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SCHOOL OF PUBLIC HEALTH  
COLLEGE OF HEALTH SCIENCES  
UNIVERSITY OF GHANA



**MICROPLASTIC CONTAMINATION OF FISH FROM THE KORLE LAGOON IN  
ACCRA, GHANA AND POTENTIAL HEALTH RISKS**

**BY**

**DANIEL GYAMFI FRIMPONG**

**(11365780)**

**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN  
PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MSc IN  
OCCUPATIONAL HYGIENE DEGREE**

**INTEGRI PROCEDAMUS**

**(JUNE, 2025)**

## DECLARATION

I, Daniel Gyamfi Frimpong, now declare that this dissertation is a result of my original work undertaken under the supervision of Dr. John Arko-Mensah. No part of it has previously been submitted for another degree at the university or elsewhere. This work is my own, except for the work of others duly acknowledged.

Signed:



Date: 10th June, 2025

Daniel Gyamfi Frimpong

(STUDENT ID:11365780)

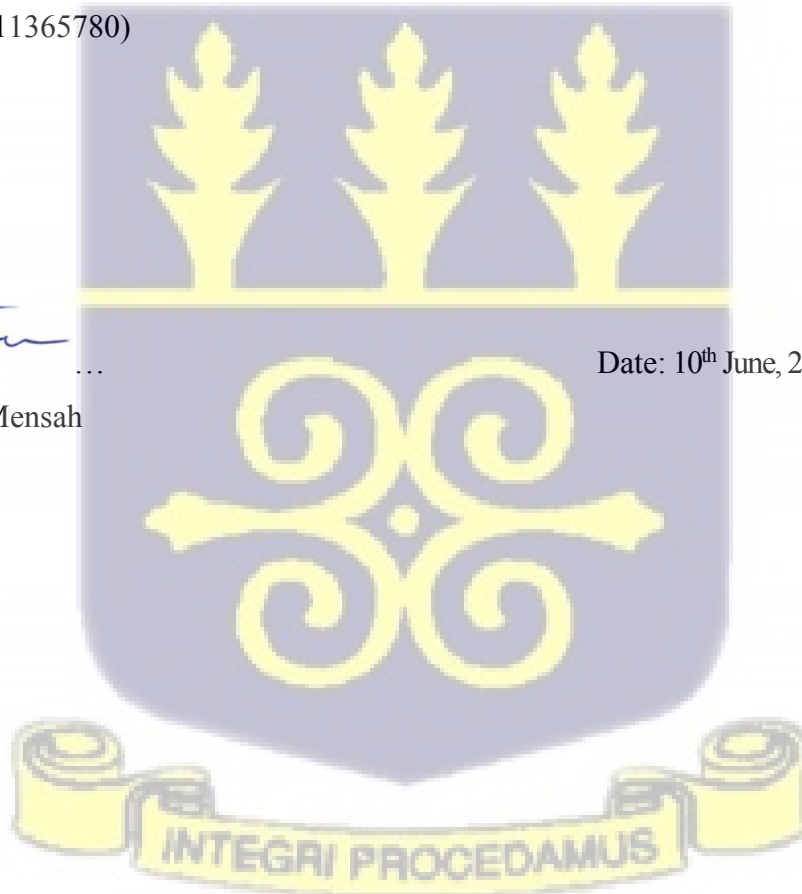
Signed: ...



Dr. John Arko-Mensah

(SUPERVISOR)

Date: 10<sup>th</sup> June, 2025



## DEDICATION

I dedicate this labour of love to the Almighty God, to my parents whose prayers and encouragements ignited and replenished my strength and also to the young version of myself, who dared to dream big and never gave up.



## ACKNOWLEDGEMENT

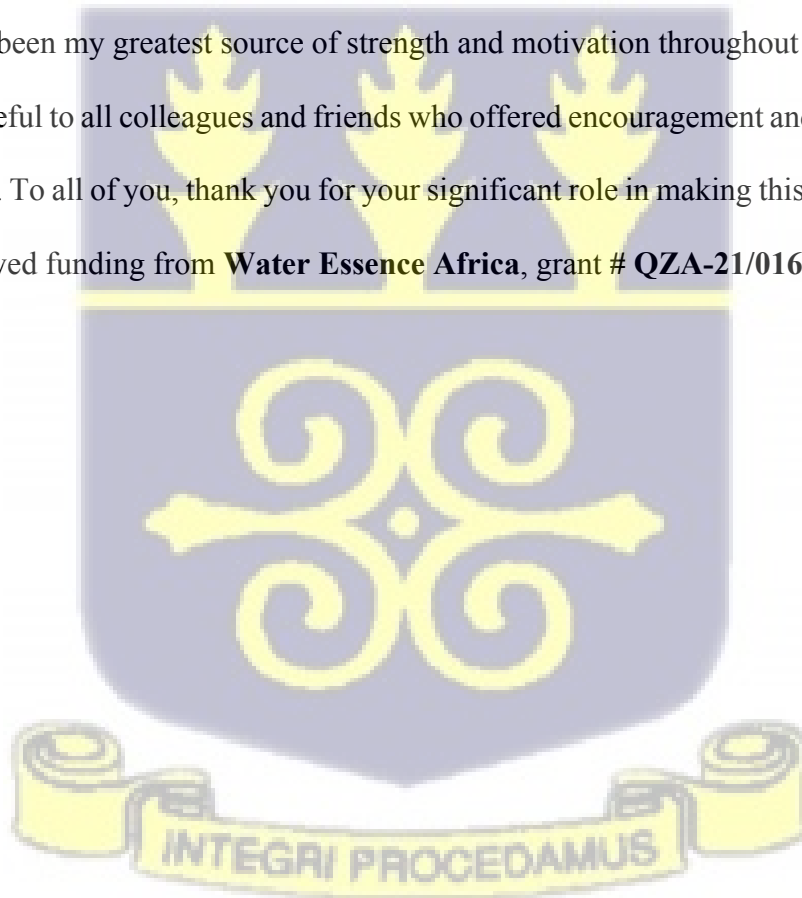
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**Table of Contents**

DECLARATION.....	i
DEDICATION.....	ii
ACKNOWLEDGEMENT.....	iii
LIST OF FIGURES.....	vii
LIST OF TABLES.....	viii
LIST OF ABBREVIATIONS.....	ix
ABSTRACT.....	x
CHAPTER ONE INTRODUCTION.....	1
1.1 Background.....	1
1.2 Problem Statement.....	3
1.3 Conceptual Framework.....	5
1.3.1 Narrative for conceptual framework.....	7
1.4 Justification.....	9
1.5 Research Questions.....	10
1.6 Study Objectives.....	12
1.6.1 General Objective.....	12
1.6.2 Specific Objectives.....	12
CHAPTER TWO LITERATURE REVIEW.....	13
2.1 Introduction.....	13
2.2 Microplastics in Freshwater Ecosystems.....	13
2.3 Sources and Distribution of Microplastics.....	16
2.3.1 Sources of Microplastics.....	16
2.3.2 Distribution of Microplastics.....	17
2.4 Microplastic Contamination of Fish.....	18
2.4.1 Presence of Microplastics in Fish.....	18
2.4.2 Characteristics of Microplastics.....	19
2.5 Potential Health Implications of Microplastic Contamination in Fish.....	20
2.5.1 Toxicological Effects of Microplastics.....	20
2.5.2 Bioaccumulation and Biomagnification.....	21
2.6 Current Knowledge and Research Gaps.....	22

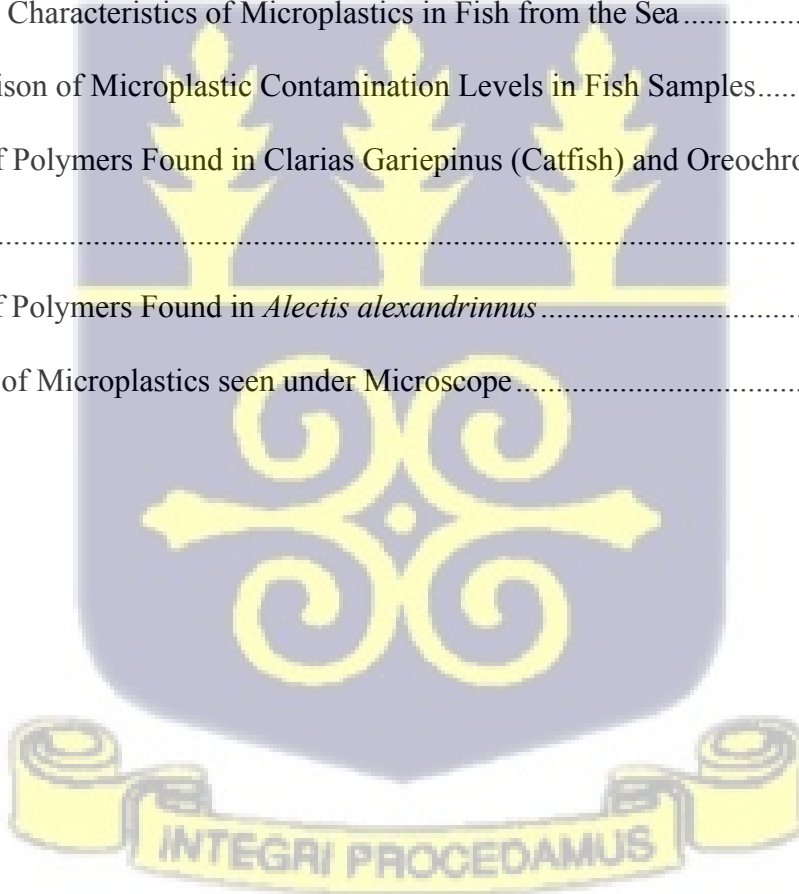
2.7 Critical Analysis of Regional Studies.....	22
CHAPTER THREE METHODS.....	25
3.1 Study Design.....	25
3.2 Study Area/Site.....	26
3.3 Study population.....	28
3.4 Sampling Method and Sample Size.....	29
Samples from the Lagoon.....	30
Sample from the sea.....	32
3.5 Laboratory analysis of microplastics in fish.....	32
Observational Techniques.....	34
Polymer Identification.....	34
3.6 Selection Criteria.....	34
3.6.1 Inclusion Criteria.....	34
3.6.2 Exclusion Criteria.....	35
3.7 Study Variables.....	36
3.8 Data Analysis.....	36
3.9 Quality Control.....	38
CHAPTER FOUR RESULTS.....	40
4.1 Microplastics in fish.....	40
4.2 Physical Characteristics of Microplastics Identified in Fish from The Lagoon and Sea.....	42
Source of Microplastics.....	45
Nature of Microplastics.....	45
4.3 Comparing contamination levels of samples from the lagoon and the sea (Gulf of Guinea).....	47
4.4 Inferential Statistics.....	52
CHAPTER FIVE DISCUSSION.....	55
5.1 Discussion.....	55
5.1.1 Prevalence and Distribution of Microplastics in Fish from Korle Lagoon and the Gulf of Guinea..	55
5.1.2 Tissue-Specific Accumulation and Interspecific Variation.....	56
5.1.3 Characterization of Microplastics by Shape, Color, and Size.....	56
5.1.4 Toxicological and Ecological Implications.....	57
5.1.5 Policy Relevance and Risk to Vulnerable Populations.....	58

5.1.6 Contribution to Literature and Future Directions .....	59
5.2 Public Health Implications .....	59
Chemical Composition and Toxicological Implications .....	60
Vulnerable Populations and Exposure Risk .....	60
CHAPTER SIX CONCLUSION AND RECOMMENDATIONS .....	62
6.1 Conclusion .....	62
6.2 Recommendations .....	63
REFERENCES .....	67



## LIST OF FIGURES

Figure 1.1: Conceptual Framework.....	6
Figure 3.1: Map of Korle Lagoon.....	27
Figure 3.2: Picture of Korle Lagoon.....	28
Figure 3.3: <i>Oreochromis niloticus</i> (Tilapia).....	30
Figure 3.4: <i>Clarias gariepinus</i> (catfish).....	31
Figure 3.5: <i>Alectis alexandrinnus</i> (Silver Trevally).....	32
Figure 4.1: Physical Characteristics of Microplastics in Fish from the Lagoon.....	46
Figure 4.2: Physical Characteristics of Microplastics in Fish from the Sea.....	47
Figure 4.3: Comparison of Microplastic Contamination Levels in Fish Samples.....	48
Figure 4.4: Types of Polymers Found in <i>Clarias Gariepinus</i> (Catfish) and <i>Oreochromis niloticus</i> (tilapia).....	50
Figure 4.5: Types of Polymers Found in <i>Alectis alexandrinnus</i> .....	52
Figure 4.6: Pictures of Microplastics seen under Microscope.....	54



**LIST OF TABLES**

Table 4.1: Microplastic abundance by Fish Species and Tissue Type from the lagoon.....41

Table 4.2: Microplastic abundance by Fish Species and Tissue Type from the sea.....41

Table 4.3: Physical Characteristics of Microplastics Identified in Fish from the Lagoon.....42

Table 4.4: Physical Characteristics of Microplastics Identified in Fish from the Sea.....43

Table 4.5: Three-way Mixed ANOVA Results for Microplastic Abundance.....53

Table 4.6: MANOVA Results for Microplastic Characteristics by Fish Species.....53



## LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BPA	Bisphenol A
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
FTIR	Fourier-Transform Infrared Spectroscopy
IBM	International Business Machine
MANOVA	Multivariate Analysis of Variance
MPs	Microplastics
NP	Nanoplastic
PAHs	Polycyclic Aromatic Hydrocarbons
PE	Polyethylene
POPS	Persistent Organic Pollutants
PP	Polypropylene
PPS	Proportional to Population Size
PS	Polystyrene
PSU	Primary Sampling Units
SPR	Source–Pathway–Receptor
SPSS	Statistical Package for the Social Sciences
WRI	Water Research Institute



## ABSTRACT

**Background:** The growing production of plastics and inadequate waste management has exacerbated microplastic pollution in aquatic ecosystems, posing significant ecological and human health risks. Despite increasing awareness of microplastic pollution, limited research has been conducted on its extent in Ghanaian aquatic ecosystems, particularly in fish commonly consumed by local populations. This study investigates the microplastic burden in fish from the Korle Lagoon and adjacent Gulf of Guinea, comparing contamination levels across different species and tissue types while exploring potential implications for human consumption.

**Objective:** The aim of the study was to determine microplastic contamination of fish from the Korle lagoon and adjacent Gulf of Guinea (sea).

**Methods:** This study was a cross-sectional study that involved analysis of microplastics on different fish species harvested from the Korle lagoon and the Gulf of Guinea. One hundred and fifty (150) fishes from the lagoon and sea were analyzed in the laboratory using stereomicroscopy and Fourier-transform infrared (FTIR) spectroscopy to identify and count microplastics.

**Results:** Gut tissues exhibited the highest contamination levels, accounting for 60 – 70% of total particles, predominantly fragments and fibres. Black and transparent microplastics, linked to urban and industrial sources, were most common. Sediment-dwelling species showed significantly higher microplastic accumulation due to their sediment interactions, underscoring habitat-driven exposure risks.

**Conclusions:** Although microplastic contamination in muscle tissues which is the edible part was less than 10%, its presence still raises legitimate concerns and may pose a health risk to humans after consumption.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Microplastics (MPs) have emerged as significant environmental pollutants that pose potential risks to ecosystems and human health (Alberghini *et al.*, 2022). These tiny plastic particles, generally less than 5mm in size, originate from various sources, including the degradation of larger plastic debris and the direct use of products containing microplastics, such as cosmetics, clothing, and industrial applications (Smith *et al.*, 2018). With the increasing use and disposal of plastic materials worldwide, microplastic contamination has become a critical concern in aquatic environments, including oceans, rivers, and lagoons.

The global surge in plastic production and inadequate waste management practices have aggravated the pollution of marine and freshwater ecosystems (Rochman *et al.*, 2019). As plastics break down into smaller fragments, they accumulate in water bodies where they are ingested by various organisms, including fish (Adu-Boahen *et al.*, 2022). Microplastics in aquatic environments pose significant ecological risks, with fish being the primary vector for transferring these pollutants into the human food chain (Bošković *et al.*, 2021). Given the widespread consumption of fish as a primary protein source—particularly in coastal and low-income communities—understanding the level and impact of microplastic contamination in fish is crucial for assessing potential public health risks (Mahu *et al.*, 2023). Mahu *et al.* (2023) conducted a comprehensive assessment of microplastic ingestion in 160 fish species from Nigerian coastal waters, reporting an average of  $39.65 \pm 5.67$  microplastic particles per individual. Notably, microbeads constituted the most prevalent type of microplastic (43%), and over 85% of particles recovered were under 1,000  $\mu\text{m}$ , with some small enough to translocate

into fish muscle tissues. This suggests a potential route for human exposure through fish consumption, especially in communities with high dietary reliance on fish.

The Korle Lagoon, located in Accra, Ghana, is a vital water body supporting ecological functions and local livelihoods. It is a significant site for fishing despite being heavily polluted by solid waste, including plastics, industrial discharge, and untreated domestic waste (Kyeremeh *et al.*, 2023). The lagoon receives waste from densely populated areas and produces a high concentration of pollutants. Among these pollutants, microplastics have been identified as a growing concern because of their persistence and the difficulty in removing them from the environment (Awewomom *et al.*, 2024).

Similarly, in Ghana, Nuamah *et al.* (2023) investigated the presence of microplastics in sediments and two commercially important fish species—*Sardinella maderensis* and *Ilisha africana*—collected off the coast of the Gulf of Guinea. They reported microplastic concentrations ranging from 8.35 to 20.95 particles per fish, with higher accumulation in gills and guts. Pellets and fibers were the most common types observed. These findings are crucial as they provide empirical evidence of microplastic pollution in Ghana's marine ecosystems and raise concerns about ecological and food safety impacts. Despite these important contributions, the extent of microplastic contamination in fish from urban aquatic systems such as the Korle Lagoon—one of Ghana's most polluted water bodies—has not been established. This gap is particularly concerning given the lagoon's proximity to densely populated areas and its historical use for fishing and recreational purposes.

Recent research has also emphasized the potential health risks associated with consuming fish contaminated with microplastics. These risks stem from chemicals associated with plastics, such as additives and persistent organic pollutants (POPs), which may leach into fish tissues and,

consequently, into humans upon ingestion (Bhuyan, 2022). As microplastics accumulate in the food chain, there is growing concern about their long-term effects on human health, including the risks of inflammation, toxicity, and exposure to harmful chemicals (Barboza *et al.*, 2020).

Given the critical role of fish in the local diets and economies, this study is essential for public health and environmental management. By quantifying and characterizing the types of microplastics in fish from the Korle Lagoon, this study seeks to inform policies to mitigate pollution and safeguard food safety in the region. Furthermore, understanding the potential sources of microplastic contamination will provide insights into necessary interventions to reduce plastic waste and its impact on marine life and human health (Onsrud, 2023).

This study aims to fill this knowledge gap by assessing the levels and types of microplastics present in fish species harvested from Korle Lagoon. Understanding contamination levels is crucial for evaluating the potential risks to human health, especially in communities that rely heavily on fish as a staple food source (Pappoe *et al.*, 2022).

## 1.2 Problem Statement

Recently, there has been increasing concern about microplastic-contaminating fish species, especially those consumed by humans (Bhuyan, 2022). The Korle Lagoon in Accra, Ghana, is an essential resource for local communities, providing livelihood and nutrition through fishing activities. However, the lagoon faces severe pollution challenges, leading to potential health risks associated with the consumption of contaminated fish.

The extent of microplastic contamination in Korle Lagoon is alarming. The Korle lagoon drains directly into the Gulf of Guinea. A study by Nuamah *et al.* (2023) revealed that 97% of sampled fish species from the Gulf of Guinea contained microplastics, with an average concentration of

2.3 particles per gram of fish tissue. The study highlighted that microplastics were prevalent in both gill and gut tissues, underscoring the extent of exposure and potential for bioaccumulation. This level of contamination raises significant public health concerns, especially in regions like Ghana, where fish is a staple component of the daily diet. Moreover, microplastic ingestion has been associated with health issues such as inflammation and toxicological effects of associated chemicals (Bhuyan, 2022). The magnitude of this problem is underscored by the fact that approximately 60% of the population in the coastal areas of Ghana relies on fish as a primary protein source, making the health implications of microplastic contamination particularly critical (Pappoe *et al.*, 2022).

Several factors contribute to the high levels of microplastic contamination in Korle Lagoon. First, rapid urbanization and population growth in Accra have significantly increased waste generation. Much of this waste ends up in the lagoon due to inadequate waste management systems and weak enforcement of proper disposal practices (Kyeremeh *et al.*, 2023). Second, industrial activities near the lagoon exacerbate contamination through the discharge of untreated effluents and improper disposal of plastic waste (Amponsah 2021). Third, the infamous Agbogbloshie electronic waste recycling and dumpsite is near the lagoon (Armoo 2019). Fourth, local fishing practices, particularly the use of synthetic fishing nets, contribute to microplastic pollution as these nets degrade over time and release plastic particles into the water.

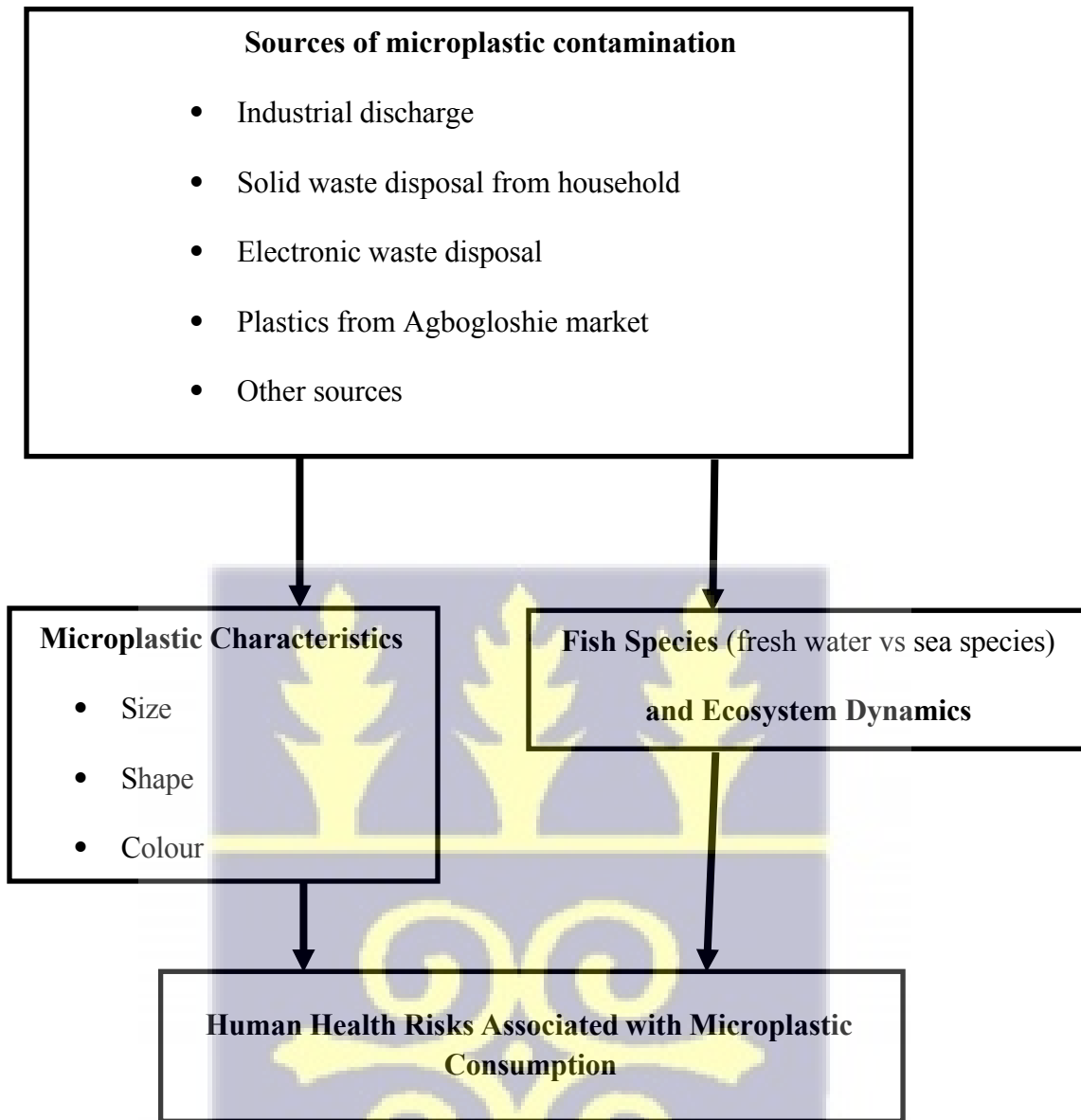
Efforts to address microplastic pollution in aquatic environments have been implemented in various countries, including the introduction of regulations to reduce plastic waste and the promotion of sustainable waste management practices (Güven *et al.*, 2017). Mahu *et al.* (2023) further emphasized the implications of microplastic contamination for food safety in West Africa by estimating annual human intake of microplastics based on the consumption of whole fish.

Their findings suggested that common fish species in coastal waters may contribute significantly to human microplastic exposure, with estimated annual intakes exceeding 100,000 microplastic particles per adult for some species. These findings reflect a growing body of evidence linking microplastic pollution in fish to broader human health risks in the region. Despite these alarming findings, policy responses in Ghana remain limited. While preliminary environmental regulations exist, specific interventions aimed at mitigating microplastic contamination—particularly in urban aquatic ecosystems like the Korle Lagoon—are still underdeveloped. Existing literature points to an urgent need for localized and comprehensive studies that quantify microplastic contamination and identify specific pollution sources, particularly in fish species consumed by the urban poor (Mahu et al., 2023).

Microplastic contamination in fish species commonly consumed in the region has become a growing concern, highlighting the urgent need for focused research to investigate the levels, types, and associated health. Understanding the specific types and quantities of microplastics in these species is essential for developing evidence based public health policies and interventions to mitigate the risks of consuming contaminated fish. This study addresses the pressing issue of microplastic pollution in the Korle Lagoon, providing critical insights to inform future research and guide initiatives aimed at protecting both the environment and public health in Ghana.

### **1.3 Conceptual Framework**

The conceptual framework for this study visually represents the relationships between the various components involved in microplastic contamination in fish from the Korle Lagoon and its implications for public health. It is structured around four main components: sources of microplastic contamination, microplastic characteristics, fish species and ecosystems, and human health risks.



**Figure 1.1: Conceptual Framework**

*Source: Researcher's own conceptualization*

### 1.3.1 Narrative for conceptual framework

The conceptual framework of this study is grounded in interdisciplinary models drawn from environmental health risk assessment and ecological toxicology. It is primarily informed by the Source–Pathway–Receptor (SPR) model, which links pollution sources to environmental and biological receptors through defined exposure pathways. Additionally, the Ecological Risk Assessment (ERA) framework and elements of the Adverse Outcome Pathway (AOP) model are used to frame the biological and health implications of microplastic exposure in aquatic ecosystems.

#### 1. Sources of microplastic contamination

Aligned with the ‘source’ component of the SPR model, this component identifies the key anthropogenic activities contributing to microplastic pollution in urban water systems such as the Korle Lagoon. These include informal landfilling, industrial effluents, urban runoff, and domestic waste inputs. The accumulation of plastics is exacerbated by poor infrastructure and socio-environmental pressures. Understanding these sources is essential for exposure characterization in risk assessment models and for identifying entry points for regulatory intervention.

#### 2. Microplastic Characteristics and Bioavailability

This component corresponds to the ‘pathway’ in the SPR model and draws from ecotoxicological principles to explain how the physical and chemical properties of microplastics determine their environmental behavior and uptake by biota. Characteristics such as size, shape, and surface chemistry influence bioavailability and trophic transfer. For example, smaller particles are more likely to be ingested and translocate into fish tissues. The AOP model supports

this by tracing a mechanistic pathway from molecular interaction (e.g., oxidative stress) to adverse outcomes (e.g., tissue damage or endocrine disruption). This component is critical in understanding the hazard identification and dose-response stages of the ERA framework.

### 3. Fish Species and Ecosystem Dynamics

Representing the ‘receptor’ element in the SPR model, this component emphasizes biological susceptibility based on ecological and species-specific traits. Feeding behavior, trophic level, and habitat influence the likelihood and degree of microplastic ingestion. The ERA framework further supports the need to evaluate species sensitivity distributions and ecosystem-level consequences, particularly for species that serve as ecological indicators or subsistence resources. This component helps contextualize exposure within real biological systems and strengthens the ecological validity of the findings.

### 4. Human Health Risks and Exposure Pathways

This component extends the SPR model to human receptors and integrates with established Human Health Risk Assessment (HHRA) frameworks. Here, the ingestion of fish contaminated with microplastics—particularly muscle tissues—acts as the primary exposure route. Potential toxicological risks are informed by studies on chemical leachates (e.g., phthalates, BPA) and the bioavailability of adsorbed pollutants. The inclusion of vulnerable populations (e.g., communities dependent on local fisheries) aligns with the risk characterization phase in HHRA. This framing emphasizes the translation of ecological contamination into public health implications.

### 5. Policy and Public Health Interventions

While not a component of the SPR model itself, this segment reflects its application and policy

translation, particularly in the context of risk management—a final step in both ERA and HHRA frameworks. By identifying critical control points (e.g., waste discharge sites, fish consumption patterns), the framework can guide the development of targeted environmental policies, regulatory tools, and health advisories. It also aligns with the One Health paradigm, which underscores the interconnectedness of environmental, animal, and human health.

#### Relationship between Components

The conceptual relationships map coherently onto the Source–Pathway–Receptor model, which is widely used in environmental risk assessment. Microplastic sources lead to environmental dissemination via physical and biological pathways, modulated by microplastic characteristics. Fish species act as ecological receptors, with contamination outcomes influenced by species-specific and ecological traits. In turn, human populations become secondary receptors through dietary exposure. Integrating the ERA and AOP models adds depth to this framework, allowing for mechanistic interpretation of observed contamination patterns and their health implications. Ultimately, the framework supports a translational research model that connects scientific evidence to policy and public health action.

#### 1.4 Justification

The justification for this study stems from the urgent need to address the growing concern of microplastic contamination in aquatic environments, particularly in the Korle Lagoon in Accra, Ghana. Given that fish from the Korle Lagoon represent a significant dietary component for local communities, it is essential to investigate the levels of microplastic contamination in these fish species comparing it with the predominant fish from the sea (Gulf of Guinea) consumed by the local communities

Understanding the levels and types of microplastics in fish from Korle Lagoon is critical for assessing the potential health risks associated with their consumption. Studies indicate that microplastics can contain harmful chemicals and pollutants that may leach into fish tissues, posing risks to human health upon ingestion (Smith *et al.*, 2018; Mahu *et al.*, 2023). By quantifying microplastic contamination, this research can inform stakeholders about the safety of fish consumption in the area, thereby enhancing food safety and public health.

In addition, the findings of this study fill a critical gap in the existing literature regarding microplastic contamination in aquatic ecosystems in Ghana. Although several studies have documented microplastic pollution globally, limited research has focused explicitly on the Korle Lagoon and its fish populations (Amponsah *et al.*, 2024). By providing localized data, this research can support environmental monitoring efforts and contribute to the development of effective mitigation strategies tailored to the unique challenges faced in Ghana.

### 1.5 Research Questions

1. What are the levels and sizes of microplastics found in different fish species commonly consumed from Korle Lagoon?
2. How do microplastic contamination levels vary among different fish species and across various locations within the Korle Lagoon?
3. What types of microplastics (including polymers, shapes, and colors) are present in fish from Korle Lagoon, and what might be their potential sources?
4. What is the level of microplastic contamination levels in the lagoon compared to the sea?
5. What are the potential health risks of consuming fish from the Korle Lagoon contaminated

with microplastics?



## 1.6 Study Objectives

### 1.6.1 General Objective

This study aimed to quantify microplastic contamination in fish from the Korle Lagoon and adjacent Gulf of Guinea.

### 1.6.2 Specific Objectives

1. To identify and quantify the presence of microplastics—by number, shape, size, and colour—in selected fish species commonly harvested from the Korle Lagoon and the adjacent sea (Gulf of Guinea), and assess interspecies variation in microplastic characteristics.
2. To statistically compare microplastic concentrations across different fish species and tissue types (gut, gill, muscle), and evaluate whether observed differences are significant using Multivariate Analysis of Variance (MANOVA).
3. To infer the potential sources and types of microplastics based on the distribution of physical properties (colour, shape, size) and, where applicable, polymer composition, thereby linking microplastic profiles to likely anthropogenic activities.
4. To assess spatial differences in microplastic contamination levels between fish sampled from the Korle Lagoon and those from the sea, using MANOVA to determine the statistical significance of site-based variation.
5. To evaluate the potential human health risks associated with consuming microplastic-contaminated fish, particularly by examining contamination in muscle tissues in relation to toxicological thresholds established in the literature.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

The scientific literature reviewed in this section was done based on search of relevant literature from online databases such as Science Direct, PubMed, Hinari, Google Scholar, African Journals Online, and ResearchGate. Microplastic contamination of aquatic ecosystems has emerged as a critical global issue due to its pervasive presence and potential health risks. Fish, as a significant component of the human food chain, are particularly vulnerable to microplastic ingestion, which can result in bioaccumulation and adverse health effects (Mahu et al., 2023; Bhuyan, 2022). This literature review examines existing research on microplastic contamination in fish, its implications for human health, and the relevance of these findings to the Korle Lagoon in Ghana.

#### 2.2 Microplastics in Freshwater Ecosystems

Microplastics are defined as plastic particles less than 5 mm in size, either produced intentionally or resulting from the breakdown of larger plastic debris (Rochman et al., 2019). They can be categorized into two main types: primary microplastics, which are manufactured to be small for use in personal care products, industrial scrubbers, and plastic pellets, and secondary microplastics, which are derived from the fragmentation of plastic waste through environmental degradation (Rodríguez-Seijo & Pereira, 2017). This classification is essential for understanding the different pathways through which microplastics enter aquatic ecosystems and ultimately affect human health.

Historically, the presence of plastics in the environment became a prominent issue in the mid-20th century when plastic production skyrocketed because of its versatility and low cost (Güven

et al., 2017). However, concerns about its persistence and accumulation in the environment were not widely acknowledged until the 1970s when researchers first documented the existence of tiny plastic particles in oceanic waters (Smith et al., 2018). This initial discovery spurred further investigation of the environmental impact of plastics, culminating in the recognition of microplastics as a pervasive pollutant in marine and freshwater environments by the early 2000s (Lusher et al., 2020).

Plastic waste management has been a growing concern in Ghana as urbanization and population growth have increased plastic consumption and improper disposal (Awewomom et al., 2024). Korle Lagoon, located in the capital city of Accra, is a notable example of severe plastic pollution, as it receives significant amounts of plastic waste from surrounding communities and industrial activities (Gbogbo et al., 2023). The lagoon, which once served as a critical resource for fishing and recreation, has become heavily polluted, posing risks to the ecosystem and the health of the population that relies on its resources.

Microplastic pollution in aquatic environments, particularly in fish species, has gained significant attention because of its potential human health implications. Studies have shown that fish can ingest microplastics either by directly consuming contaminated water or by consuming prey that has already ingested microplastics (Roch et al., 2021). Once inside fish, microplastics can accumulate in the gastrointestinal tract, gills, and other tissues, which may eventually lead to their presence in fish consumed by humans (Li et al., 2020). In Ghana, where fish is a staple food source, understanding the level of microplastic contamination in fish from polluted water bodies, such as the Korle Lagoon, is crucial (Nuamah et al., 2023).

Previous studies on microplastic contamination in aquatic ecosystems have revealed that the size and type of microplastics vary widely, with most particles being smaller than 1 mm and

composed of polymers, such as polyethylene, polypropylene, and polystyrene (Garrido Gamarro et al., 2020). These polymers are commonly used in packaging, single-use plastics, and other everyday items and break down into microplastics over time when exposed to environmental factors such as sunlight and wave action (de Vries et al., 2020). Alberghini et al. (2022) further emphasized that microplastic ingestion can have toxic effects on fish, leading to oxidative stress, immune dysfunction, and reduced growth, affecting fish populations and their availability for human consumption.

A study conducted by Adika et al. (2020) in the Eastern Central Atlantic Ocean off the coast of Ghana found that both pelagic and demersal fish species ingested microplastics, with higher concentrations observed in fish species that feed closer to the seafloor. This finding suggests that bottom-dwelling fish may be more prone to ingesting microplastics because of their feeding habits and the accumulation of plastic debris in benthic environments. Similarly, in a study of fish from the Gulf of Guinea, Pappoe et al. (2022) observed the presence of microplastics in the gastrointestinal tracts of various fish species, further indicating that microplastic contamination is widespread in Ghana's coastal waters.

The ingestion of microplastics by fish is of concern not only for marine and freshwater ecosystems but also for human health. Once ingested by humans, microplastics can cause physical damage, lead to inflammation, and act as vectors for harmful chemicals and pathogens (Smith et al., 2018). Several studies have highlighted the potential of microplastics to adsorb toxic substances, such as persistent organic pollutants (POPs), heavy metals, and endocrine-disrupting chemicals from the surrounding environment (Makhdoumi et al., 2023). When fish contaminated with microplastics are consumed by humans, these chemicals may be released into the body, potentially leading to adverse health effects such as hormonal imbalances, immune

system disruption, and an increased risk of cancer (Barboza et al., 2020).

Despite growing awareness of the risks posed by microplastics, research on the extent of microplastic contamination in fish from inland water bodies such as the Korle Lagoon remains limited. However, studies from other regions suggest that urbanized and industrialized areas are particularly vulnerable to microplastic pollution owing to higher levels of plastic waste production and improper waste management practices (Boahen et al., 2023). In Ghana, addressing this issue requires better waste management systems and greater public awareness of the dangers of plastic pollution and the need for sustainable practices (Awewomom et al., 2024).

### **2.3 Sources and Distribution of Microplastics**

Microplastics, defined as plastic particles smaller than 5 mm, have become widespread environmental pollutants, particularly in aquatic ecosystems. These particles are distributed through various direct and indirect sources, primarily through the breakdown of larger plastic debris and the release of plastic pellets during manufacturing processes (Barboza et al., 2020). Understanding the sources and distribution of microplastics is critical for assessing their prevalence in local fish species, such as those in the Korle Lagoon and their potential risks to human health.

#### **2.3.1 Sources of Microplastics**

The primary sources of microplastics in aquatic environments are categorized as primary and secondary microplastics. Primary microplastics, such as microbeads used in cosmetics, industrial abrasives, and pre-production plastic pellets, are deliberately manufactured to be minor (Awewomom et al., 2024). These particles enter the environment through various pathways, including industrial waste discharge, surface runoff, and accidental spillage during transportation

(Addo et al., 2022). In coastal areas, like the Korle Lagoon, where industrial activities and urban waste disposal are prevalent (Kyeremeh et al., 2023), primary microplastics are likely to make a significant contribution to the overall microplastic burden.

Secondary microplastics result from the degradation of larger plastic items, such as bottles, bags, and fishing gear, through physical, chemical, and biological processes (Amponsah, 2021). The degradation of these items is accelerated by environmental factors, such as UV radiation, wave action, and microbial activity, which break the plastic into progressively smaller fragments (Bhuyan, 2022). This process is particularly relevant in areas surrounding the Korle Lagoon, where high levels of plastic waste compounded by poor waste management practices contribute to the ongoing release of secondary microplastics into the water.

Textile fibers are another vital source of microplastics, especially in urban areas. Synthetic fibers from clothing, such as polyester and nylon, are released during washing and enter water bodies through untreated or partially treated wastewater (Nuamah et al., 2023). Given the dense population and industrial activities in the vicinity of the Korle Lagoon, it is likely that microfiber pollution contributes to the microplastic contamination observed in the area's aquatic life.

### **2.3.2 Distribution of Microplastics**

Microplastic distribution in aquatic environments is influenced by various factors, including water currents, wind, and the physical characteristics of the particles themselves, such as size, shape, and density (Rodríguez-Seijo & Pereira, 2017). Lighter, buoyant particles remain suspended in the water column, while denser particles sink and accumulate in sediments (Bošković et al., 2021).

Studies have shown that microplastics are unevenly distributed within water bodies, with higher

concentrations typically found near urbanized or industrialized coastal regions, such as the Korle Lagoon, where human activities are more intense (Gbogbo et al., 2023).

The accumulation of microplastics in sediments is particularly concerning, as these particles can become resuspended due to tidal movements, dredging, or storm events, leading to their re-entry into the aquatic food web (Simionov et al., 2023). In the Korle Lagoon, where waste disposal and industrial effluent discharge are common practices, sediments are expected to contain significant levels of microplastics. These sediments serve as microplastic reservoirs, contributing to their persistent presence in the water and eventual uptake by aquatic organisms, including fish (Kyeremeh et al., 2023).

Microplastics can also be distributed through marine organisms' ingestion and egestion processes. Studies have demonstrated that fish and other marine life ingest microplastics, which can then be excreted or accumulate in their tissues (Lusher et al., 2020). Once ingested, these particles may be transferred along the food chain, leading to bioaccumulation at higher trophic levels (de Vries et al., 2020). This process is a significant concern for human health, as consuming fish contaminated with microplastics may pose risks due to the associated toxic substances, such as heavy metals and persistent organic pollutants (Garrido Gamarro et al., 2020).

## **2.4 Microplastic Contamination of Fish**

### **2.4.1 Presence of Microplastics in Fish**

Numerous studies have reported the presence of microplastics in fish from various aquatic environments, including freshwater and marine ecosystems (Adika et al., 2020; Bošković et al., 2021). Fish ingest microplastics either directly by mistaking them for food or indirectly by

ingesting smaller organisms that have accumulated microplastics in their tissues (Lusher et al., 2020). In the Korle Lagoon, fish species commonly consumed by the local population are at risk of microplastic contamination due to the lagoon's proximity to heavily populated and industrialized areas, where plastic waste is abundant (Kyeremeh et al., 2023).

The ingestion of microplastics by fish can harm their health, such as physical damage to their digestive systems, reduced feeding efficiency, and impaired growth (Bhuyan, 2022). Moreover, microplastics can act as carriers for toxic chemicals, including heavy metals and persistent organic pollutants, which may be absorbed by fish and transferred to humans through consumption (Rochman et al., 2019).

#### **2.4.2 Characteristics of Microplastics**

Microplastics in aquatic environments vary in size, shape, color, and polymer composition, which can influence their environmental behavior and impact on organisms (Rodríguez-Seijo & Pereira, 2017). The size of microplastics plays a significant role in determining their interaction with fish and other marine life. Larger particles may be ingested by mistake, while smaller particles can be taken up by filter-feeding organisms or absorbed into fish tissues (Roch et al., 2021). Microplastics found in fish from the Korle Lagoon are likely to range in size from a few micrometers to several millimeters, depending on the source and degradation processes (Simionov et al., 2023).

The shape of microplastics also influences their interaction with organisms. Common shapes include fragments, fibers, films, and spheres, with fibers being particularly prevalent in urbanized areas due to the release of synthetic textile fibers from washing machines (Nuamah et al., 2023). In the Korle Lagoon, where household wastewater is often discharged untreated, fibers may be a dominant form of microplastic contamination. Fish quickly ingest these fibers

and can accumulate in their digestive tracts, leading to potential physical and toxicological harm (de Vries et al., 2020).

The color of microplastics can affect their likelihood of being ingested by fish, as brightly colored particles may be mistaken for prey (Lusher et al., 2020). Studies have shown that fish are more likely to ingest microplastics that resemble their natural food in color and size (Güven et al., 2017). In heavily polluted environments like the Korle Lagoon, where plastic debris is abundant, fish may ingest microplastics of various colors, increasing the risk of contamination.

Finally, the polymer composition of microplastics can provide insights into their sources. Common polymers in aquatic environments include polyethylene, polypropylene, and polystyrene, which are used in packaging, household products, and fishing gear (Addo et al., 2022). Identifying the types of polymers present in fish from the Korle Lake can help trace the sources of microplastic pollution and inform mitigation strategies.

## **2.5 Potential Health Implications of Microplastic Contamination in Fish**

The ingestion of fish contaminated with microplastics poses significant health risks to humans, raising concerns about the potential transfer of harmful chemicals and particles through the food chain (Garrido Gamarro et al., 2020). As microplastics accumulate in aquatic organisms, including fish, they can carry toxic substances such as heavy metals, persistent organic pollutants (POPs), and other chemical additives, which may enter human bodies upon consumption (Rochman et al., 2019).

### **2.5.1 Toxicological Effects of Microplastics**

Due to their small size, microplastics can interact with biological systems in various harmful ways. When ingested by fish, these particles may cause physical damage, such as inflammation

or obstruction in the digestive tract (Bhuyan, 2022). However, the primary concern for human health arises from the toxic chemicals that microplastics can carry. Studies have shown that microplastics adsorb pollutants from the surrounding environment, including heavy metals, bisphenol A (BPA), and polycyclic aromatic hydrocarbons (PAHs) (Rochman et al., 2019). These substances are known for their carcinogenic, endocrine-disrupting, and neurotoxic effects (Boahen et al., 2023).

In fish, microplastics act as vectors, allowing harmful chemicals to enter the food web and eventually be consumed by humans (Smith et al., 2018). Once ingested, these toxic substances may accumulate in human tissues, potentially causing long-term health issues (Bhuyan, 2022; Mahu et al., 2023). Exposure to microplastics and their associated chemicals has been linked to various adverse outcomes, including reproductive toxicity, immune system suppression, and metabolic disorders (Barboza et al., 2020). The persistence of these chemicals in the environment and their ability to bioaccumulate heighten concerns about chronic exposure through seafood consumption (Alberghini et al., 2022).

### **2.5.2 Bioaccumulation and Biomagnification**

Microplastics can enter the food chain through different pathways, and fish are particularly vulnerable due to their role as prey and predator in aquatic ecosystems (Garrido Gamarro et al., 2020). When fish ingest microplastics, the particles may remain in their digestive systems and transfer into their tissues, particularly the liver and muscles (Gad & Midway, 2022). As larger predators consume these contaminated fish, the microplastics and associated toxins accumulate at higher trophic levels, a process known as biomagnification (Wang et al., 2021).

In humans, consuming fish that contain microplastics can result in the accumulation of these particles in the body. While the extent of this accumulation and its direct impact on human health

is still being researched, evidence suggests that microplastics may lead to cellular stress, oxidative damage, and inflammation when ingested in significant quantities (Boahen et al., 2023). The long-term effects of microplastic exposure on human health remain uncertain, but the potential for chronic exposure through fish consumption is a growing concern (Mahu et al., 2023).

## **2.6 Current Knowledge and Research Gaps**

Current scientific research highlights the importance of studying microplastics and their health risks, but much remains unknown. Studies have demonstrated that humans are exposed to microplastics through various routes, including seafood consumption, drinking water, and inhalation (Rodríguez-Seijo & Pereira, 2017). However, the direct health impacts of microplastic ingestion from fish remain a subject of ongoing investigation (Barboza et al., 2020). Some researchers argue that the physical presence of microplastics in the human digestive system may lead to inflammation or gut dysbiosis. In contrast, others focus on the potential chemical toxicity caused by the release of harmful substances (de Vries et al., 2020).

In addition, the size and shape of microplastics may influence their ability to pass through biological barriers and reach vital organs. Smaller particles, known as nano plastics, may be absorbed more readily by human tissues, posing a greater health risk (Roch et al., 2021). Understanding how different types of microplastics interact with human physiology is essential for assessing the full extent of the potential health risks.

## **2.7 Critical Analysis of Regional Studies**

The literature review includes a broad range of global studies which is important to critically analyze and compare regional studies from Ghana. For instance, the study by Adika et al. (2020) in the Eastern Central Atlantic Ocean off the coast of Ghana provides valuable insights into the

ingestion of microplastics by both pelagic and demersal fish species. The study found that the frequency of occurrence of microplastics in fish species followed the order: *Sardinella maderensis* (41%) > *Dentex angolensis* (33%) > *Sardinella aurita* (26%). The mean numbers of microplastics ingested were  $40.0 \pm 3.8$ ,  $32.0 \pm 2.7$ , and  $25.7 \pm 1.6$  for *S. maderensis*, *D. angolensis*, and *S. aurita* respectively. Industrially produced pellets were the most dominant (31%) microplastic type, followed by microbeads (29%), burnt film plastics (22%), and unidentified fragments (9%). Microfibers (2%), threads (2%), and foams (<0.1%) were the least occurring microplastics in the fish species. Condition factors estimated for *D. angolensis* and *S. aurita* were >1 and below 1 for *S. maderensis*. The findings of the study show the common occurrence of microplastics in fish stocks and pave the way for future studies on microplastics in this region.

Similarly, the study by Pappoe et al. (2022) on fish from the Gulf of Guinea underscores the widespread nature of microplastic contamination in Ghana's coastal waters. The study found that microplastics were abundant in all investigated samples, with 68% of the fishes contaminated with microplastics and a total of 133 plastic items identified in the fish. The presence of fibers, black colored particles, and microplastics in the size range of 0.5–1.0 mm was the most abundant in the samples examined. Three polymers specifically, polyethylene, polyvinyl acetate, and polyamide were identified in the study. The presence of microplastics in the fishes investigated may pose severe ecological and health concerns, and hence comprehensive policies targeted at preventing plastic pollution of Ghana's maritime environment are warranted.

Moreover, the research by Nuamah et al. (2023) on the Gulf of Guinea provides a detailed analysis of microplastic concentrations and distribution in sediments, gills, and guts of fish. The study found an average concentration of  $0.144 \pm 0.061$  items/g (dry weight) in the sediment, with

pellets and transparent particles being the most common types. The concentration of microplastics in contaminated fish ranged from 8.35 to 20.95, with fibers and pellets being the most abundant plastic-type in fish. Individual organ concentrations of microplastics varied. In fish gills, concentrations ranged from 1 to 26 MPs/individual for *I. africana* and 1–22 MPs/individual for *S. maderensis*. Concentrations in the fish guts ranged from 1 to 29 MPs/individual for *I. africana* and 2–24 MPs/individual for *S. maderensis*. Results from the study highlight the importance of both gills and guts as important organs in terms of microplastic contamination and emphasize the significance of monitoring microplastic contamination in fish gills and guts. This offers valuable insight into the impact of microplastics on the marine environment and human health.

By integrating these regional studies, the literature review contextualizes the findings and provides a more comprehensive understanding of the microplastic contamination in the Korle Lagoon. This highlights the unique challenges and opportunities for mitigating microplastic pollution in Ghana. The higher concentrations observed in bottom-dwelling fish, as reported by Adika et al. (2020), suggest that targeted interventions in benthic environments are necessary. The widespread contamination found by Pappoe et al. (2022) underscores the need for comprehensive policies to prevent plastic pollution in Ghana's maritime environment. Additionally, the detailed analysis of microplastic concentrations and distribution by Nuamah et al. (2023) emphasizes the importance of considering multiple pathways of microplastic entry into fish and the potential for bioaccumulation. These studies collectively provide a robust foundation for developing effective strategies to address microplastic pollution in the Korle Lagoon and other coastal regions of Ghana.

## CHAPTER THREE

### METHODS

#### 3.1 Study Design

This study employed a cross-sectional observational design to investigate microplastic contamination in fish sampled from the Korle Lagoon and the adjoining Gulf of Guinea. The design involved the collection and analysis of fish specimens at a single point in time to determine the presence, concentration, and characteristics of microplastics in edible fish tissues.

The cross-sectional approach was selected primarily because it enables efficient, cost-effective assessment of contamination levels across multiple species and sampling sites within a defined period. Given the exploratory nature of this research, which seeks to establish baseline data on microplastic pollution in an under-studied urban aquatic system, a cross-sectional design offers a practical starting point for characterizing the extent of contamination and identifying potential exposure risks to human consumers.

Although longitudinal designs can provide valuable insights into seasonal or interannual trends in microplastic pollution, they typically require extended time frames, sustained funding, and logistical resources that were beyond the scope of this study. Moreover, the infrastructure for long-term monitoring in the Korle Lagoon is currently limited. Therefore, this cross-sectional design is well-aligned with the study's immediate objectives: to provide a snapshot of current contamination levels and to inform future monitoring efforts, risk assessments, and policy development.

Future research can build upon these findings by implementing longitudinal or time-series designs to examine temporal variations and long-term trends in microplastic contamination within the lagoon and adjacent marine ecosystems.

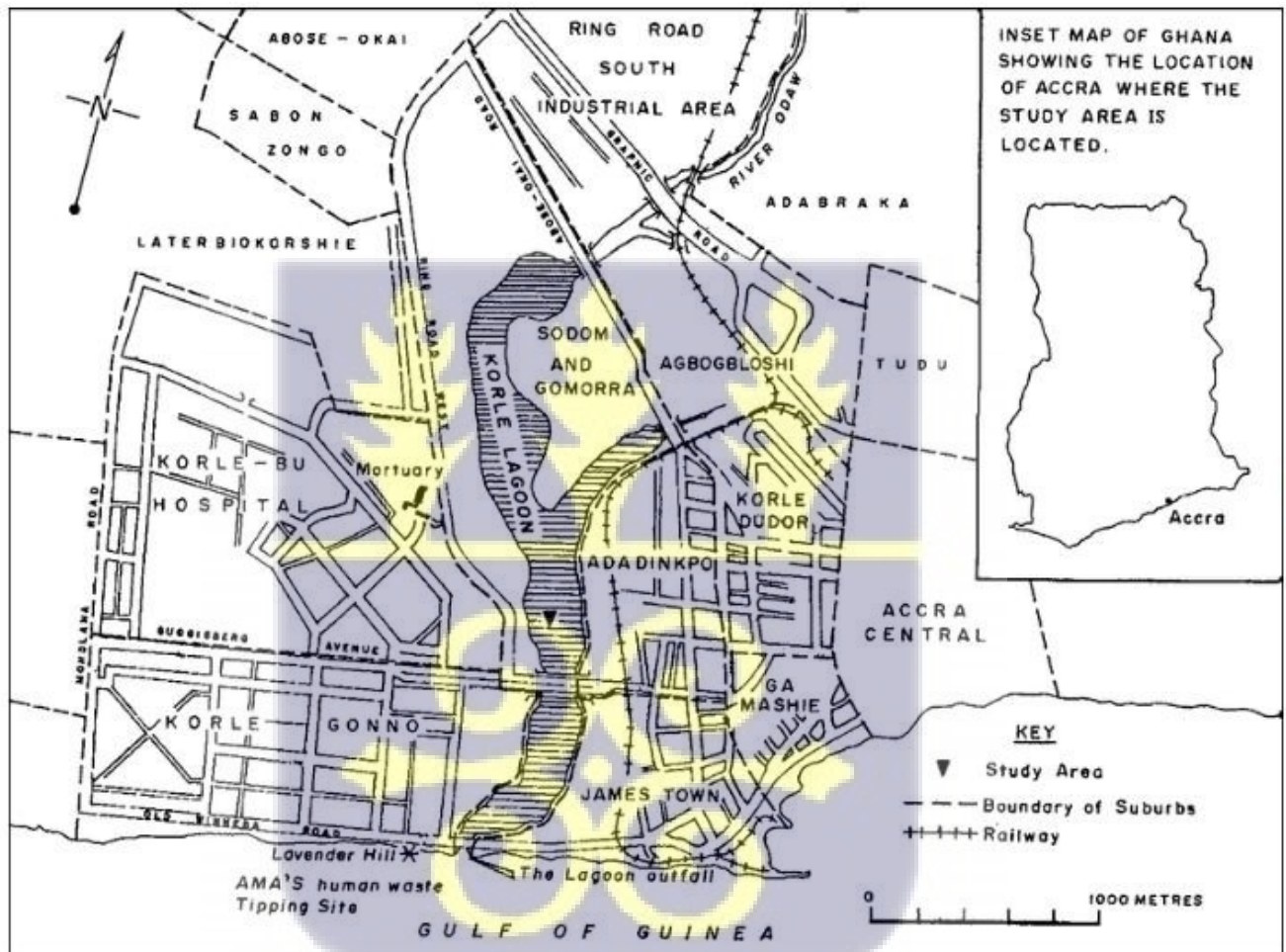
### 3.2 Study Area/Site

The study was conducted at the Korle Lagoon and the adjoining sea of the Gulf of Guinea. The Korle Lagoon is a major water body situated in Accra, the capital of Ghana, and it plays a vital historical and economic role in the region. However, over the years, it has become severely degraded by pollution. The lagoon receives inflows from various sources, most notably from the Odaw River. Originating in the Akwapim Mountains, the Odaw River traverses Accra, collecting urban runoff, industrial discharge, and domestic sewage before emptying into the lagoon. This riverine input contributes significantly to the pollutant load of the lagoon, as it carries waste from both rural and urban areas.

The urban drainage systems of Accra, coupled with direct discharges from industries, exacerbate the contamination. In particular, the Agbogbloshie market and its adjacent informal e-waste recycling site have emerged as critical pollution sources. Agbogbloshie is notorious for its unregulated recycling practices, where discarded electronic devices are dismantled manually. These operations release hazardous substances including heavy metals like lead and cadmium, as well as plastic residues into the environment. These pollutants are eventually washed into the Odaw River and accumulate in the Korle Lagoon.

Furthermore, the densely populated Korle Klottey Municipality, located just west of Accra's city center, intensifies the pollution problem. The area's combination of industrial activities, informal settlements, and inadequate waste management practices leads to the discharge of large volumes of both industrial and domestic waste into the lagoon. This constant influx of pollutants makes the lagoon a hotspot for microplastic contamination, posing significant environmental and public health risks, particularly as local communities rely on fish from this water body for their sustenance.

Overall, the convergence of water from the Odaw River, the influence of urban runoff, and the direct impact of e-waste recycling at Agbogbloshie create a complex pollution dynamic. This makes the Korle Lagoon not only a critical site for studying microplastic contamination but also a focal point for understanding broader environmental and public health challenges in rapidly urbanizing regions.



Map of the Korle Lagoon, Accra, and its environs (Source: Survey Department of Ghana, Accra).

**Figure 3.1: Map of Korle Lagoon**

Source: Survey Department of Ghana, 2024



**Figure 3.2: Picture of Korle Lagoon**

*Source: Researcher field work, 2024*

### **3.3 Study population**

The study population consisted of species of fish commonly harvested from the Korle Lagoon or adjacent sea and consumed especially by local communities nearby or sold on various food markets. The most dominant and commonly consumed fish species were selected for the study.

Fish were obtained from the Korle Lagoon and the adjacent sea to compare the level of contamination between fresh water fish in the lagoon and that from the sea, since water from the lagoon empties directly into that portion of the sea. By focusing on fish regularly consumed by

patrons, the study aimed to provide some data on the public health risk of consumption of fish from these two sources.

### **3.4 Sampling Method and Sample Size**

Fish specimens were obtained directly from local fishermen operating along the Korle Lagoon and the adjoining coastal waters of the Gulf of Guinea. The fishermen assisted in identifying and selecting commonly available and widely consumed fish species from each location. A total of 150 fish specimens were sampled, comprising 100 individuals from the lagoon and 50 from the sea, to reflect both the ecological characteristics of the sites and the dietary patterns of local communities.

Although the sample size may appear modest relative to the overall fish diversity in these ecosystems, it was strategically determined based on feasibility, logistical constraints, and the exploratory nature of the study. The primary aim was to establish baseline data on microplastic contamination in edible fish species, rather than to conduct a comprehensive biodiversity survey. Furthermore, the selected sample allowed for representation across multiple species and habitats, while enabling detailed laboratory analysis, which is time- and resource-intensive.

Potential sampling biases, such as seasonal variation in microplastic accumulation, are acknowledged as a limitation. Samples were collected during a single season (Rainy season), which may not fully capture seasonal fluctuations in contamination levels due to rainfall patterns, fishing activity, or hydrological changes. However, the choice of sampling period was informed by the period of peak fish availability and fishing activity, ensuring access to species that are most commonly consumed by the public.

Future research should build upon this foundational work by incorporating seasonal or longitudinal sampling strategies, which would enhance understanding of temporal dynamics in microplastic pollution and its impact on food safety.

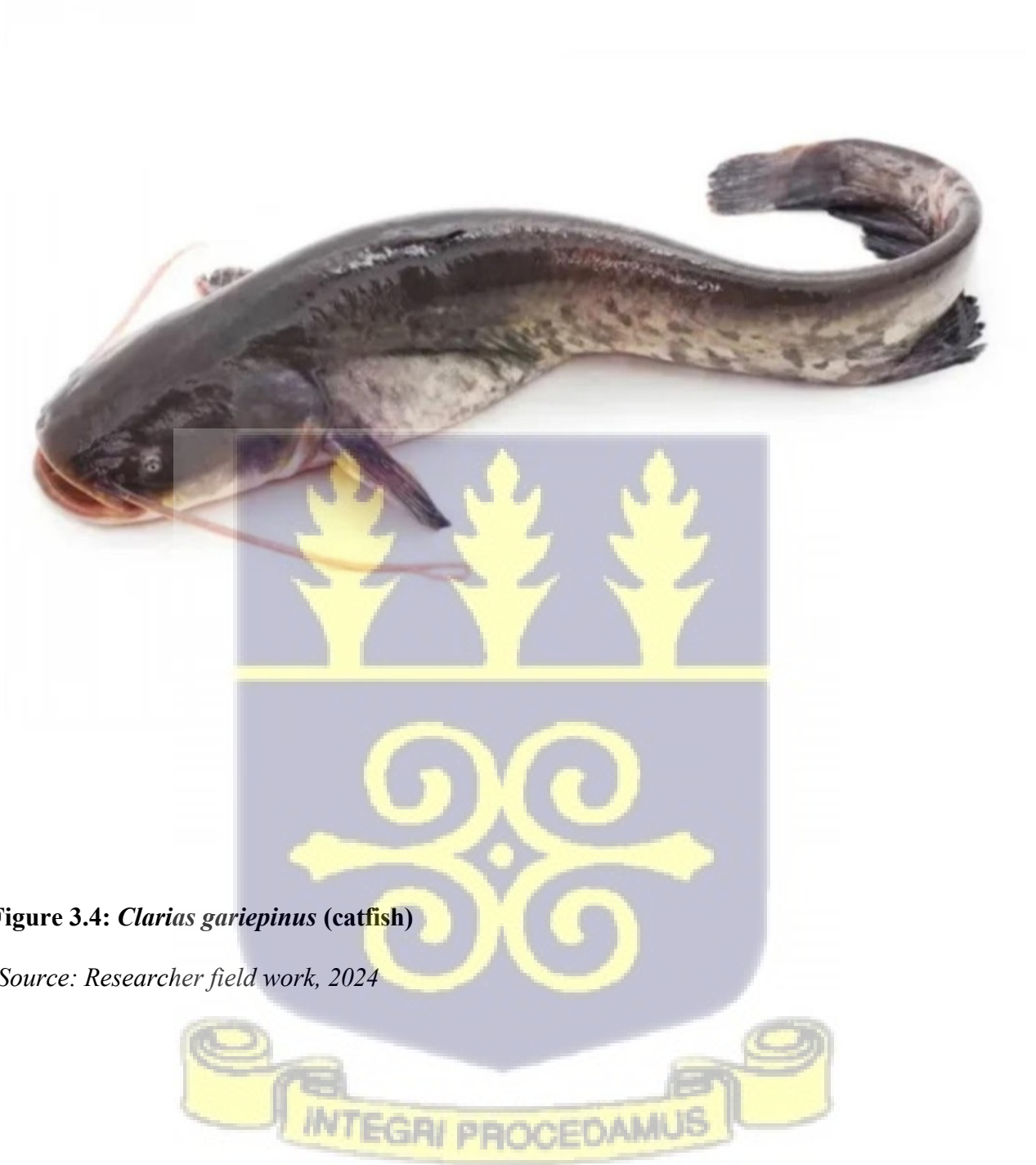
### Samples from the Lagoon



**Figure 3.3: Oreochromis niloticus (Tilapia)**

*Source: Researcher field work, 2024*





**Figure 3.4: *Clarias gariepinus* (catfish)**

*Source: Researcher field work, 2024*

### Sample from the sea



**Figure 3.5:** *Alectis alexandrinnus* (Silver Trevally)

*Source: Researcher field work, 2024*

### 3.5 Laboratory analysis of microplastics in fish

Once the fish samples were obtained, they were kept on ice in an ice chest and transported to the Material Science laboratory at the school of engineering, University of Ghana for analysis. First, each fish was properly identified by an expert, then dissected to separate the gastrointestinal tract and gills from the body. The extraction of microplastics was conducted using chemical digestion with a 10 percent concentration, a pH of 12 into 10ml of potassium hydroxide (KOH) to break

down organic matter in each sample. After digestion, the solution was filtered using a 0.45 µm pore-size GF3 Grade glass microfiber filter paper by CHMLAB Group to capture the microplastic particles effectively.

A combination of visual inspection using a stereomicroscope and Fourier-transform infrared (FTIR) spectroscopy, Model ALPHA manufacturer by Bruker Optics in Germany was used to identify and quantify microplastics. The stereomicroscope model MSC-ST7045T manufactured in China by Infitek Company Limited was employed to examine the morphology and physical properties of the microplastics, while FTIR spectroscopy was used to determine the polymer types of the microplastic particles.

### **Visual Sorting and Classification (Morphology Analysis)**

This involves categorizing microplastics based on their shape. Common classifications include:

**Fibers:** Thin, thread-like particles

**Fragments:** Irregularly shaped pieces.

**Films:** Thin, sheet-like pieces.

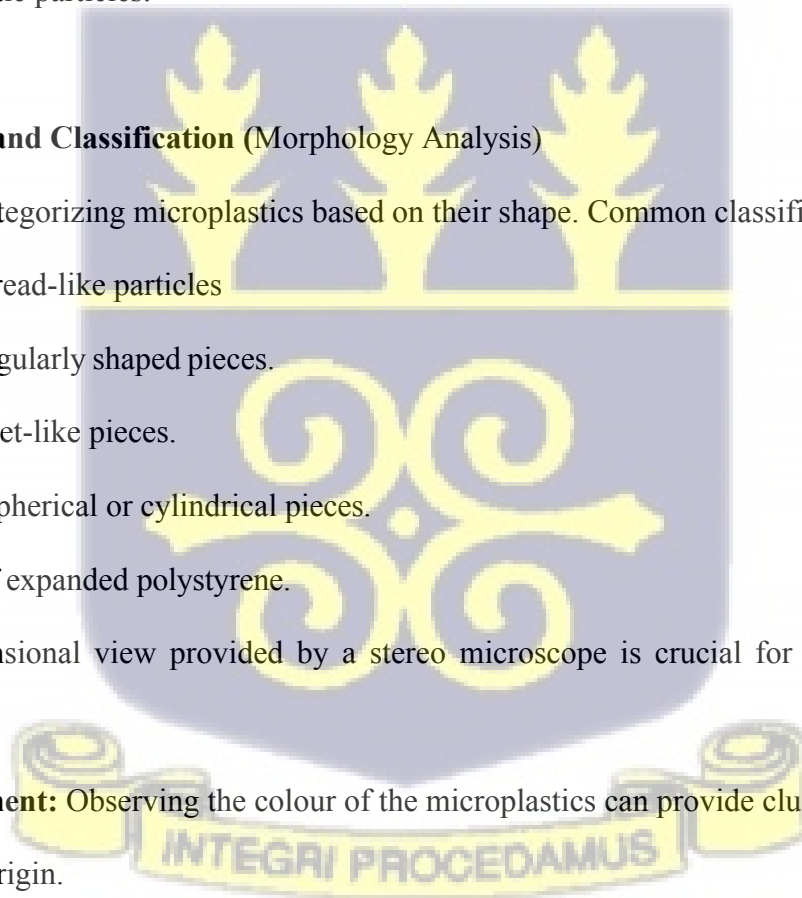
**Pellets:** Small, spherical or cylindrical pieces.

**Foam:** Pieces of expanded polystyrene.

The three-dimensional view provided by a stereo microscope is crucial for accurate shape determination.

**Colour Assessment:** Observing the colour of the microplastics can provide clues about the type of plastics and origin.

**Size measurement:** Using calibrated reticles or software within the microscope to measure length, width and other dimensions of the microplastic particles.



## Observational Techniques

Bright-field Microscopy is used, where light is transmitted through the sample after which careful observation of the texture is done. This helps in distinguishing between plastic and non-plastic particles.

## Polymer Identification

Fourier-transform infrared (FTIR) spectroscopy involves shining infrared (IR) light onto a sample. Different chemical bonds within a material absorb specific wavelengths of IR light and the FTIR instrument measures which wavelengths of IR are absorbed by the sample.

This data is transformed into a spectrum, which is a graph showing the amount of light absorbed at each wavelength and the resulting spectrum is compared to a database of known polymer spectra and by matching the absorption patterns, the specific type of plastic present in the microplastic sample can be identified.

FTIR can accurately identify various types of plastics such as polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and others.

### 3.6 Selection Criteria

#### 3.6.1 Inclusion Criteria

Fish species were selected based on three key scientific and practical considerations:

1. **Human Consumption and Public Health Relevance:** Only species that are widely consumed by local communities were included, due to their importance in dietary exposure assessments and food safety risk evaluations. The selected species—*Clarias gariepinus*, *Oreochromis niloticus*, and *Alectis alexandrinnus*—are among the most

commonly marketed and ingested fish in the study areas, thus posing a higher likelihood of human microplastic intake.

2. **Ecological and Trophic Characteristics:** Species were chosen to represent a range of ecological niches and feeding behaviors. *C. gariepinus* and *O. niloticus* are benthic or demersal feeders, which are more likely to ingest microplastics embedded in sediments, while *A. alexandrinnus* is a pelagic predator. This allowed for comparative analysis across trophic levels and habitat types, consistent with approaches used in similar microplastic bioaccumulation studies (e.g., Mahu et al., 2023; Bhuyan et al., 2022).
3. **Bioindicator Suitability:** The selected species have been previously identified in regional studies (Nuamah et al., 2023; Adu-Boahen et al., 2023) as suitable bioindicators for monitoring environmental contamination due to their abundance, resilience, and tendency to bioaccumulate pollutants.

Information on local fish consumption patterns was corroborated through interviews with artisanal fishermen and fishmongers, to ensure contextual relevance and practical feasibility in sample acquisition.

### 3.6.2 Exclusion Criteria

Fish species Fish species that did not meet the above criteria were excluded from the study.

Specifically, species that are:

- Rarely consumed or of minimal dietary importance;
- Ecologically redundant with already selected species (e.g., similar feeding niche or habitat);

- Not readily available during the sampling period, leading to potential inconsistencies in data representativeness;
- Too small to yield sufficient tissue for standardized laboratory analyses.

This exclusion ensured methodological consistency and relevance of findings to both ecological monitoring and food safety assessment.

### **3.7 Study Variables**

The study variables were carefully selected to align with the research objectives and provide a comprehensive understanding of microplastic contamination in fish from the Korle Lagoon. The primary dependent variable was the presence of microplastics in fish. Independent variables included number, size, shape, color, and type of microplastic particles found in the fish.

### **3.8 Data Analysis**

Data analysis was conducted to assess the levels and characteristics of microplastic contamination in fish from the Korle Lagoon and the adjoining Gulf of Guinea, as well as to evaluate potential human health risks associated with fish consumption. All statistical analyses were performed using IBM SPSS Statistics 25.

The analysis began with descriptive statistics, including frequencies, percentages, medians, means, standard deviations, and 95% confidence intervals, which were used to summarize the number, types, sizes, shapes, and colors of microplastics found in fish tissues. Confidence intervals were particularly important in quantifying the precision of microplastic concentration estimates across species and tissue types, thereby enhancing the reliability of the findings.

Subsequently, inferential statistical methods were applied to identify significant patterns and variations in contamination:

- A three-way mixed Analysis of Variance (ANOVA) was conducted to assess the effects of three independent variables—fish species, tissue type (gills, gut, and muscle), and location (lagoon vs. sea)—on the abundance of microplastics. This allowed for the detection of main effects and interaction effects, thereby clarifying how ecological and anatomical variables influence contamination levels.
- Following any statistically significant ANOVA results, post-hoc multiple comparison tests were conducted using Tukey's Honestly Significant Difference (HSD) test for equal variances, or Games-Howell test when the assumption of homogeneity was violated. These tests were essential in identifying specific group differences (e.g., between tissue types or fish species), allowing for clearer interpretation of the nature and direction of the effects.
- A Multivariate Analysis of Variance (MANOVA) was further employed to evaluate whether the characteristics of microplastics—specifically shape, size, and color—varied significantly across different fish species and sampling locations. This multivariate approach provided deeper insights into how species-specific behaviors and spatial factors may affect microplastic retention profiles. For dependent variables found to be significant in MANOVA, follow-up univariate ANOVAs and Bonferroni-adjusted post-hoc comparisons were conducted to control for Type I error and to clarify which characteristics differed across the groups.

To ensure the validity of these statistical tests, the following assumptions were assessed:

- Normality of residuals was evaluated using the Shapiro-Wilk test and visual inspection of Q-Q plots. Where data violated normality assumptions, appropriate log transformations were applied prior to analysis.
- Homogeneity of variances was tested using Levene's test. In cases of significant heterogeneity, Welch's ANOVA was used as an alternative to standard ANOVA procedures.
- Multicollinearity in the MANOVA model was assessed using correlation matrices, while Box's M test was used to examine the equality of covariance matrices across groups.

In addition to these statistical procedures, spatial interpretation of microplastic distribution was conducted, considering proximity to known pollution sources (e.g., stormwater drains, dumping sites) and local anthropogenic activities. These contextual insights were used to hypothesize plausible contamination pathways.

Finally, the analytical findings were interpreted within the broader framework of existing toxicological and public health literature. This provided a scientific basis for understanding the potential health risks of microplastic ingestion through fish consumption and guided the development of relevant risk communication and mitigation strategies.

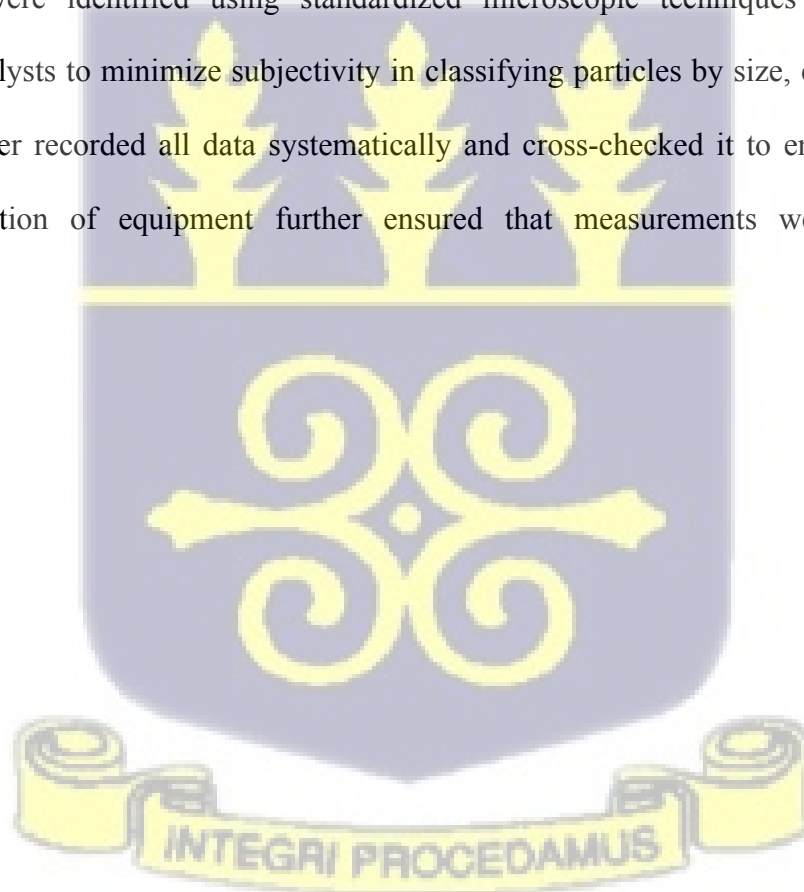
### 3.9 Quality Control

Quality control measures were essential to ensure the accuracy and reliability of the data collected in this study on microplastic contamination in fish from the Korle Lagoon. Standardized protocols

were followed throughout the sampling and laboratory analysis process to maintain data integrity. All fish samples were collected using sterile equipment to prevent cross-contamination from external sources of microplastics.

Good laboratory practices were followed during laboratory analysis prevent contamination during the microplastic extraction and identification process. Laboratory instruments were regularly cleaned with distilled water and controlled air environments were used to avoid introducing airborne plastic particles. To validate the results, analysis was done in replicates, and spiked controls were included to serve as positive control.

Microplastics were identified using standardized microscopic techniques and verified by experienced analysts to minimize subjectivity in classifying particles by size, color, and type. A second researcher recorded all data systematically and cross-checked it to ensure consistency. Regular calibration of equipment further ensured that measurements were accurate and reproducible.



## CHAPTER FOUR

### RESULTS

#### 4.1 Microplastics in fish

One hundred fish species comprising fifty *Clarias gariepinus* (catfish) and fifty *Oreochromis niloticus* (tilapia) were analyzed from the lagoon, as well as fifty *Alectis alexandrinus* (Silver Trevally) from the sea.

The results of the analysis provided valuable insights into the distribution of microplastics across different fish species from the lagoon with tissue types, as shown in Table 4.1. In *Clarias gariepinus* (catfish), microplastic abundance was highest in the gut tissues ( $8.16 \pm 1.56$ ). This was followed by the gills ( $6.82 \pm 1.24$ ) and then the muscles ( $4.32 \pm 0.98$ ). Similarly, in *Oreochromis niloticus* (tilapia), the gut also exhibited the highest levels of microplastics ( $7.78 \pm 1.42$ ), followed by the gills ( $5.94 \pm 1.18$ ) and the muscles ( $3.88 \pm 0.86$ ). In *Alectis alexandrinus* (Silver Trevally), the trend was consistent, with the gut showing the highest microplastic contamination ( $7.14 \pm 1.38$ ), followed by the gills ( $5.36 \pm 1.12$ ) and the muscles ( $3.72 \pm 0.82$ ) in Table 4.2.

Across all three species, the gut tissues consistently contained higher microplastic levels compared to gills and muscles, reflecting the ingestion pathways and the accumulation of debris in digestive organs. This pattern suggests that the gut is a primary site of microplastic retention in fish and potentially poses higher risks to humans consuming these fish without adequate gut removal.



**Table 4.1: Microplastic abundance by Fish Species and Tissue Type from the lagoon**

Species	Tissue Type	Median (Md)	Interquartile Range (IQR)	95% Confidence Interval (CI)
C. gariepinus	Gills	6	1.1	[5.65, 6.35]
	Gut	8	1.4	[7.55, 8.45]
	Muscle	4	0.85	[3.75, 4.25]
O. niloticus	Gills	6	1	[5.60, 6.40]
	Gut	8	1.3	[7.50, 8.50]
	Muscle	4	0.75	[3.60, 4.40]

Source: Field Data, 2024

**Table 4.2: Microplastic abundance by Fish Species and Tissue Type from the sea**

Species	Tissue Type	Median (Md)	Interquartile Range (IQR)	95% Confidence Interval (CI)
A. alexandrinnus	Gills	5	1	[4.80, 5.20]
	Gut	7	1.25	[6.75, 7.25]
	Muscle	4	0.75	[3.50, 4.00]

Source: Field Data, 2024



#### 4.2 Physical Characteristics of Microplastics Identified in Fish from The Lagoon and Sea

**Table 4.3: Physical Characteristics of Microplastics Identified in Fish from the Lagoon**

Characteristic	Category	Percentage (%)	Key Observations (Lagoon)
Shape	Fragments	48.2%	Most dominant, indicating plastic degradation from urban runoff and waste dumping.
	Fibers	33.8%	Lower than in the sea, likely from textiles and industrial wastewater.
	Films	14.5%	Plastic bags and wrappers from household and market waste.
	Pellets	3.5%	Some evidence of direct industrial plastic discharge.
Color	Black	41.2%	More abundant than in the sea, likely from tire wear, burnt plastics, and urban pollution.
	Transparent	25.4%	Degraded plastic films from packaging and waste materials.
	Green	16.8%	Colored plastics from synthetic materials and packaging.
	Red	11.5%	Dyed textiles, colored synthetic materials.
	Other Colors	5.1%	Miscellaneous sources of plastic waste.
Size ( $\mu\text{m}$ )	<100 $\mu\text{m}$	31.5%	Smaller particles suggest advanced breakdown in the lagoon.
	100–500 $\mu\text{m}$	52.6%	Majority of plastics are in this range, showing ongoing fragmentation.
	500–1000 $\mu\text{m}$	15.9%	Larger fragments from partially degraded plastics.

Source: Field Data, 2024



**Table 4.4: Physical Characteristics of Microplastics Identified in Fish from the Sea**

Characteristic	Category	Percentage (%)	Key Observations (Sea)
Shape	Fragments	44.50%	Lower than in the lagoon, but still dominant, showing oceanic plastic breakdown.
	Fibers	36.50%	Higher than in the lagoon, likely from fishing nets, ropes, and textile fibers from ocean currents.
	Films	17.20%	Degraded plastic materials from packaging and marine debris.
	Pellets	1.80%	Fewer industrial plastic sources compared to the lagoon.
Color	Black	35.60%	Lower than in the lagoon, suggesting less direct exposure to urban pollution.
	Transparent	28.10%	More abundant than in the lagoon, likely from marine plastic degradation.
	Green	20.30%	Fishing-related plastics, marine debris.
	Red	13.00%	Colored synthetic materials, possibly from packaging.
	Other Colors	3.00%	Miscellaneous plastics.
Size ( $\mu\text{m}$ )	<100 $\mu\text{m}$	28.90%	Fewer tiny particles than in the lagoon, indicating different breakdown rates.
	100–500 $\mu\text{m}$	56.90%	Most common size range, suggesting moderate degradation.
	500–1000 $\mu\text{m}$	14.20%	Larger microplastics, indicating early-stage fragmentation.

*Source: Field Data, 2024*

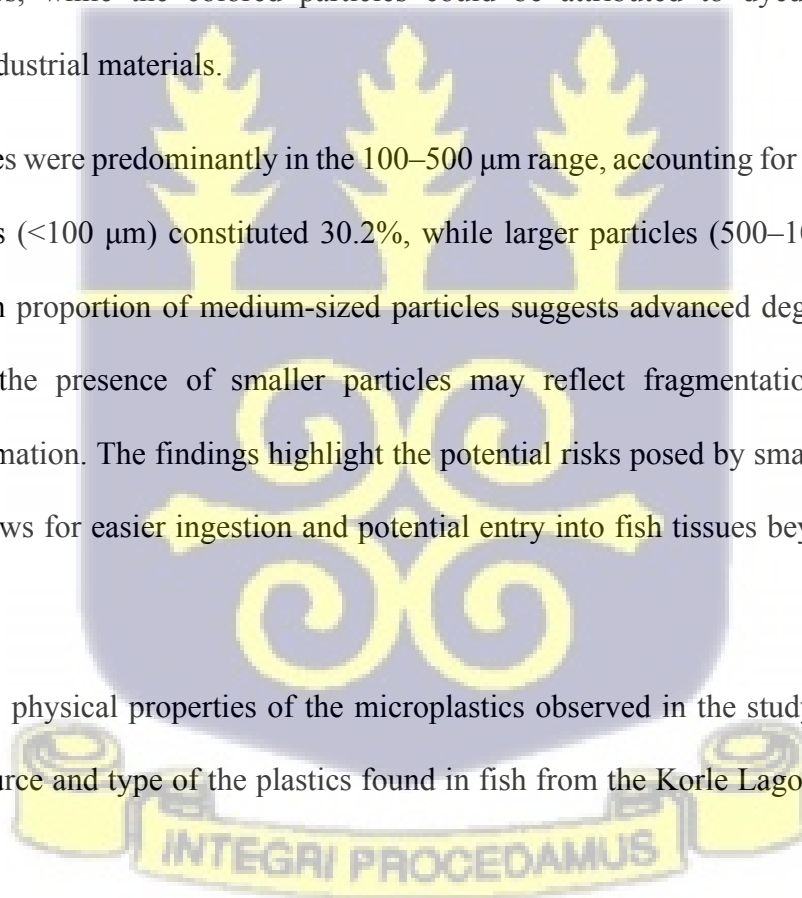
The characteristics of the microplastics across all samples further provided insights into the nature of contamination in the Korle Lagoon and the sea. Fragments were the most abundant shape of microplastics, constituting 46.5% of the total, followed by fibers at 35.2%. Films accounted for 15.8%, while pellets were the least common at 2.5%. The predominance of fragments and fibers

highlights the breakdown of larger plastic items and the presence of textile fibers likely originating from household or industrial wastewater. The smaller representation of films and pellets suggests limited direct industrial discharge or other sources of intact plastic materials.

In terms of color, black microplastics were the most prevalent (38.4%), followed by transparent particles (26.8%), green particles (18.6%), and red particles (12.2%). A small proportion of microplastics (4.0%) were categorized as "other" colors. The dominance of black microplastics could indicate a significant contribution from tire dust, burnt plastics, or other sources commonly associated with urban pollution. Transparent particles likely originate from packaging materials or degraded plastics, while the colored particles could be attributed to dyed textiles, colored packaging, or industrial materials.

Microplastic sizes were predominantly in the 100–500  $\mu\text{m}$  range, accounting for 54.8% of the total. Smaller particles (<100  $\mu\text{m}$ ) constituted 30.2%, while larger particles (500–1000  $\mu\text{m}$ ) made up 15.0%. The high proportion of medium-sized particles suggests advanced degradation of larger plastics, while the presence of smaller particles may reflect fragmentation and secondary microplastic formation. The findings highlight the potential risks posed by smaller microplastics, as their size allows for easier ingestion and potential entry into fish tissues beyond the digestive tract.

In summary, the physical properties of the microplastics observed in the study provide insights into both the source and type of the plastics found in fish from the Korle Lagoon and the nearby sea.



### Source of Microplastics

Fragments, which are most prevalent at 46.5%, are probably the result of bigger plastic objects including bottles, containers, and packaging materials breaking down as a result of contact to the environment.

Since synthetic fibers from clothing and fishing gear frequently wind up in aquatic habitats, fibers (35.2%), indicate textile and industrial wastewater pollution. Plastic bags and wrappers, which are frequently thrown away as urban waste, are shown to be degrading in films as (15.8%). Pellets (2.5%), indicate industrial waste or lost pre-made plastic pellets during production and shipping.

### Nature of Microplastics

Most microplastics were in the 100–500  $\mu\text{m}$  range (54.8%), indicating ongoing fragmentation of larger plastics. Also, smaller particles (<100  $\mu\text{m}$ , 30.2%) suggest advanced degradation, making them more likely to be ingested and absorbed into fish tissues.

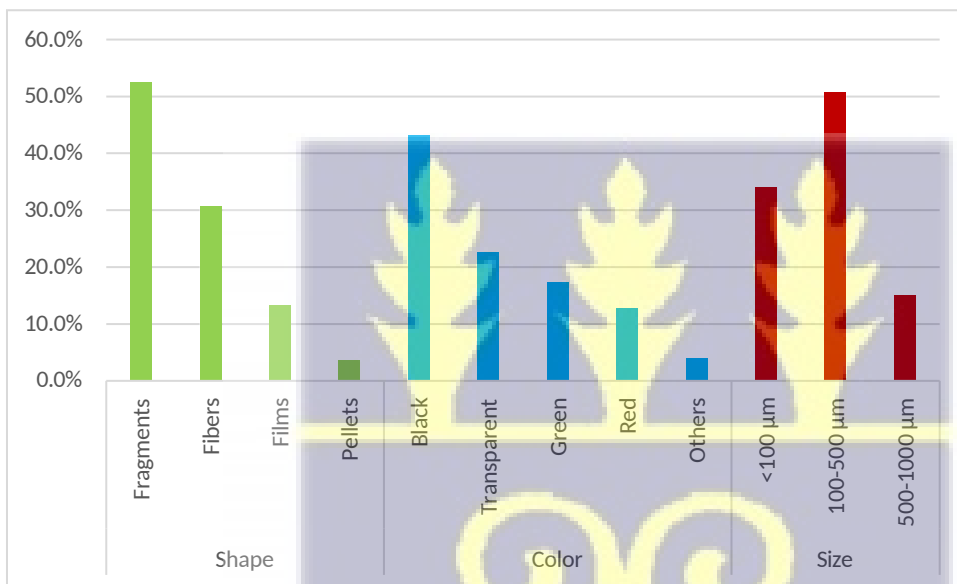
Moreover, larger particles (500–1000  $\mu\text{m}$ , 15.0%) were also present, indicating early-stage degradation.

**Color Distribution:** The prevalence of black (38.4%) and transparent (26.8%) microplastics indicates pollution sources related to urban waste from degraded plastic packaging materials as well as tire dust, burnt plastics, and industrial pollutants.

Green (18.6%) and Red (12.2%) possibly originates from fishing gear, synthetic materials, colored plastic waste and dyed textiles, synthetic industrial materials respectively.

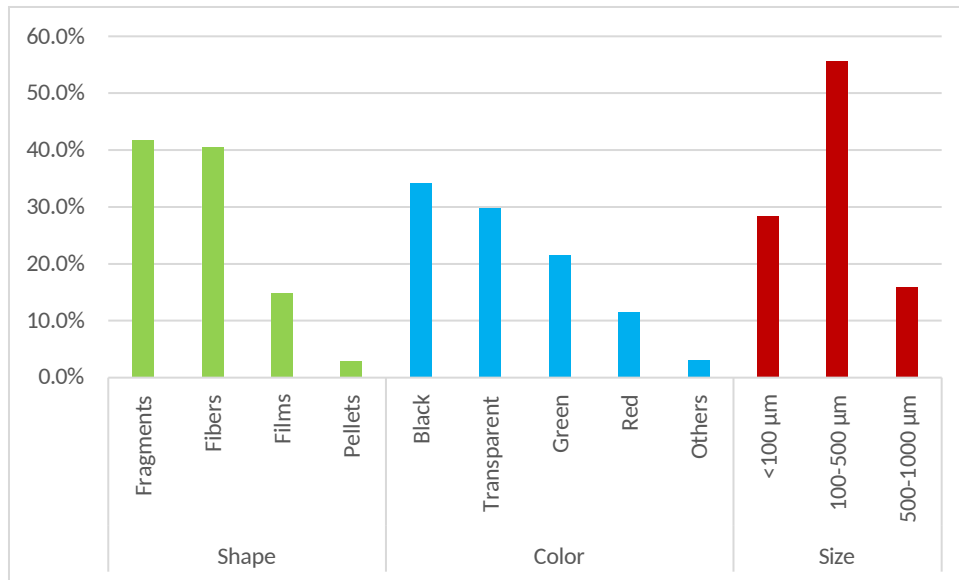
The dominance of fragments and fibers suggests that microplastic pollution in the Korle Lagoon and sea largely comes from urban waste, textile fibers, and plastic degradation rather than direct industrial plastic discharge.

The presence of small microplastics (<100  $\mu\text{m}$ ) highlights advanced breakdown stages, making them more hazardous due to their ability to be ingested at lower levels of the food chain.



**Figure 4.1: Physical Characteristics of Microplastics in Fish from the Lagoon**





**Figure 4.2: Physical Characteristics of Microplastics in Fish from the Sea**

#### 4.3 Comparing contamination levels of samples from the lagoon and the sea (Gulf of Guinea)

Fish samples from the lagoon exhibited significantly higher levels of microplastic contamination compared to those from the sea as shown in Figure 4.1. This disparity is likely due to the lagoon's relatively stagnant water, which facilitates the accumulation of pollutants, providing a more concentrated source of microplastic ingestion for fish.

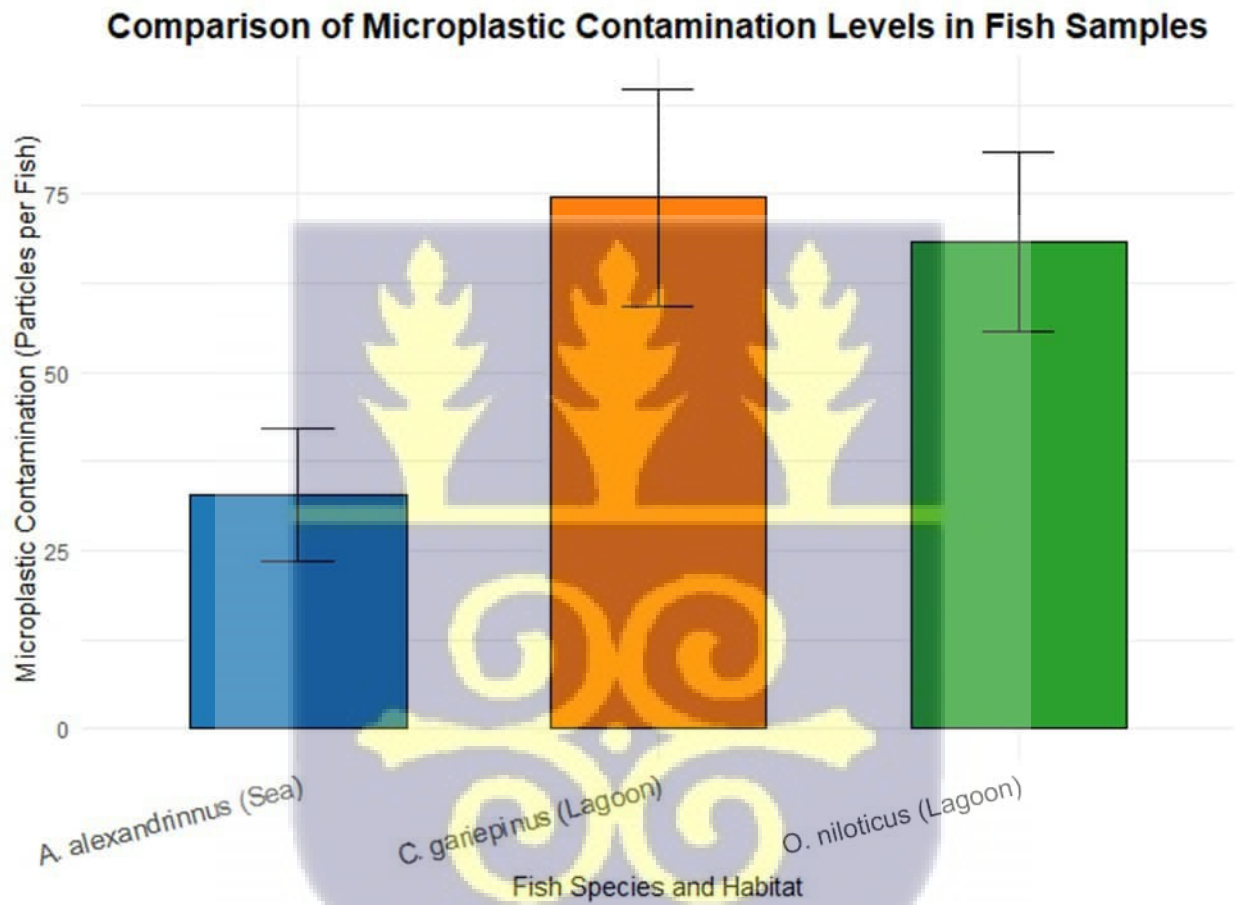
In contrast, the dynamic currents of the sea distribute pollutants over a wider area, reducing the exposure of individual fish species to microplastics.

However, the presence of microplastics in sea samples doesn't imply they are safe for consumption. Despite lower contamination levels than lagoon samples, fish from the sea still exhibited concentrations of microplastic which could pose potential risks to human health.

This could be attributed to the slow current's movement of water in the lagoon which is stagnant most of the time in which these species feed compared to fish samples from the sea which has

pollutants being distributed over a wide geographical area, minimizing the intake by fish species from the sea.

The presence of microplastic contamination in samples from the sea however does not make them safe for consumption as compared with samples from the lagoon as they also exhibited above average levels of microplastic contamination.



**Figure 4.3: Comparison of Microplastic Contamination Levels in Fish Samples**

Figure 4.4 presents the FTIR spectrum for *Clarias gariepinus* (catfish) and *Oreochromis niloticus* (tilapia), illustrating the characteristic absorbance peaks corresponding to identified polymers.

Polyethylene peaks appear at  $2915\text{ cm}^{-1}$  and  $2849\text{ cm}^{-1}$ , attributed to C-H stretching in methylene

groups. Polystyrene exhibits peaks around  $1600\text{ cm}^{-1}$  and  $1490\text{ cm}^{-1}$  (aromatic C=C stretching) and between  $700\text{--}800\text{ cm}^{-1}$  (C-H bending in the benzene ring). Cellophane peaks near  $1030\text{ cm}^{-1}$  and  $1160\text{ cm}^{-1}$ , correspond to C-O stretching vibrations in glycosidic linkages.

These results confirm significant microplastic contamination in *Clarias gariepinus*, reflecting the bioaccumulation of synthetic polymers in aquatic organisms. The findings highlight the urgent need for monitoring and mitigating plastic pollution in the Korle Lagoon, particularly given its proximity to industrial and urban centers. Addressing these issues requires enhanced waste management systems and stricter environmental regulations.

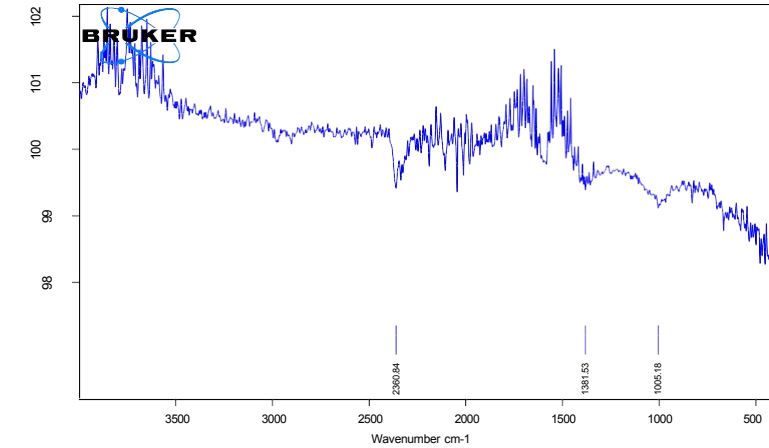
Also, the FTIR spectrum illustrates the types of polymers identified in *Oreochromis niloticus* (tilapia), specifically polystyrene (PS) and polyethylene (PE). These results provide molecular evidence of microplastic contamination in the Korle Lagoon.

Polyethylene exhibits characteristic peaks at approximately  $2915\text{ cm}^{-1}$  and  $2849\text{ cm}^{-1}$ , corresponding to the symmetric and asymmetric C-H stretching vibrations of methylene groups. These peaks are indicative of polyethylene's simple hydrocarbon chain structure. Polystyrene, a polymer with aromatic characteristics, is identified by peaks near  $1600\text{ cm}^{-1}$  and  $1490\text{ cm}^{-1}$  (aromatic C=C stretching) and a distinct peak between  $700\text{--}800\text{ cm}^{-1}$  (C-H out-of-plane bending in benzene rings).

The detection of polyethylene and polystyrene in *Oreochromis niloticus* reflects significant microplastic pollution in the Korle Lagoon, likely stemming from urban and industrial waste.

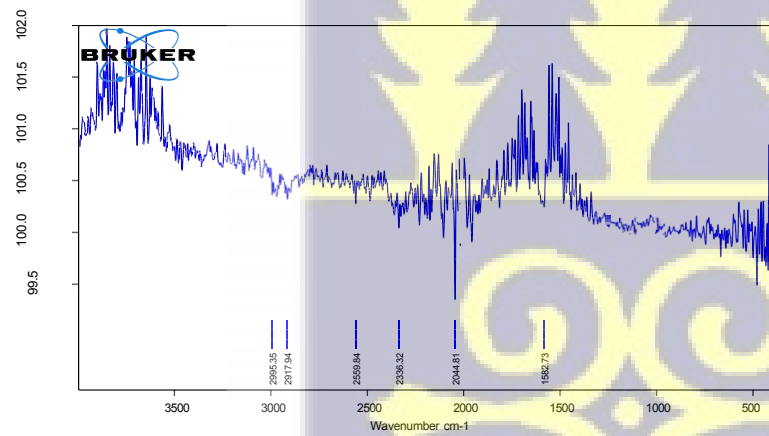
These findings highlight the role of aquatic organisms as reservoirs for synthetic pollutants, with potential ecological and human health implications. The bioaccumulation of microplastics in

edible fish species raises concerns about food safety for consumers and highlights the urgent need for effective waste management and pollution control measures.



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**Figure 4.4: Types of Polymers Found in Clarias Gariepinus (Catfish) and Oreochromis niloticus (tilapia)**

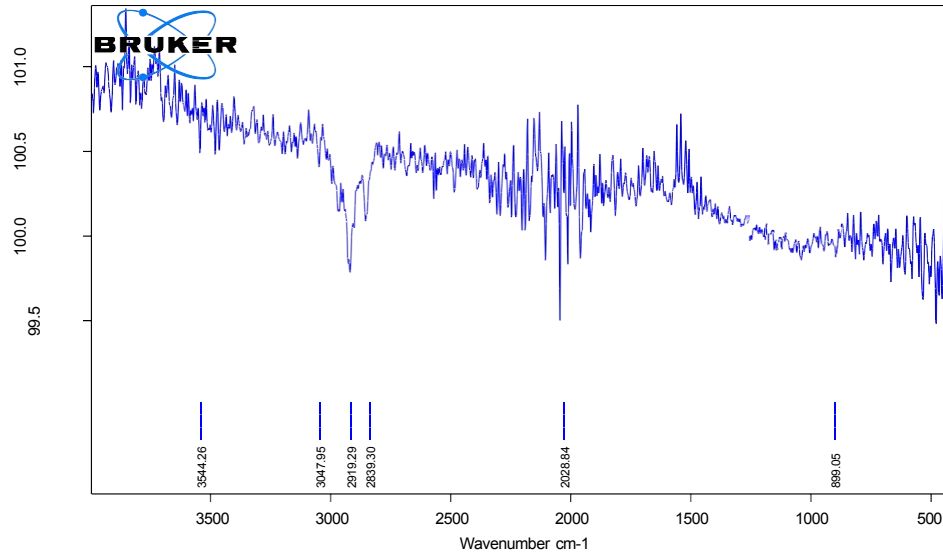


The FTIR spectrum shown in Figure 4.5 identifies the types of polymers present in *Alectis alexandrinnus*, including polypropylene, polyester, polyamide, and polyethylene. These findings provide insights into the prevalence of microplastic contamination in aquatic ecosystems.

Polypropylene exhibits characteristic peaks around  $2950\text{ cm}^{-1}$  and  $2839\text{ cm}^{-1}$ , corresponding to the asymmetric and symmetric C-H stretching vibrations in its methyl groups. These peaks reflect its widespread use in packaging materials, bottle caps, and household items. Polyester identified by distinct peaks near  $1715\text{ cm}^{-1}$ , attributed to C=O stretching of ester groups, and round  $1240\text{ cm}^{-1}$ , associated with C-O stretching, indicating contributions from textiles, plastic bottles, and industrial fabrics. Polyamide displays strong peaks near  $3300\text{ cm}^{-1}$ , indicative of N-H stretching vibrations, and around  $1640\text{ cm}^{-1}$ , corresponding to C=O stretching in amide bonds. These features suggest sources such as synthetic fibers, industrial bags, and chemical packaging. Polyethylene shows peaks at  $2915\text{ cm}^{-1}$  and  $2849\text{ cm}^{-1}$ , representing symmetric and asymmetric C-H stretching vibrations of methylene groups, commonly found in food wraps, and plastic bottles.

The presence of these polymers in *Alectis alexandrinnus* highlights the ingestion of microplastics, likely from environmental contamination in aquatic habitats. As a fish species of ecological and economic significance, its contamination raises concerns about biodiversity loss, ecosystem health, and potential risks to humans through the food chain.





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Page 1/1

**Figure 4.5: Types of Polymers Found in *Alectis alexandrinnus***

#### 4.4 Inferential Statistics

A three-way mixed ANOVA was performed to analyze the effects of species and tissue type on microplastic abundance, as shown in Table 4.5. The analysis revealed a significant effect of species on microplastic abundance,  $F(2, 147) = 42.86$ ,  $p < 0.001$ ,  $\eta^2_p = 0.368$ , indicating that microplastic levels varied significantly among the three species. Similarly, the effect of tissue type was significant,  $F(2, 294) = 186.24$ ,  $p < 0.001$ ,  $\eta^2_p = 0.558$ , suggesting considerable differences in microplastic abundance across the gills, gut, and muscles. Additionally, the interaction between species and tissue type was significant,  $F(4, 294) = 3.92$ ,  $p = 0.004$ ,  $\eta^2_p = 0.051$ , indicating that the relationship between tissue type and microplastic levels varied by fish species. This interaction likely reflects differences in feeding behavior, habitat, and physiological characteristics of each species, which influence the accumulation and retention of microplastics in specific tissues.

**Table 4.5: Three-way Mixed ANOVA Results for Microplastic Abundance**

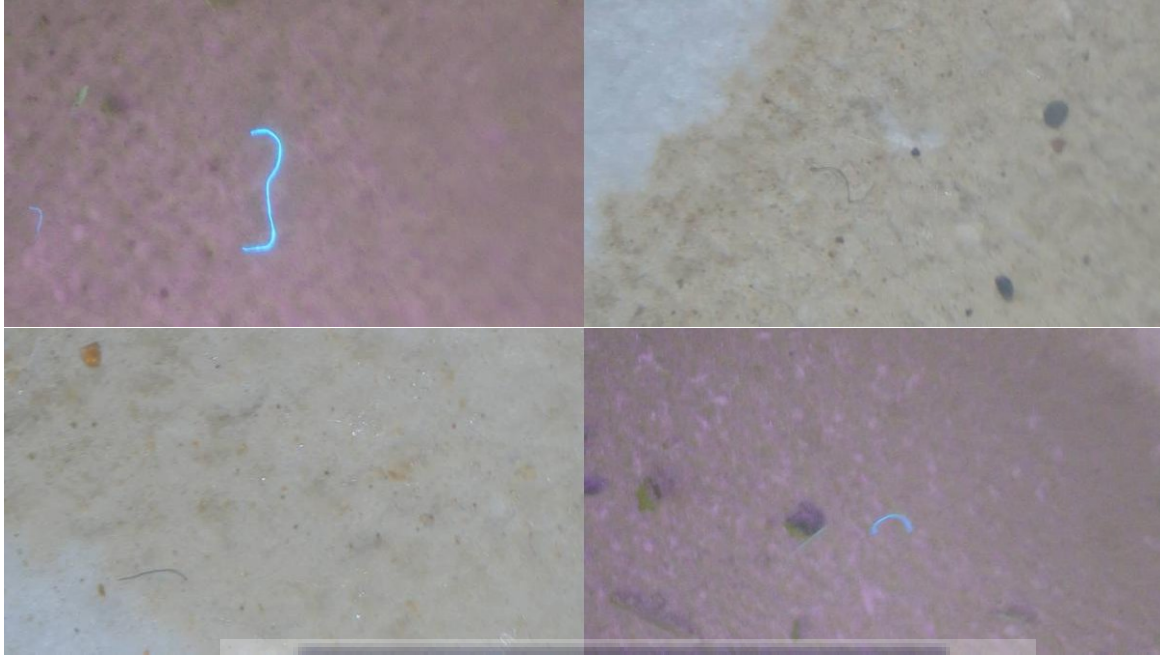
Source	df	F	p	$\eta^2p$
Species	2,147	42.86	<.001	0.368
Tissue Type	2,294	186.24	<.001	0.558
Species $\times$ Tissue Type	4,294	3.92	0.004	0.051
Error	294			

To further investigate species-specific differences in microplastic characteristics (shape, color, and size) a multivariate analysis of variance (MANOVA) was conducted as shown in Table 4.6. The results revealed a significant multivariate effect of species, Wilks'  $\lambda = .684$ ,  $F(6, 588) = 12.46$ ,  $p < 0.001$ ,  $\eta^2p = 0.172$ , indicating that microplastic characteristics varied significantly across the three fish species. Univariate analyses showed significant differences for microplastic shape, Wilks'  $\lambda = 0.726$ ,  $F(6, 588) = 15.82$ ,  $p < 0.001$ ,  $\eta^2p = 0.149$ ; color, Wilks'  $\lambda = 0.792$ ,  $F(8, 586) = 10.24$ ,  $p < 0.001$ ,  $\eta^2p = 0.116$ ; and size, Wilks'  $\lambda = 0.845$ ,  $F(4, 590) = 8.96$ ,  $p < 0.001$ ,  $\eta^2p = 0.084$ . These findings highlight significant species-specific differences in the shape, colour and sizes of microplastics ingested, which are likely influenced by variations in diet and habitats.

**Table 4.6: MANOVA Results for Microplastic Characteristics by Fish Species**

Effect	Wilks' $\lambda$	F	Df	p	$\eta^2p$
Species	0.684	12.46	6,588	<.001	0.172
Shape	0.726	15.82	6,588	<.001	0.149
Color	0.792	10.24	8,586	<.001	0.116
Size	0.845	8.96	4,590	<.001	0.084





**Figure 4.6: Pictures of Microplastics seen under Microscope**



## CHAPTER FIVE

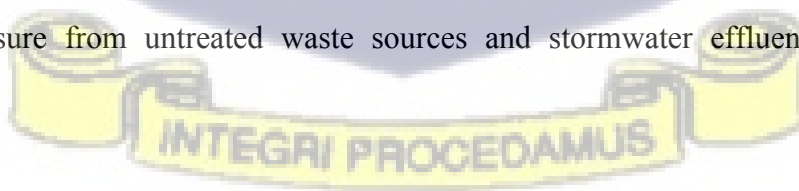
### DISCUSSION

#### 5.1 Discussion

##### 5.1.1 Prevalence and Distribution of Microplastics in Fish from Korle Lagoon and the Gulf of Guinea

This study confirms the ubiquity of microplastics in aquatic organisms from both freshwater and marine environments in Ghana. All three species examined—*Clarias gariepinus*, *Oreochromis niloticus*, and *Alectis alexandrinnus*—contained microplastics in their tissues, suggesting pervasive environmental contamination. The elevated prevalence of microplastics in *C. gariepinus*, particularly in muscle tissue, underscores the intensity of pollutant exposure in Korle Lagoon. This finding is aligned with earlier observations by Nuamah et al. (2023) but indicates even higher contamination levels, likely reflecting increased urban runoff, improper plastic disposal, and sediment-bound pollutants in this catchment (Aglanu & Appiah, 2014; Gbogbo et al., 2023).

Globally, comparable studies in heavily impacted systems such as the Chemu Lagoon (Adu-Boahen et al., 2023), the Liaohe Estuary in China (Wang et al., 2021), and the Montenegrin Coast of the Adriatic Sea (Bošković et al., 2021) have reported similar bioaccumulation patterns. However, the concentration observed in this study is distinctive for its consistent presence across edible tissues and the relative homogeneity of contamination, which may be attributed to prolonged exposure from untreated waste sources and stormwater effluents (Agbemabiese, 2020).



### 5.1.2 Tissue-Specific Accumulation and Interspecific Variation

Consistent with Mahu et al. (2023) and Jovanović (2017), the highest microplastic concentrations were detected in the gastrointestinal tissues, followed by gills and then muscle. This gradient underscores the physiological and anatomical susceptibilities of fish organs, with the digestive tract serving as the primary site for ingestion and retention.

Importantly, the statistically significant interspecific and inter-tissue variation ( $F(2,147) = 42.86$ ,  $p < 0.001$ ;  $F(2,294) = 186.24$ ,  $p < 0.001$ ) points to ecological and trophic-level influences on microplastic accumulation. *C. gariepinus* and *O. niloticus*, both benthic feeders, demonstrated higher microplastic burdens than the pelagic *A. alexandrinus*. This corroborates findings by Adika et al. (2020) and Gad and Midway (2022), who identified feeding strategy as a determinant of exposure. Such variations may also relate to habitat structure and sediment-particle interactions, as noted in freshwater species from Bangladesh (Parvin et al., 2021).

While de Vries et al. (2020) reported weak associations between microplastic load and physiological traits, the more pronounced differentiation observed here suggests that ecological conditions in tropical, urbanized systems might amplify species-specific vulnerability.

### 5.1.3 Characterization of Microplastics by Shape, Color, and Size

The microplastic profile was dominated by fragments (46.5%) and fibers (35.2%), a pattern consistent with degradation products of plastic bags, textiles, and automotive residues. The high prevalence of black-colored particles (38.4%) is particularly indicative of regional waste practices involving tire wear, burnt plastic, and electrical waste (Awewomom et al., 2024; Amponsah et al., 2024). FTIR spectroscopy confirmed the presence of polymers such as polyethylene, polypropylene, and polystyrene, commonly associated with these materials.

Compared to studies in industrial coastal zones such as Suzhou, China (Li et al., 2020), where synthetic fibers were dominant and black fragments largely absent from fish tissues, the present findings reflect a different contamination paradigm—one driven not by industrial production but by municipal neglect. Additionally, fish feeding from benthic zones and ingesting particles embedded in sediments appear more susceptible to ingesting charred or fragmented plastics from degraded urban refuse, reinforcing concerns raised by Onsrud (2023) and Amponsah (2021) about estuarine sediment contamination in Ghana.

Such differences highlight how the interaction between local socio-environmental factors and species-specific behaviors influences microplastic contamination profiles. Furthermore, the detection of smaller particles ( $<100\ \mu\text{m}$ ) in over 30% of the samples suggests a high potential for translocation into fish circulatory systems, with implications for trophic transfer and systemic toxicity (Roch et al., 2021).

#### **5.1.4 Toxicological and Ecological Implications**

The implications of these findings extend beyond contamination prevalence. Sub-lethal and chronic toxicological risks—including neurotoxicity, reproductive disruption, and oxidative stress—have been linked to microplastic ingestion in fish (Barboza et al., 2020; Bobori et al., 2022). While the muscle tissue displayed comparatively lower concentrations, it remains the primary edible component, raising concerns for food safety.

Bioaccumulation of microplastics in fish consumed by local communities introduces a persistent route of exposure for humans. Evidence from Addo et al. (2022) and Garrido Gamarro et al. (2020) indicates that ingested microplastics can act as vectors for toxic additives and adsorbed pollutants such as heavy metals and persistent organic pollutants (POPs). Simionov et al. (2023)

have emphasized the potential of such co-contaminants to exacerbate risks of endocrine disruption, gastrointestinal inflammation, and immunological responses.

Ecologically, the contamination of fish populations may impair reproduction, growth, and predator-prey interactions, thereby disrupting trophic dynamics in both lagoonal and marine ecosystems (Bhuyan, 2022; Markic et al., 2020). Findings from polluted coastal lagoons such as those in Tunisia (Digka et al., 2018) and Turkey (Güven et al., 2017) echo this, showing ecosystem-wide stress due to microplastic accumulation in commercially and ecologically significant species.

#### **5.1.5 Policy Relevance and Risk to Vulnerable Populations**

The observed contamination of muscle tissue, coupled with known toxicological pathways, demands targeted responses in public health and fisheries governance. Given that economically marginalized communities depend on fish from Korle Lagoon and coastal Ghana for protein intake (Kyeremeh et al., 2023), the potential for chronic low-dose exposure is non-trivial.

Current food safety policies do not adequately regulate microplastic content in seafood, partly due to the lack of established threshold limits. However, Alberghini et al. (2022) and Makhdoumi et al. (2023) call for precautionary limits and monitoring frameworks to address this emerging threat. There is an urgent need for localized health risk assessments and institutional responses that integrate microplastic surveillance into routine seafood safety programs.

Recommendations include:

- Mandatory testing of fish for microplastic content, particularly from high-risk water bodies;
- Strengthening enforcement of plastic waste regulations as outlined in Ghana's national

sanitation policy;

- Targeted education campaigns in high-consumption, low-awareness zones;
- Inclusion of microplastic exposure in health vulnerability assessments for women, children, and informal-sector fishers.

Such policy reforms will align with broader SDG 3 (Good Health and Well-being) and SDG 14 (Life Below Water) targets, ensuring a balance between ecosystem protection and public health resilience.

### **5.1.6 Contribution to Literature and Future Directions**

This study strengthens the body of empirical evidence on microplastic contamination in West African aquatic systems, complementing earlier work by Adu-Boahen et al. (2022), Amponsah (2021), and Pappoe et al. (2022). Importantly, it integrates FTIR-based polymer characterization to enhance diagnostic clarity—an approach still underutilized in regional assessments (Lusher et al., 2020; Rodríguez-Seijo & Pereira, 2017).

Beyond documenting prevalence, the study exposes the urgent need for ecological toxicology frameworks tailored to tropical freshwater-marine interfaces. Further research should explore histopathological effects in exposed species, biotransformation of plastic additives, and socio-economic impacts on artisanal fisheries. International comparisons with estuarine systems in Latin America and Southeast Asia may also yield transferable insights for policy harmonization and adaptive risk governance.

### **5.2 Public Health Implications**

The microplastic contamination patterns observed in fish species from the Korle Lagoon, Ghana

and the sea, present significant public health concerns that warrant careful consideration. The quantification of microplastic levels across different fish species and tissues has revealed several critical implications for human health through the food chain.

### ***Chemical Composition and Toxicological Implications***

The microplastics identified in this study predominantly consisted of polymer types such as polyethylene (PE) and polystyrene (PS), with fragments (46.5%) and fibers (35.2%) being the most common forms. The identification of these polymer types is significant because different polymers are associated with varying levels of toxic substances. For instance, polyethylene and polystyrene may carry additives such as plasticizers, flame retardants, and stabilizers, which can leach into the environment or tissues upon ingestion. This aligns with findings by Barboza *et al.* (2020), who emphasized that polymer composition plays a crucial role in determining the toxicological profiles of microplastics. Additionally, the high prevalence of black particles (38.4%) is noteworthy. These particles are often associated with pigments like carbon black, which have been linked to carcinogenic and toxic effects, as documented by Simionov *et al.* (2023).

### ***Vulnerable Populations and Exposure Risk***

The findings of this study, which revealed significant microplastic contamination in fish species from the Korle Lagoon, have important implications for populations that rely heavily on these fish for their protein intake. Specifically, the identification of high concentrations of polymer types such as polyethylene and polystyrene, along with black particles often linked to toxic additives, underscores the potential health risks for consumers.

These risks are particularly critical for vulnerable groups, such as pregnant women and children, who are more susceptible to the effects of microplastic-associated toxins. Bhuyan (2022)

highlighted that such populations face increased risks of endocrine disruption due to chronic exposure. Furthermore, Makhdoumi *et al.* (2023) emphasized that regular consumption of contaminated fish can lead to the bioaccumulation of harmful substances, amplifying health concerns for communities dependent on fish from polluted ecosystems like the Korle Lagoon.



## CHAPTER SIX

### CONCLUSION AND RECOMMENDATIONS

#### 6.1 Conclusion

This study demonstrated that fish from both the Korle Lagoon and the Gulf of Guinea are contaminated with microplastics, with the highest concentrations observed in gut and gill tissues, particularly in *Clarias gariepinus* (catfish). Although microplastic levels in muscle tissue were lower, their presence still raises concerns about human exposure through fish consumption. The predominance of black fragments and particles sized between 100–500 µm reflects ongoing plastic degradation in the environment, most likely sourced from urban runoff, tire wear, and improperly managed waste.

These findings underscore the broader issue of microplastic pollution in urban aquatic systems and its potential implications for both ecosystem health and food safety. However, the conclusions should be interpreted with consideration of certain limitations. The study employed a limited sample size, and data were collected within a single season. As such, seasonal variations—which may affect both pollution levels and fish behavior—were not captured. Future studies should therefore aim to incorporate larger and more temporally diverse samples to strengthen generalizability and detect seasonal trends in microplastic exposure.

Despite these limitations, the study effectively meets its objectives by identifying spatial and interspecific patterns in microplastic contamination, characterizing microplastic types, and highlighting potential health risks.

## 6.2 Recommendations

1. **Establish a Routine Monitoring Framework for Microplastics in Fish Tissues and Sediments (Short- to Medium-Term | Responsible Agencies: EPA Ghana, Fisheries Commission)**

The study confirms high levels of microplastics in gill and gut tissues of *Clarias gariepinus* and other commonly consumed fish species, particularly in the Korle Lagoon. A context-appropriate monitoring protocol should be introduced to track microplastic concentrations over time.

- **Actions:**

- Initiate quarterly sampling of gut and gill tissues from sentinel fish species.
- Use existing laboratories within CSIR-WRI and EPA Ghana to conduct FTIR-based polymer identification.
- Develop a national microplastic data repository under the Ministry of Environment, Science, Technology, and Innovation (MESTI).

- **Barriers:**

- Limited laboratory capacity and trained personnel.
- Need for external funding or academic partnerships for equipment maintenance and method standardization.

2. **Targeted Waste Management Interventions in the Korle Lagoon Catchment (Medium-Term | Responsible Actors: Accra Metropolitan Assembly, Zoomlion Ghana Ltd, Local NGOs)**

The predominance of fragmented microplastics in the sediments suggests advanced breakdown of macroplastics. Therefore, emphasis should be placed on removing macroplastics before

fragmentation and enhancing solid waste handling near aquatic interfaces.

- **Actions:**

- Conduct monthly cleanup exercises along the Odaw River and urban drains feeding into the lagoon, involving local waste contractors and community youth groups.
- Provide color-coded bins at key fish landing sites and enforce segregation of recyclable plastic waste.
- Offer financial incentives to informal waste collectors for recovering PET bottles and plastic packaging.

- **Feasibility Considerations:**

- Moderate cost, with potential for donor support (e.g., UNDP Ghana's plastic circularity projects).
- Requires public-private coordination and community buy-in.

### 3. **Strengthen Regulation of Industrial and Domestic Effluent Discharges (Long-Term | Responsible Agencies: Ghana Water Company Ltd, EPA, Ministry of Sanitation)**

The significant presence of black microplastics—likely from tire wear, synthetic textiles, and burnt plastics—suggests diffuse sources. This warrants a long-term regulatory strategy that is both sector-specific and spatially targeted.

- **Actions:**

- Map industrial hotspots along the Korle Lagoon and conduct quarterly effluent testing.

- Introduce pollutant discharge permits with microplastic thresholds for high-risk industries (e.g., auto-repair garages, e-waste recycling centers).
- Install decentralized silt traps and preliminary filters at stormwater outlets.

- **Barriers:**

- Enforcement capacity is low, especially for informal settlements.
- High initial investment required for effluent monitoring infrastructure.

4. **Promote Community-Based Education and Risk Communication**  
**(Short-Term | Responsible Actors: Ghana Health Service, Municipal Assemblies, Local CSOs)**

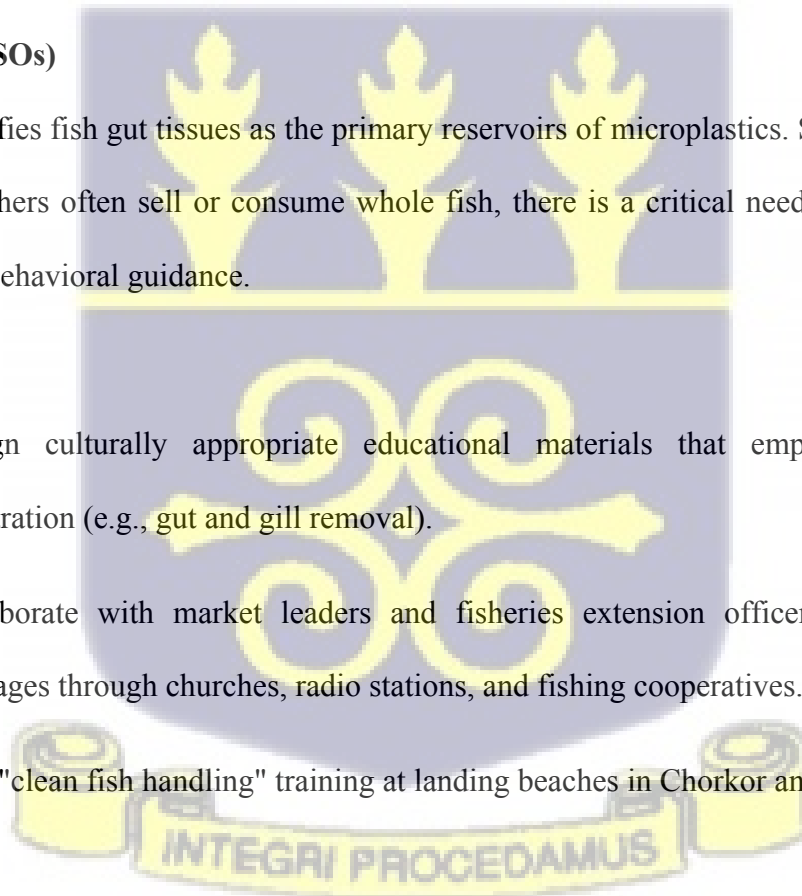
The study identifies fish gut tissues as the primary reservoirs of microplastics. Since fishmongers and artisanal fishers often sell or consume whole fish, there is a critical need for public health messaging and behavioral guidance.

- **Actions:**

- Design culturally appropriate educational materials that emphasize safe fish preparation (e.g., gut and gill removal).
- Collaborate with market leaders and fisheries extension officers to disseminate messages through churches, radio stations, and fishing cooperatives.
- Pilot "clean fish handling" training at landing beaches in Chorkor and Jamestown.

- **Feasibility:**

- High. Low-cost and easily scalable through existing public health outreach platforms.



**5. Invest in Applied Research and Technological Interventions  
(Medium- to Long-Term | Responsible Actors: Universities, GWCL, NGOs,  
Development Partners)**

To reduce microplastic inflows from point and non-point sources, applied research should focus on technologies that capture microplastics before they reach aquatic environments.

• **Actions:**

- Pilot low-cost microplastic filtration units at wastewater treatment facilities.
- Support student-led research on alternative biodegradable packaging.
- Collaborate with international partners (e.g., UNEP, FAO) to fund innovation hubs focused on marine pollution solutions.

• **Barriers:**

- Requires sustained funding and technical expertise.
- Policy uptake may be delayed without strong advocacy and proof of concept.

While the feasibility of the above recommendations varies by scale and institutional readiness, all are grounded in the empirical findings of the study. Strategic partnerships between government, academia, industry, and communities are essential to reduce microplastic pollution and protect public health along Ghana's coastal zones.



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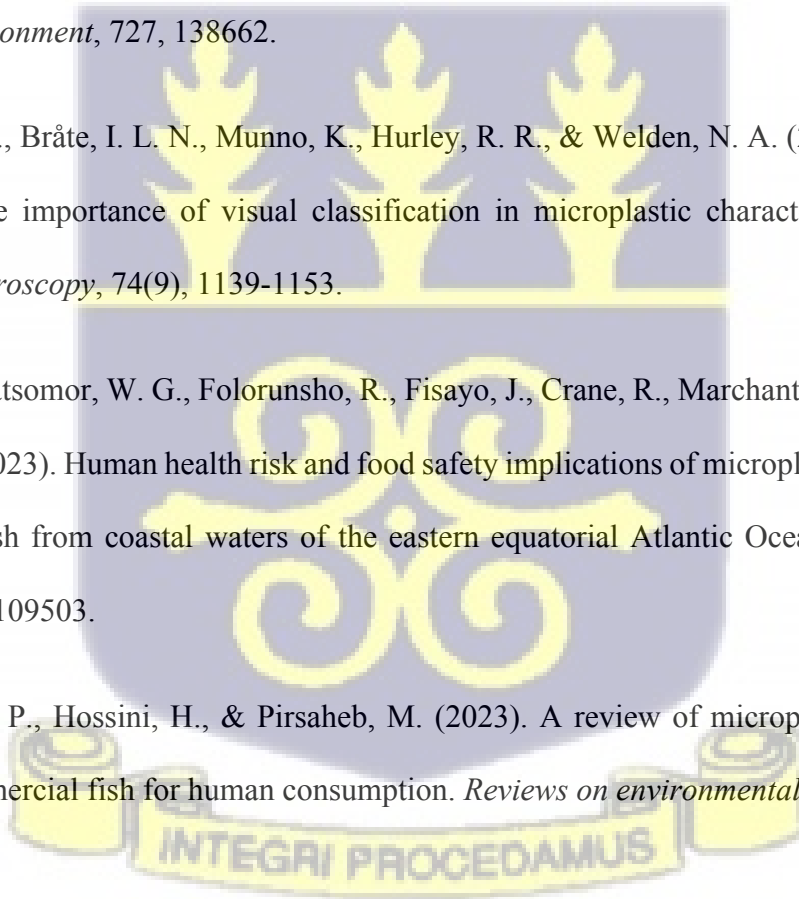
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