sense to forage effectively at night or in murky waters where vision is minimal (Sukhum *et al*., 2018).

2.2 Microplastic Pollution in Aquatic Systems

2.2.1 Sources of Microplastics in Aquatic Systems

Microplastics can enter the aquatic system through varying amount of ways. These sources are grouped into two major categories which are primary and secondary sources. Together these sources ensure that microplastics are continuously supplied to freshwater, marine and even polar environment where they accumulate and persist.

2.2.1.1 Primary Sources

Primary microplastics are plastic particles measuring <5mm intentionally manufactured or directly released, designed to be small in size rather than formed from the breakdown of larger plastics. Synthetic textile microfibres which are shed during washing and wearing of clothes made from polyester, nylon, acrylic etc. One wash can release hundreds of thousands of fibres (De Falco *et al.*, 2019). Globally, textiles are estimated to contribute about 35% of primary MPs in the oceans (Boucher and Friot, 2017). Tyre and road wear particles which are generated by abrasion of tyres (synthetic rubber) and road marking paints. Washed into rivers via stormwater runoff are considered the second largest source globally (Boucher and Friot, 2017). The pre-production pellets used as feedstock in the plastics industry are called plastic pellets, or nurdles. Nurdles are among the most prominent sources of MP contamination due to the many spills that occur during handling and transportation (Andrady, 2011). Microbeads found in cosmetics and personal hygiene goods, such as polyethylene or polypropylene beads used in toothpaste, scrubs, and other exfoliating items. Although prohibited in most nations, it remains a source with lax laws (Osman *et al*., 2023).

2.2.1.2 Secondary Sources

The physical, chemical, and biological breakdown of macroplastics (>5 mm) into smaller pieces results in secondary microplastics. Under the influence of sunlight (UV radiation), waves, and abrasion, plastic packaging and single-use plastics such as bottles, bags, wrappers, and other litter decompose into MPs (Andrady, 2011). Fishing nets, lines, ropes, and other aquaculture and fishing equipment can be misplaced or abandoned, which causes them to fragment over time and produce MPs (Yang *et al.*, 2021). Degraded shoes, containers, and construction plastics are examples of household and industrial plastic products that might discharge MPs into wastewater streams and stormwater (Osman *et al*., 2023). One of the main sources of secondary microplastics in aquatic systems are littering, insufficient waste management systems, and plastic debris from landfills (Laskar and Kumar, 2019). Also, agricultural plastics such as mulching films, irrigation pipes, and greenhouse covers degrade and contribute MPs that are transported into rivers via runoff.

2.2.2 Distribution of Microplastics in Aquatic Systems

2.2.2.1 Microplastics in Freshwater Systems

Around the world, microplastics have been found in rivers, lakes, and reservoirs; the amounts in various freshwater habitats vary greatly. Population density and the degree of commercial and industrial activity are two variables that can affect the abundance of microplastics (Mohan and Lakshmanan, 2023). In general, freshwater ecosystems in urbanized areas have unquestionably higher MPs than rural water bodies (Tibberts *et al*., 2018). The effects of microplastics on freshwater environments are especially significant because freshwater ecosystems are essential to human life and biodiversity on Earth because they supply industrial, drinking, and irrigation water, maintain ecological balance, and allow for the survival and reproduction of innumerable species (Shi *et al*., 2024).

Complex hydraulics, such as flow velocity and turbulence, as well as environmental and hydrological factors, such as riverbed morphology, sediment coarseness, and the relative sizes of sediment grains and microplastics, all affect the movement and retention of MPs in freshwater environments (Hoellein *et al*., 2019; Corcoran *et al*., 2020; Yu *et al*., 2022). Lakes, lagoons, dams, meanders (separated from rivers and streams), creeks, and floodplains are examples of freshwater systems with low flow velocities where elevated amounts of microplastics have been found (Watkins *et al*., 2019; Chico-Ortiz *et al.,* 2020). While high-flow rivers move MPs downstream into estuaries and coastal regions, slow-flowing or stationary systems like lakes, reservoirs, and wetlands typically hold onto MPs for longer (Eerkes-Medrano *et al.*, 2015).

Size and density are the main factors influencing MP dynamic behavior under quiescent settings; larger and denser MP settle more quickly and have greater retention rates (Khatmullina and Isachenko, 2017). MPs are exposed to a wide range of dynamic transport processes (such as diffusion, advection, and mixing) as well as numerous external climatic impacts (such as precipitation, wind exposure, and different chemical and biological activity) after being discharged into freshwater systems. Surface waters, sediments, and aquatic life all include microplastics; sediments often exhibit greater accumulation because of particle settling and biofilm attachment (Eerkes-Medrano *et al.*, 2015). In rivers and lakes, fibers, primarily from synthetic textiles are most prevalent, followed by pieces and films made from packaging materials (Free *et al*., 2014; Horton *et al*., 2017).

Urban runoff, industrial discharge, wastewater effluents, and improperly managed plastic trash are the primary sources of freshwater microplastics (Horton *et al*., 2017). Wastewater treatment facilities have been found to be important contributors to large volumes of MPs being discharged into the rivers despite tertiary treatment (Talvitie *et al*., 2015). As a small fraction of the coastal plastic is transported into the ocean by rivers (estimated at 2.818.6 per cent), rivers play an important role in the transportation of plastic debris on land to the ocean (Lebreton *et al*., 2017). Recent studies suggest that atmospheric deposition is also a significant contributor to MP contamination of freshwater systems, especially in the case of fibres (Allen *et al*., 2019). This is why MPs have been detected in remote freshwater lakes in the Arctic and the highlands, where there is no source of pollution (Bergmann *et al*., 2019).

2.2.2.2 Microplastics in Marine Systems

Sources and sinks of microplastics are surface waters, the water column, shorelines, coastal sediments, continental shelf and deep-sea sediments, polar sea ice and marine creatures, and they are ubiquitous in the marine environment (Browne *et al*., 2011; Eriksen *et al*., 2014; Woodall *et al*., 2014). The primary source of ocean pollution on the global level is plastic waste, transported by the ever-shifting rivers out of the cities and the depths of the interior and often thrown into the waters. An estimated 8 million tons of plastic debris are dumped into the ocean each year (Jaikumar *et al.,* 2025).

Subtropical gyres are oceanic convergence zones where currents and wind-driven transport cause accumulation of floating microplastics, such as garbage patches (Cózar *et al.*, 2014; Law *et al.,* 2014). Coastal shorelines and estuarine environments are widely recognized as major hotspots of microplastic pollution because of their close proximity to land-based pollution sources such as urban runoff, sewage discharge, stormwater inputs, and poorly managed solid waste. Microplastics are not confined to the water surface; instead, they are distributed throughout the water column due to turbulent mixing, biofouling, aggregation with organic matter, and differences in particle shape and density. As a result, fibers and fragments can accumulate in large quantities within bottom sediments, including continental slopes and deep-sea environments (Woodall *et al.,* 2014). Fragmented plastics and films, which mainly originate from packaging materials and the breakdown of larger plastic debris, are commonly detected in surface waters and coastal litter surveys. In contrast, fiber-type microplastics, largely derived from textiles and sewage effluents, are more frequently reported in sediments and aquatic organisms. Whether particles float, suspend, or sink is determined by particle density, biofouling rates, and hydrodynamics (Browne *et al.,* 2011; Woodall *et al.*, 2014).

2.2.2.3 Microplastics in Polar Systems

Microplastics have been documented across the full range of polar compartments, sea ice, snow, surface and subsurface seawater, sediments, and biota, demonstrating that even the Earth’s most remote marine regions are not free from plastic contamination (Obbard *et al.*, 2014; Peeken et al., 2018). Sea ice in particular acts as a temporary reservoir, concentrating particles that were scavenged from seawater during ice formation. When that ice melts, stored microplastics can be released back into the marine environment (Peeken *et al*., 2018; Kanhai *et al*., 2020). Polar microplastics arrive via multiple pathways including long-range oceanic transport (advected by currents and Atlantic/Pacific inflows), atmospheric transport and wet deposition, local sources (shipping, fishing, research stations, tourism), and ice-rafting of debris (Bergmann *et al*., 2019).

2.3 Effects of Microplastics Contamination

2.3.1 Effects of Microplastic Contamination on Aquatic Organisms

One of the most immediate effects of microplastic contamination on aquatic organisms is physical injury. Filter feeders mussels, copepods and oysters easily consume microplastics since they have a size comparable to that of natural food particles (Setälä *et al*., 2014). Consumption may cause gut obstruction, internal abrasion, and false satiety, thus lowering the feeding behavior and causing malnutrition (Wright *et al*., 2013). In crustaceans and fish, MPs may build up in the gut, disrupting the digestion and energy absorption process, thus causing reduced growth and reproduction (Lu *et al*., 2016; Barboza *et al*., 2018). Moreover, microplastics that have an irregular or sharp edge can cause physical damage to epithelial tissues, particularly gills and digestive linings (Avio *et al*., 2015).

Microplastics are capable of causing oxidative stress and impairment of biochemical homeostasis. Microplastics exposure causes overproduction of reactive oxygen species (ROS), which causes oxidative damage to lipids, proteins, and DNA (Zhang *et al*., 2019). MPs in zebrafish (*Danio rerio*) have been associated with an augmented antioxidant enzyme action and lipid peroxidation, which are indicators of oxidative stress reactions (Lu *et al*., 2016). Toxic additives and adsorbed contaminants like heavy metals, persistent organic pollutants (POPs), and polycyclic aromatic hydrocarbons (PAHs) can be carried by MPs, thus increasing their toxicity further (Rochman *et al*., 2013). These sorbed chemicals may be desorbed in the digestive system resulting in chemical toxicity and accumulation of the chemicals in tissues (Bakir *et al*., 2014).

Exposure to microplastic has adverse impacts on reproduction and embryonic development of most aquatic organisms. MPs have been detected to decrease the egg and sperm development in the oyster (Crassostrea gigas), which in turn decreases fertilisation (Sussarellu *et al*., 2016). Equally, in fish, the exposure to MPs has led to a decrease in gonadal development, lowered fecundity, and disturbed sex hormone levels (Rochman *et al*., 2014). Organisms exposed to nano-sized plastics have been found to develop developmental abnormalities, delayed hatching, and lower larval survival, and can cross cellular boundaries and be found in embryonic tissues (Mattsson *et al*., 2018).Exposure to MPs may result in a decreased feeding efficiency, poor predator avoidance, and abnormal swimming behavior in fish, which is probably caused by neurotoxicity (Mattsson *et al*., 2017; Barboza *et al*., 2018). Reduced levels of acetylcholinesterase, a neuro-important enzyme, have been linked to neurobehavioral changes, indicating the possibility of neurotoxicity of MPs and their additives (Kirstein *et al*., 2016). These disturbances in behaviour can amplify the risk of predation and decrease the survival in the natural environments.

Microplastics may be transported through the food chains through trophic transfer and therefore it is dangerous to the higher trophic organisms, such as human beings. Small fish and zooplankton consume the MPs and they are passed on to predators who in turn feed on them (Farrell and Nelson, 2013). MPs are passed on to predators, accumulating in the higher organisms (Batel *et al*., 2016). The toxicological effects of associated contaminants, including PCBs and PAHs, may also increase along the food chain, increasing their toxicological effects (Rochman *et al*., 2013). Microplastics serve as carriers of other environmental pollutants such as metals, antibiotics and perfluoroalkyl substances (PFAS). Plastics are hydrophobic, which means they can adsorb high concentrations of pollutants, which can be subsequently released into organisms when ingested (Bakir *et al*., 2014; Wang *et al*., 2020). PFAS and microplastics demonstrate synergistic toxicity, such as decreased reproduction and growth in aquatic invertebrates, such as Daphnia magna (Soltanighias *et al*., 2024).

2.3.2 Effects of Microplastic Contamination on Aquatic Ecological Processes

Microplastics affect basic water quality parameters, including turbidity, penetration of light, and oxygen. The floating pieces of plastic may decrease the amount of sunlight reaching the surface, thus inhibiting photosynthesis of phytoplankton and submerged aquatic plants (Nizzetto *et al*., 2016). This decrease in primary productivity may be transmitted via the food web and less energy is available to higher-trophic species (Andrady, 2011). Furthermore, microplastics tend to release additives and products of degradation like bisphenol A (BPA), phthalates, and flame retardants, which can elevate chemical oxygen demand (Rochman *et al*., 2013).

Microplastics clog the sediments and coastal areas, changing the organization and activity of the benthic environment (Nizzetto *et al*., 2016). In ecosystems with sediment dwellers, MPs may alter the porosity, permeability, and oxygen diffusion of substrate, which influences microbial processes, and bioturbation (Green *et al*., 2016). The changes may impede nutrient recycling, denitrification, and organic matter decomposition (Zhang *et al*., 2019). Moreover, benthic organisms, including worms, clams, and crustaceans, ingest or interact with microplastics during feeding or burrowing and may be physically harmed, not able to feed effectively and have lower population densities (Wright *et al*., 2013). With time, the build-up of MPs in sediments may change the species composition, as tolerant or opportunistic taxa may be favoured against sensitive ones (Green *et al*., 2016).

Microplastics can easily get into the aquatic food webs by getting digested by planktons, filter feeders, and small fish (Cole *et al*., 2011; Setaela *et al*., 2014). When primary consumers consume MPs, they can be passed on to higher trophic levels via predation (Farrell and Nelson, 2013). The effect of this trophic transfer is that it leads to the bioaccumulation of plastics and other harmful chemicals in larger organisms, such as commercially significant fish species and marine mammals (Batel *et al*., 2016). The breakage of the feeding and energy flow may undermine the trophic interactions, decrease the resilience of the population, and eventually result in the decrease of the biodiversity. Moreover, the consumption of microplastics by the keystone species (e.g., zooplankton or bivalves) may change the stability of the whole food webs, since they are crucial to nutrient cycling and energy transfer (Rochman *et al*., 2014).

Microplastics are used as artificial surfaces of microbial colonisation and they develop distinct biofilms known as the plastisphere (Zettler *et al*., 2013). Heterotrophic bacteria, algae, and even pathogenic microorganisms that are very different than natural microbial assemblages are often present in these biofilms (Kirstein *et al*., 2016). The formation of plastisphere communities has the potential to change the local nutrient processes by changing the intensity of decomposition and changing carbon, nitrogen, and phosphorus cycling (Amaral-Zettler *et al*., 2020).

Moreover, MPs impact on key aquatic environments of the coast such as nearshore wetlands, mangroves, as well as remote deep-sea habitats. The impacts of the MPs on coral reefs are caused in many ways among which include: smothering, crushing and breaking off parts of coral. Also, they encourage the growth of algae, which also competes with corals (Nama *et al*., 2023). Other vital marine ecosystems, such as mangroves and seagrass beds, which are nursery habitats and shoreline defense, are also threatened by microplastic pollution, which undermines their vital roles (Corinaldesi *et al*., 2021).

2.3.3 Effects of Microplastic Contamination on Human Health

The major route of exposure is through ingestion since microplastics are found in seafood, drinking water, salt, and other foods. After absorption, they can lead to the inflammation of the gut wall, intestinal microbiota disruption, and nutrient absorption (Sun *et al*., 2023). In animal models, smaller particles are capable of penetrating the intestinal barrier into the blood and settling in the liver and kidney, where they cause oxidative stress and immune responses (Li *et al*., 2023). Microplastic fibres suspended in the air are an increasing concern, particularly within the indoors and industrial settings. The inhaled particles may cause irritation of the respiratory tract and trigger oxidative stress and inflammation which can worsen the conditions like asthma and bronchitis (Lee *et al*., 2023). Excessive exposure may lead to fibrosis and damage the lung capacities in the long term. Nanoplastics have the potential to enter the circulatory system and induce endothelial damage and lipid imbalance, which can put cardiovascular risk at risk (Bai *et al*., 2024).

Microplastics and their additives (e.g., bisphenol A, phthalates) have endocrine-disrupting properties that can interfere with hormonal balance, these substances may reduce fertility and alter embryonic development (Alqahtani *et al*., 2023). MPs release toxic pollutants such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and dichlorodiphenyl-dichloroethylene (DDE) (Laist, 1997; Teuten *et al*., 2009). These toxic organic chemicals accumulate in marine organisms, subsequently entering the human food chain (Ma *et al.*, 2019). Consumption by humans can lead to chronic inflammation , potentially damaging DNA and increasing the risk of cancer development (Park *et al.*, 2020).

2.4 Previous Studies on Microplastic Contamination

2.4.1 Previous Studies in Nigeria

Idowu *et al*. (2024) examined microplastic contamination in the river water, sediments, and fish species of the Osun River, Nigeria. At a maximum of 22,079 ± 134 particles/litre, the abundance of microplastics in the river water samples was the highest reported for river water worldwide. Seven polymer compounds that have not been frequently reported for river environments were identified by FTIR investigations, including ethylene vinyl acetate (EVA) and acrylonitrile butadiene styrene (ABS). In the gastrointestinal tract (GIT) of six fish species examined, microplastic concentrations ranged from 407 ± 244 to 1691.7 ± 443 particles, with the greatest concentration found in silver catfish (*Chrysichthys nigrodigitatus*). Fish levels are comparable to several other plastic pollution hotspots in Africa, but greater than those recorded for fish in Asia and Europe.

Akinhanmi *et al.* (2024) carried out a study to assess the molecular damage due to microplastic accumulation in the liver of four commercial fish species *(Oreochromis niloticus, Chrysichthys nigrodigitatus, Clarias gariepinus, and Gymnarchus niloticu*s) from the Lagos lagoon. The findings showed that the MP load in the fish species' livers varied from 7.2 ± 1.9 to 9.5 ± 4.4 particles/individual, with G. niloticus exhibiting the highest concentration. The Fourier Transform Infrared spectroscopy showed that polyethylene dominated the polymeric polymers, although the extracted MPs were primarily blue and black fibers. According to their study's findings, microplastic contamination in fish tissues may worsen cellular toxicity in commercially available biota in the Lagos Lagoon, necessitating immediate action to reduce microplastic and eventually plastic pollution.

Adeogun et al. (2020) conducted a study to identify and test for microplastics in the stomachs of fish species that are supplied commercially from Eleyele, a municipal water supply lake in southwest Nigeria. A total of 109 fish samples of eight (8) species were collected during the period between February and April 2018: *Coptodon zillii* (CZ: n = 38), *Oreochromis niloticus* (ON: n = 43), *Sarotheron melanotheron* (SM: n = 19), *Chrysicthys nigrodig* The content of the fish stomach was examined using a fluorescence microscope after being screened against MPs using the density gradient separation technique (NaCl hypersaline solution). MPs were present in all species screened except H. fasciatus and a positive rate of 69.7% in the species being investigated. The highest MP prevalence was found in ON (34%), followed by CZ (32%), SM (13%), CN (6%), and LN (5%). The mean number of MPs per specie was 1-6, with the size of the MPs going down to 124 ug to 1.53 mm. A. SM however, had the highest number of MPs in the stomach (34). Habitat, feeding style, and trophic levels were ecological variables, which were identified to be significant factors that can influence and determine uptake of MP among fish population through principal coordinate analysis (PCA). Unlike the demersal species (PO, CN, HO and LN), PCA showed that fish habitat, feeding mode and trophic level and MP size and number showed a higher correlation between benthopelagic species (ON, CZ and SM).

Ilechukwu *et al*. (2021) carried out a study into the consumption of microplastics by silver catfish (*Chrysichthys nigrodigitatus*) from the Niger Delta's New Calabar River. A total of 45 individuals were sampled with their gastrointestinal tracts between June and August 2019 and were digested with 10% KOH to remove organic materials, and the residues were examined using a microscope. Microplastics were found in about 56% of the samples and were mainly in the form of pieces with an average of 3.87±5.97 particles per fish. This study brings out the impacts of plastic pollution in freshwater systems and the potential danger of this pollution to aquatic and human life.

Olanipekun *et al*. (2024) carried out a study to investigate the presence of microplastics (MPs) contamination in surface water and two fish species (*Clarias gariepinus* and *Oreochromis niloticus*) in Owe River. One Litre (1L) of water samples were collected from four different locations along the river, samples were digested to remove organic matters. Eighteen (18) numbers of fishes were collected for each species. Samples collected were dissected and the guts digested with 10% Potassium hydroxide and 10% Hydrogen Peroxide. For every species, eighteen (18) fish were gathered. After the samples were dissected, 10% potassium hydroxide and 10% hydrogen peroxide were used to digest the guts. Fish samples and digested water were both filtered by a vacuum filtration device utilizing a 0.45µm membrane. After that, the filter papers were examined under a digital microscope to identify MPs. The guts of both fish species included 104 items in total, with an average of 4.33 ± 1.71 and 1.44 ± 0.70 items per individual for *Clarias gariepinus* and *Oreochromis niloticus*, respectively. Compared to other MPs forms found, fiber was shown to be predominant in fish species. The water samples had an MP abundance of 1898± 198.34 Items/L, ranging from 203 ± 50.64 to 724.33 ± 129.89 Items/L. The majority of MPs found in river water samples were pieces. Four (4) plastic polymer species were identified using attenuated total reflectance–Fourier transform infrared (ATR–FTIR) spectroscopic studies; polyethylene (PE) and polypropylene (PP) together accounted for 82% of the plastic particles.

Doherty *et al*. (2024) carried out a cross-regional survey aimed to assess the abundance, distribution, and composition of MPs in fishes, sediment, and water from inland rivers across Nigeria's six geopolitical zones. Samples were collected from selected rivers in each geopolitical zone (Rivers Yauri, Benue, Argungu, Jamare, Ogun, Ethiope and Orashi). MPs were isolated using a combination of filtration, density separation, and visual identification. MPs abundance, distribution, shapes, colors, and chemical composition were determined using microscopy and Fourier transform infrared spectroscopy. Fibers were the most prevalent shape in both the water and fish samples, according to their study, which also found that the composition and abundance of MPs differed among the various sample types. PET, PP and PE were the most prevalent types of plastics in fish samples, and PE/PA/Nylon, PVA, and PVC were the most prevalent types of plastics in water samples. PA/Nylon, PUR, PVC and PET were the most common materials found in sediment samples. Local anthropogenic activities largely influenced the presence of MPs, as source analysis based on Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA).

Onaji et al. (2025) used a study to measure the occurrence of MPs and related oxidative stress reactions in two commercial fish, Clarias gariepinus (Catfish) and Oreochromis niloticus (Nile Tilapia) in the Kubanni reservoir, Zaria, Nigeria, over six months between the dry and rainy seasons. Fibres, fragments, films, and beads respectively were the most common MP particles: fibres> fragments > films > beads. Clarias garipinus (11.5 MP items/individual) and

Oreochromis niloticus (22.5 MP items/individual) gills contained the greatest amount of fibre. The majority of ingested microplastics were black and ranged in size from 1.0 to 2.0 mm. Polypropylene and polyethylene terephthalate were the two main polymers found. The gills, liver, and dorsal muscles of both fish species showed signs of oxidative stress and cellular damage, which were linked to MPs consumption.

2.4.2 Previous Studies Around the World

Prusty *et al*. (2023) evaluated the level of microplastic pollution in *harpadon nehereus*, an economically significant marine fish, from the main fishing harbors along India's northwest coast. A total of 213 specimens were gathered from the main fishing harbors in the states of Maharashtra (Mumbai) and Gujarat (Jakhau, Okha, and Jaffrabad). Using a stereomicroscope, the MPs were separated and measured. MPs were found to be present in all investigated specimens, with an abundance of 6.98 ± 6.73 MPs/g. The study site in Jaffrabad has the highest MP pollution, followed by Jakhau, Mumbai, and Okha. Threads were found to be the most prevalent shape in MP morphometric study. The polymer compositions of extracted MPs were found to be polyethylene (PE), polystyrene (PS), and polyurethane (PU). According to their research, trophic transfer poses a serious risk to human health and seafood safety.

Horton *et al* (2024) studied the abundance of microplastics in the gastro-intestinal tracts of three commercially important fish species in the UK, to determine whether catch location, feeding habits and fish size influence the amount of microplastics within fish. Fish were collected from two rivers in the UK: the River Thames and the River Stour (East Anglia). Species selected were European flounder (*Platichthys flesus*), whiting (*Merlangius merlangus*), and Atlantic herring (*Clupea harengus*), and were chosen to represent benthic and pelagic feeding habits. Across all locations, 41.5 % of fish had ingested at least one microplastic particle (37.5 % of European flounder, 52.2 % of whiting, and 28.6 % of Atlantic herring). European flounder had an average of 1.98 (±3.50) microplastics per fish, whiting had an average of 2.46 (±3.10), and herring had an average of 1.47 (±3.17). Based just on river, site, species, or catch location, there were no appreciable variations in the quantity or mass of microplastics in fish. As environmental circumstances change, exposure and uptake are likely to change as well. Larger fish typically contain more microplastics, making fish size an excellent indicator of contamination. Their research shows that feeding patterns and catch location alone are not reliable indicators of fish contamination.

Munno *et al*. (2024) examined the gastrointestinal tracts of tiger sharks (*Galeocerdo cuvier*) captured in the western North Atlantic Ocean for high levels of microplastic and anthropogenic particle pollution. Eight individuals taken off the Atlantic and Gulf of Mexico coasts of the United States had seven stomachs and one spiral valve investigated. Before measuring and classifying probable anthropogenic particles by size, shape, and color, specimens were chemically broken down in potassium hydroxide (KOH) and density separated using calcium chloride ($CaCl_2$). Every shark had anthropogenic particles in its stomach and spiral valve. A single specimen contained 1603 anthropogenic particles out of the 3151 anthropogenic particles found in all stomachs. Raman spectroscopy and μ-Fourier Transform Infrared spectroscopy were used to confirm the anthropogenic origin of a selection of suspected anthropogenic particles (14%). Overall, spectroscopic analysis revealed that at least 95% of the particles were anthropogenic, with 45% of those particles being identified as microplastics. The most prevalent polymer among the microplastics was polypropylene (32%). There were a variety of microparticle shapes, but the most common ones were fibers (41%) and fragments (57%). Tiger sharks' high trophic position in relation to other marine species and their generalist feeding approach are probably the causes of the high incidence and quantity of anthropogenic particle contamination.

Jamal *et al.* (2025) evaluated microplastic contamination in three popular seafood fish species from the northern Bay of Bengal. Wet peroxide oxidation, stereomicroscopy, and Fourier transform infrared (FTIR) spectroscopy were used to examine samples of gill, gastrointestinal tract (GIT), and muscle tissues from *Thunnus obesus*, *Pampus chinensis*, and *Acanthopagrus datnia*. MPs varied from 1.57 ± 0.58 to 8.73 ± 2.55 MP items/g in gill samples, 1.37 ± 0.62 to 5.39 ± 1.55 MP items/g in the GIT, and 0.2 ± 0.15 to 0.475 ± 0.21 MP items/g in muscle tissue, according to analyses. MPs were found in fish muscle, indicating that the particles had been absorbed into bodily tissues after passing through the digestive system and directly exposing consumers. Compared to omnivore species, carnivorous species typically showed larger MPs loads. Overall, sheet and fragment MPs were less common than fiber-type MPs. Interestingly, the most common colors seen were violet and crimson. Four types of polymers, EVA, nylon, PE, and PP were found by FTIR tests, indicating that packaging materials or fishing gear could be possible MP sources.

Aunurohim *et al.* (2024) determined the prevalence of microplastics and compared their characteristics in the surface water, flesh, and gastrointestinal tract (GIT) of Nile Tilapia (*O. niloticus*) from Lake Ranu Grati, Pasuruan, East Java, Indonesia. Visual characteristics of MPs were observed using a stereo microscope, and polymers were analyzed by ATR-FTIR (Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy). MPs from water samples had an abundance of 1116 MPs particles. Fiber and black are the most prevalent MP types and colors, with polyethylene (PE) predominating. There were 724 MP particles in the gastrointestinal tract (GIT) and 576 MP particles in the meat of 25 *O. niloticus* samples. Blue fibers with a size range of 101–250 µm dominated the microplastics in Nile tilapia meat samples, and PA (polyamide) was the polymer discovered. In contrast, black fiber, which ranged in size from 251 to 500 µm, predominated among the microplastics in the GIT samples, and PA (polyamide) was the polymer discovered.

Lusher *et al.* (2013) investigated the occurrence of ingested microplastics (MPs) in pelagic and demersal fish from the English Channel. 504 individuals from ten different species (such as

Clupea harengus and *Merlangius merlangus*) were gathered in 2011–2012. When fish were inspected, 36.5% of them had plastics in their digestive tracts. Every one of the five demersal and pelagic species had consumed plastic. The average number of plastic pieces consumed by each of the 184 fish was 1.90±0.10. Using FTIR Spectroscopy, 351 fragments of plastic were identified; the most frequent types were polyamide (35.6%) and rayon (57.8%), a semi-synthetic cellulosic substance. The quantity of plastic consumed by demersal and pelagic fish did not differ significantly.

Constant *et al*. (2022) investigated the presence and makeup of microplastics in eighteen coastal fish species from the northwest Mediterranean Sea. Hydrogen peroxide was used to break down digestive tracts, and residues were examined under a stereo-microscope. A Fourier Transform InfraRed (FTIR) spectrometer was used to examine suspected microplastics in order to verify their plastic nature and determine the type of polymer. After applying a strict blank control and FTIR correction, 78% of the initially sorted and suspicious particles were eliminated. The corrected concentrations range from 0.00 to 5.15 items per fish, which is comparable to the range reported for other coastal species that have been studied in this region. The majority of microplastic forms (91%) are fibers composed of polyester (PES), polyamide (PA), acrylic (A), and polypropylene (PP). The quantity of microplastics consumed may be influenced by a number of species characteristics (morphology, feeding, and habitat), but a single driving mechanism could not be found.

Baalkhuyur et al. (2020) investigated Nine commercially significant fish species from various environments (coastal, pelagic, and reef-associated) in the Saudi EEZ of the Arabian Gulf had microplastic particles (MPs) in their digestive systems measured and categorized. Out of the 140 fish that were tested, eight MPs were recovered, with an average of 0.057 ± 0.019 microplastic objects per fish (not including potential plastic fibers). MPs were found in an average of 5.71% of the fish that were dissected; among the species (*Siganus canaliculatus* and

Rastrelliger kanagurta, respectively), MPs were found in 5 to 15% of the individual fish that were investigated. Fishing threads (1.04 ± 0.06 mm) and fragments (1.16 ± 0.11 mm) made up the majority of the ingested plastic. The fibers, which were present in 58.58% of the fish examined, most likely came from household wastewater, laundry, recreational boating, fishing, and other human activities. The most prevalent polymers consumed by the fish were found to be polyethylene (PE) and polypropylene (PP). The presence of microplastic in fish did not differ significantly ($p < 0.05$) based on their habitat. Despite the Saudi Arabian Gulf's extensive industrialization, MPs are not as common as they are in other areas.

Jabeen *et al.* (2017) examined plastic pollution in six freshwater fish species and twenty-one marine fish species from China. It was discovered that every species consumed micro- or mesoplastics. Microplastic abundance ranged from 0.2 to 17.2 items per gram and from 1.1 to 7.2 items per individual. Mesoplastic abundance ranged from 0.1 to 3.9 items per gram and from 0.2 to 3.0 items per individual. 26 species had a high concentration of microplastics, making up 55.9–92.3% of all plastic objects in each species. Microplastics were most abundant in *Thamnaconus septentrionalis* (7.2 items/individual). By items/individual, sea benthopelagic fish had a far greater average abundance of plastics than freshwater benthopelagic fish. Fiber in shape, transparent in color, and cellophane in composition dominated the plastics.

2.4.3 Instrumentation Used in Microplastics Identification

The most commonly used instrumentation in microplastics identification include stereo microscopy, Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS), and scanning electron microscopy (SEM) (Li et al., 2018). Microscopy is used for physical characterization of the microplastics, this includes the size, shape, colour, and surface features while spectroscopy is used for chemical characterization, that is the chemical composition and polymer type of the microplastic.

Stereo microscopy is used to visually inspect and manually isolate suspected particles. It works by using two optical paths that create a three-dimensional view of the sample, making it useful for observing shape, colour, and surface texture (Hidalgo-Ruz *et al.*, 2012). This method is mainly used to sort plastics from sediments, water samples, or biological tissues before more advanced analysis. It is simple, inexpensive, and widely accessible, making it ideal for preliminary screening (Prata *et al.*, 2019).

Scanning Electron Microscopy (SEM) is a technique that helps to obtain extremely detailed images of microplastic surfaces. The principle behind its operation is a focused electron beam scanned over the sample and measuring signals that show the surface structure (Shim *et al*., 2017). SEM can be useful in investigating plastic weathering, fragmentation patterns and interactions with organisms. It offers significantly greater resolution compared to the light microscopy and allows observing the features that are not visible using the traditional microscopes. SEM when used with Energy-Dispersive X-ray Spectroscopy (EDS) can also identify elemental composition to reveal whether the particles are additives (metals or pigments) or not (Zhang *et al*., 2021).

In microplastic studies, Fourier-Transform Infrared (FTIR) spectroscopy is among the most popular methods of identifying the type of polymer. It works by shining infrared light on a particle. IR wavelengths have varying absorption in different polymers, creating a distinctive spectral fingerprint (Araujo *et al*., 2018). Polymer libraries can be compared with these spectra to determine the material. FTIR can be used on particles bigger than 20 µm and in multiple modes, such as Attenuated Total Reflectance (ATR-FTIR) or micro-FTIR. ATR-FTIR is effective with relatively large or flat particles and micro-FTIR can be used to analyze very small plastics on filters (Löder *et al*., 2015). Accuracy in identifying polymers is the key benefit of FTIR. Nevertheless, it is not as efficient with particle sizes below about 1020 µm and most often needs clean, dry samples to make accurate measurements (Käppler *et al.*, 2016). Moreover, sometimes spectral clarity can be reduced by coloured or worn plastics.

Another widely used tool to detect microplastics, particularly very small particles, is Raman spectroscopy. It operates by focusing laser light on a sample and quantifies the light scattering. The molecular vibrations identified in the scattering pattern can be associated with particular types of polymers (Araujo *et al.*, 2018). One of the greatest benefits of Raman spectroscopy is that the method can detect particles down to 1 µm in size, which is very useful in detecting microplastics and nanoplastics (Primpke *et al.*, 2020). It is also able to analyse dark or coloured plastics which FTIR sometimes cannot manage. Nonetheless, there are disadvantages of Raman spectroscopy. Fluorescence of organic substance or plastics that are very weathered may affect measurements, and in some cases, a spectrum may not be obtained. Raman instruments are costly and even take more time to conduct the analysis of the particle (Kaepler *et al.*, 2016).

Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS) is a type of chemical analyses that is applied to identify plastics through their products of thermal decomposition. Under this technique, the particles are heated at extremely high temperatures, which leads to the particles breaking down into smaller molecules that are further separated and analyzed using mass spectrometry (Dierkes *et al.*, 2019). All the polymers have characteristic degradation products, which can be recognized. Py-GC/MS does not need individual particles to be isolated as FTIR and Raman. Rather, it is able to analyse complex mixtures, which is especially beneficial when dealing with environmental samples that have numerous polymer types (Fuller and Gautam, 2016). It is also very sensitive and is capable of measuring the mass of each polymer in it. The biggest restriction however is the fact that the method destroys the sample, thus, size, shape and colour cannot be determined. It is costly as well, needs specialized operators, and is not applicable to visual classification (Dierkes *et al.*, 2019)

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Benin City is the capital and largest urban center of Edo State, located in the south–south geopolitical zone of Nigeria, lying approximately between latitude 6°33′N and longitude 5°60′E. Benin City is located in the humid tropical rainforest zone, characterized by two main seasons, a long rainy season (April–October) and a short dry season (November–March). The city experiences an average annual rainfall of about 2,500 mm and mean annual temperature of approximately 26°C (Eghomwanre and Oguntoke, 2022). The surrounding landscape is generally flat with gentle undulations, underlain by ferrallitic red soils derived from unconsolidated coastal plain sands (Aigbedion and Iyayi, 2007). Numerous rivers and streams, including the Ikpoba River, traverse the city, making it ecologically suitable for hydrological and environmental studies (Owamah *et al*., 2021). Benin City has an estimated population of approximately 1.97 million as of 2024, making it one of the most populous cities in Nigeria (Iduseri *et al*., 2024). The city's economy is driven by commerce, education, civil service, small-scale manufacturing, and transportation. Additionally, informal economic activities such as market trading and artisan work contribute significantly to livelihoods (Aigbedion and Iyayi, 2007). Like many urban centers in Nigeria, Benin City faces environmental challenges including flooding, waste mismanagement, and traffic-related air pollution (Owamah *et al*., 2021). Seasonal flooding, especially during the heavy rains, affects low-lying areas such as Ikpoba Hill and Upper Mission Extension. The rapid pace of urbanization and inadequate waste disposal infrastructure contribute to environmental degradation and pollution of surface waters (Nwachukwu *et al*., 2022).

3.2 Site Description

Ikpoba River is a freshwater body located in Benin City, the capital of Edo State in Southern Nigeria. The river originates from the Esan plateau and flows in a south-westerly direction eventually joining the Benin River which is a tributary of the Niger Delta system (Ezemonye and Enuneku, 2005; Asonye *et al*., 2007). It lies within latitude 6.5°N and Longitude 5.8°E and is surrounded on both sides by the sloppy terrain of the Ikpoba slope. The surrounding vegetation largely consists of a tropical rainforest which has been subjected to deforestation and other anthropogenic activities (Ogbomida *et al*., 2023). The river's hydrology is influenced by seasonal rainfall patterns, during rainy season increased runoff leads to higher sediment and pollutant loads (Oguzie, 2005). Land use activities along the river bank include farming, fishing, car washing, waste disposal and sand dredging. These activities contribute to the physical and chemical degradation of the river causing a varying degree of pollution by heavy metal, organic matter and microbial contaminants (Arimoro and Ikomo 2008; Owamah *et al* 2014). The study was conducted at three designated stations along Ikpoba River (Figure 1)

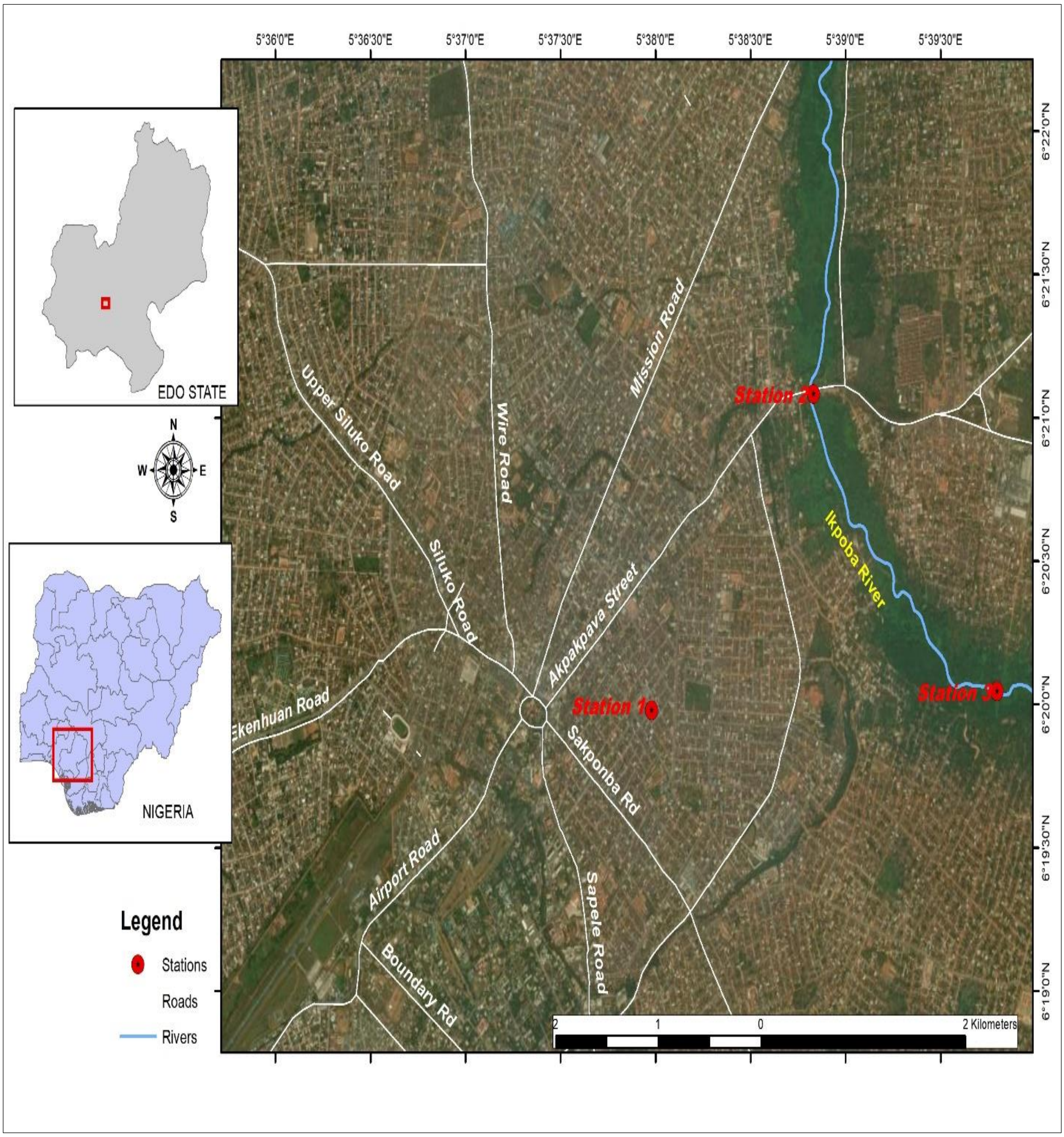

Fig 3.1 Map of the Study Area

3.2.1 Station One (Tenboga)

Tenboga is one of the selected sampling stations along the Ikpoba River located in Benin City, Edo State, Nigeria. The station is located at coordinates 6.3514°N, 5.6472°E. The station is within a densely populated urban setting and is characterized by mixed residential and commercial land use. The area is bordered by local market activities, small-scale trading shops, and clusters of residential buildings, many of which lack formal waste disposal systems. The riverbank located close to Tenboga is readily available to the populace and is often utilized by the general people in their household chores like laundry, bathing and water harvesting, particularly by the lower-income earners residing in the nearby communities.

Direct surface run-off of adjoining streets and drains into the river is also present in the Tenboga reach, especially during rain, which enhances the supply of solid waste, such as plastics, into the waterway. Waste dumping along the river bank is also a common phenomenon and you will find the plastic waste that includes sachet water bags, water bottles, food wrappers and polythene materials littering the banks and floating on the water surface. The close proximity of Tenboga to urban access roads that are busy also leads to hydrological disruptions and potential microplastic sources such as the wear of tires, road dust, and road traffic activities. Plants in this part of the river are meager and much disturbed because of constant human activities. The river channel at Tenboga is of a middle order, and at times stagnates in shallow places, where the rubbish may collect itself.

Plate 3.1 Station 1(Temboga)

Plate 3.1 Station 1(Temboga)

3.2.2 Station 2 (Ikpoba slope)

Ikpoba Slope which is the Station 2 in this work is situated in the middle of the Ikpoba River in Benin City, Edo State, Nigeria. It is located on the axis of Ikpoba slope at coordinates 6.3514°N, 5.6472°E. The slope is a busy city street that has a lot of traffic of vehicles, business, and residential houses. The sampling location of Ikpoba Slope is near the river bridge crossing, which is a key transport route between various sections of the city. The riverbank here is fairly open and open to the general public, thus being a frequent location of informal garbage dumping, domestic washing and some recreational use.

There are various anthropogenic inputs to the station, including traffic related pollution, effluents from car wash activities and waste disposal practices in the surrounding area.

Many storm-water drains and roadside gutters are running into the river, particularly during rainy events. These drainage systems contain the municipal waste, plastic litter, and the sediments that are washed away by the nearby roads, markets and residential places. A high rate of urban waste production in the area is evident through the large amount of plastic sachet water wrappers, food packaging, nylon bags, and bottle fragments found along the shoreline. The heavy traffic in the area could also create microplastic loading at this station because of road dust and tires wear particles. River flow at Ikpoba Slope is moderate to rapid with seasons but regions around the bank might have slower water flow where debris can be deposited. The vegetation around is significantly out of place with only few riparian plants surviving as a result of frequent disturbance by people.

Plate 3.2 Station 2 (Ikpoba slope)

3.2.3 Station 3 (Guinness)

The Guinness Nigeria industrial facility is situated in Benin City and in close proximity to the Guinness station (Station 3). It is situated between latitude 6.33’41°N and longitude 5.66’33°E. Industrial, commercial and residential wastes are discharge in this part of the river. The region is typified by a combination of factory infrastructure, light industry activities and subsidiary business entities. This station being an industrial corridor is prone to the potential input of manufacturing processes, wastewater discharge routes, and industrial runoff. The vegetation is sparse and highly disturbed with mainly riverbank grasses and isolated shrubs, which are constrained by the industrial environment. Potential informal waste disposal by local residents or commuters is also a possibility, as there are public access points close to the river at this station, though access to the river is comparatively limited by factory boundaries and security measures.

Plate 3.3 Station 3(Guinness)

3.3 Sample Collection

A total of sixteen samples of *Mormyrus rume* (MR: n=16) were purchased from artisanal fishermen at Ikpoba River who made use of gill and cast nets (mesh size 50-60mm) to capture samples from the three selected sites. The sites where selected due to the noticeable concentration of plastic litter along the river bank and water surface, serving as an indicator of elevated anthropogenic input and potential microplastic presence. The purchased samples were kept in a cooler filled with ice and transported to a Biochemistry laboratory in the University of Benin, Benin City. On arrival at the laboratory, the fish species was identified using Idodo-Umeh (2003) fresh water fishes of Nigeria. Morphometric parameters such as the total length and standard length (cm) and weight (Kg) of each fish were recorded. The standard and total length were measured using a steel metre rule, the weight was measured using a camry manual table scale. Each fish was dissected for the removal of the GIT, which was then weighed using a high precision digital mini scale, wrapped in aluminum foil and placed in a Ziploc bag and stored in a freezer. The stored samples were placed in a cooler filled with ice and transported to a laboratory at Redeemer's University, Osun State, Nigeria for FTIR laboratory analysis

Plate 3.4 ***Mormyrus rume*** **sample from the study**

3.4 Laboratory Analysis

The GIT of each individual fish was placed in a beaker, and 10% potassium hydroxide was added for the digestion of organic tissue. It was later placed in a hot air oven at 60◦C for 24 hours to achieve complete digestion of organic tissue. A density separation was performed using a supersaturated aqueous solution of NaCl, this was added to the digested material to cause flotation of the MPs as per the density gradient, the solution was continuously stirred with a glass rod, the stirring was to prevent MPs from settling and enhance separation efficiency. After this process was complete the solution was kept at room temperature for 24hour. The result containing the floated MPs was filtered through an ash-less Whatman filter paper with pore size 0.45 µm (Prusty *et al*., 2023). The filter paper was then rinsed with deionized water to remove any residual digestive solution and dried in a desiccator to prevent contamination. The dried filter papers containing suspected MPs were analyzed using Fourier Transform Infrared Spectroscopy (FTIR) in attenuated total reflectance (ATR) mode (Ogbomida *et al.,* 2023). Each particle was carefully placed on the FTIR crystal, and infrared spectra were recorded across a wavelength range of 4000–600 cm^{-1}. The obtained spectra were compared with a reference spectral library to identify polymer types such as polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), polyamide(PA), polyurethane(PU), polyvinyl chloride(PVC), and polycarbonate(PC)

3.5 Statistical Analysis

The data obtained from the analysis was analyzed for means, standard error and standard deviation using Microsoft Excel. Data was presented using tables and charts. Pie chart was generated using PASS software.

CHAPTER FOUR

RESULTS

4.1 Percentage Abundance and Composition of Microplastics in Mormyrus rume

The percentage abundance of microplastics in *mormyrus rume* across the three stations is shown in table 4.1. Station 1 is dominated by PET (23.33%) and PP (18.89%), with PC at (6.67%) having the least value, and no detected PVC polymer. Station 2 is dominated by PET (20.72%) and PA (19.82%), PU at 11.71% having the least value with no detected PC/PVC polymer. Station 3 had PA (18.98%), PE (18.25%), and PET (18.25%) polymer more prominent, while PVC (1.46%) and PC (0.73%) were less prominent.

Table 4.1: Percentage Abundance of each Microplastic distributed across Stations

Type	Station 1 (%)	Station 2 (%)	Station 3 (%)
PET	23.33	20.72	18.25
PE	12.22	17.12	18.25
PA	13.33	19.82	18.98
PU	8.89	11.71	13.14
PP	18.89	17.12	17.52
PS	16.67	13.51	11.68
PC	6.67	<BDL	0.73
PVC	<BDL	<BDL	1.46

PVC was not detected (below detection limits) for station 1 while PVC and PC were not detected at station 2.

Table 4.2 shows the percentage abundance and polymer count of microplastics distributed by the three stations. The total of polymer particles were 338. Station 1 (90) having the lowest count, followed by station 2 (111) and Station 3 (137) with the highest particle count. The percentage abundance of microplastics distributed across the three stations is represented in Fig 4.1. Station 3 had the highest percentage abundance (40.53%), followed by station 2(32.84) while station 1 had the least abundance (26.63%).

Table 4.2: Percentage Abundance and polymer count of Microplastics distributed by the Three Stations

Station	Total Count	Percentage (%)
Station 1	90	26.63
Station 2	111	32.84
Station 3	137	40.53
Total	338	100

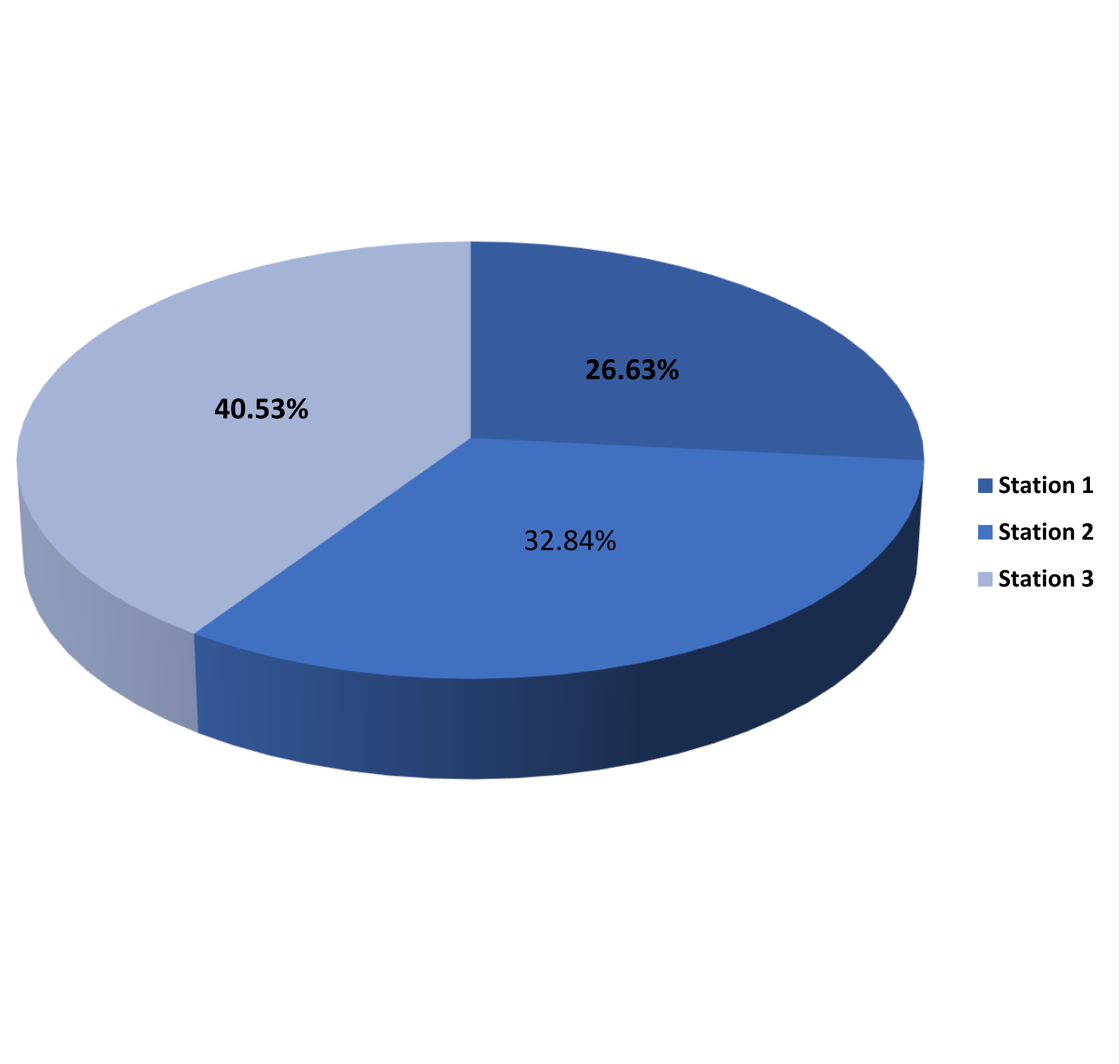

Fig 4.1: Percentage Abundance of Microplastics Distributed by the Three Stations

4.2 Fourier Transform Infrared Spectroscopy of Microplastics in Fish Samples Collected from Ikpoba River

Table 4.3, 4.4 and 4.5 presents the Fourier Transform Infrared Spectroscopy (FTIR) results for microplastics extracted from fish samples at the three stations along the Ikpoba River. The analysis revealed dominant persistence's of specific polymer types. At the three stations, PET was one of the most reoccurring polymers, it was recognized through a broad C-O stretching peak (1250 - 1015 cm^{-1}). These polymer signatures have remained constant, indicating a consistent inflow of domestic wastes such as plastic bottles, food packages, synthetic fibers. The presence of other polymers of PA, PE, PU and PS in moderate amounts support the input of plastic bags, foam products, adhesives and insulation materials that also coincide with domestic wastes.

Table 4.3 FTIR of Microplastics Samples Collected from Station 1

FTIR Peaks	Characteristics	Type of Polymer
3406	O-H Stretching	Polyamide, polyurethane
2920	C-H Stretching	Polyethylene, Polypropylene
2850	C-H Stretching	Polyethylene, Polypropylene
2337	C=C	Polyethylene
1635	C=C	Polyamide, polystyrene
1033	C-O Stretch	Polyethylene terephthalate
1215	C-O Stretch	Polyethylene terephthalate
1095	C-O	Polyethylene terephthalate

Table 4.4 FTIR of Microplastics in Fish Samples Collected from Station 2

FTIR Peaks	Characteristics	Type of polymer
3437	O-H Stretching	Polyamide, polyurethane
3290	O-H Stretching	Polyamide, polyurethane
2360	C=O Stretching	Polyethylene
2920	C-H Stretching	Polyethylene, polyurethane
1639	C=C	Polyamide, polystrene
1087	C-O Stretch	Polyethylene terephthalate
794	C-H	Polystrene
1006	C-O	Polyethylene teraphthalate

Table 4.5 FTIR of Microplastics in Fish Samples Collected from Station 3

FTIR Peaks	Characteristics	Type of polymer
3441	O-H Stretching	Polyamide, polyurethane
2399	C=O Stretching	Polyethylene
1033	C-O Stretching	Polyethylene terephthalate
1091	C-O Stretching	Polyethylene terephthalate
914	CH Wag	Poly]vinylchloride
694	Aromatic ring breathing	Polystrene
1168	C-C	Polypropylene
1635	Aromatic C=C	Polyamide, Polycarbonate

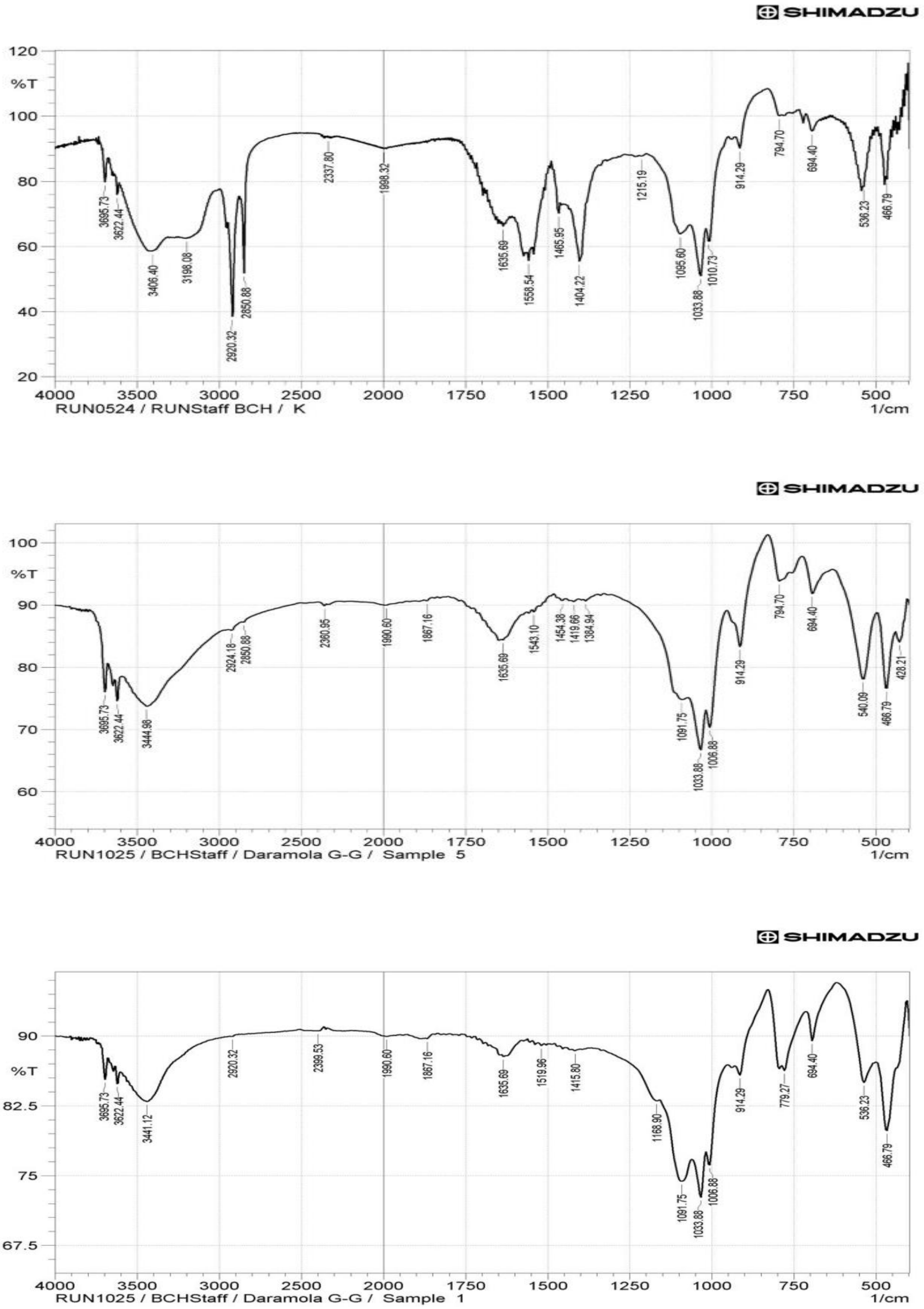

Figure 4.2: Fourier Transform Infrared (FTIR) spectroscopy analysis of microplastic particles in fish samples collected across the three stations along Ikpoba River

CHAPTER FIVE

DISCUSSION

5.1 Discussion of Results

This study examined the occurrence of microplastic contamination in *Mormyrus rume* sampled from Ikpoba River.The study observed microplastic contamination and spatial differences in the abundance and polymer mix across the stations. Eight plastic polymers were identified: polyethylene terephthalate (PET), polyethylene (PE), polyamide (PA), polyurethane (PU), polypropylene (PP), polystyrene (PS), polycarbonate (PC) and polyvinyl chloride (PVC). The dominance of PET, PP and PA implies that single-use packaging, textile fibers and household plastics contribute significantly to MP pollution. The highest mean value of PET (23.00 ± 1.15) suggests constant discharge inflow of beverage bottles and packaged water, which are usually consumed and disposed of in most Nigerian cities (Olatunde *et al*., 2022). The presence of PP and PA show textile laundry effluents, fishing lines and the general packaging materials as significant sources of this contamination. The moderate presence of PE and PS in this study likely reflects inputs from commonly used plastic materials such as plastic bags, sachet water packaging, foam products, and disposable food containers. The detection of PU further suggests the degradation of synthetic foams, adhesives, and coatings used in construction and transportation activities. Although PVC and PC were detected at lower levels, their occurrence remains environmentally important because they may release harmful substances, including chlorine-based additives and bisphenol-A (BPA), into the aquatic environment (Hahladakis *et al.*, 2018).

The high occurrence of microplastics (MPs) observed in this study suggests that *M. rume* inhabiting the river is continuously exposed to substantial microplastic contamination and likely ingests these particles during feeding activities. As a benthopelagic predator, *M. rume* actively feeds near the bottom sediments, which are known to serve as major sinks for microplastics due to water turbulence and particle density differences (Wang *et al.,* 2021). This feeding behavior increases the likelihood of ingesting microplastics trapped within sediments or associated with suspended organic materials.

The high polymer concentration at station 3 (17.12 ± 3.40) imply that this station is a probable convergence of plastic debris, which might be the recipient of the discharge points of domestic waste, agricultural run-off and informal dumping. Similar gradients have been observed in freshwater systems of Nigeria, including the Ogun River and Lagos Lagoon, where downstream locations at markets and residential settlements have a higher prevalence of microplastic contamination (Adeogun *et al*., 2020; Dada and Mayson, 2021). The continuous influx of untreated wastes into station 3 may enhance the retention and accumulation of plastic particles, particularly under conditions of reduced water flow and sediment deposition. Consequently, the station represents a potential hotspot for microplastic pollution and associated ecological risks within the river ecosystem.

The presence of diverse microplastic polymers and their high abundance across all sampling stations indicate that the Ikpoba River is a significant hotspot of plastic pollution. The detected polymers suggest continuous inputs from domestic and industrial waste sources within the surrounding environment. Similar patterns have been reported globally in freshwater fish, reflecting the widespread nature of plastic pollution driven by human activities (Prata *et al*., 2020; Su *et al.,* 2022; Mohamed *et al.,* 2022). Microplastic ingestion may negatively affect fish health by causing digestive blockage, reduced feeding, tissue inflammation, impaired growth, and altered energy allocation, which may ultimately affect reproduction and immunity (Rochman *et al.,* 2015; Wang *et al.,* 2021;). Since *M. rume* is a commercially important and widely consumed species, the occurrence of microplastics raises concerns about human exposure through fish consumption. Although gut cleaning may remove most particles, smaller microplastics and associated contaminants may still accumulate in edible tissues (Yun *et al.,* 2020). Continuous consumption of contaminated fish may therefore pose potential health risks to communities relying on the Ikpoba River for food.

5.2 Conclusion

The study identified microplastics in all fish samples from three designated stations, with PET as the most common polymer. Other detected polymers included PA, PU, PP, PE, PS, PVC, and PC, with PVC and PC present at lower concentrations. Station 3 had the highest microplastic abundance in the fish. The findings indicate inadequate waste management and domestic waste are major sources of microplastic contamination, particularly from packaging-related polymers. Thus, it is important that there is improving of waste management enforcing regulations, to enhance urban drainage, raising public awareness, and reducing single-use plastics to mitigate pollution.

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