

**CONCENTRATION OF MINERALS IN TWO FISHES (*Parachanna
obscura* and *Malapterurus electricus*) FROM IKPOBA RIVER, EDO STATE,
BENIN CITY.**

BY

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UNIVERSITY OF BENIN,

BENIN CITY.

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**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF
ANIMAL AND ENVIRONMENTAL BIOLOGY,
FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY,
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE
AWARD OF DEGREE OF B.Sc. (HONS) IN ANIMAL AND
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OCTOBER, 2025.

CERTIFICATION

This is to certify that this project work was carried out by **Elizabeth Ishioma ONWUKA** with matriculation number **LSC2009725** in the Department of Animal and Environmental Biology, Faculty of Life Sciences, University of Benin, Benin City.

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(Head of Department)

DATE

DEDICATION

This work is dedicated to God Almighty, my late parents and siblings.

ACKNOWLEDGEMENT

All thanks to Almighty God for seeing me through in the course of this project work. My gratitude goes to the Head of Department, Animal and Environmental Biology (AEB) department, Prof. (Mrs.) Isioma Tongo for her leadership. A special thanks to my project supervisor, Dr. (Mrs.) Agali, for her guidance, motherly love, and support throughout this project. I will not forget Mr. Festus Arijode for always being there with us in the field where the samples were taken. I am also grateful to my colleagues Marvelous and Gabriel, as well as Sister Precious and my siblings, for their support and encouragement. My sincere gratitude to everyone who has contributed to my project work. God bless everyone.

TABLE OF CONTENTS

TITLE PAGE	i
CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	ix
LIST OF PLATES	xii
ABSTRACT	xiii
CHAPTER ONE: INTRODUCTION	
1.1.Study Background	1
1.2. Justification of Study	2
1.3.Aim	3
1.4.Objective	3
CHAPTER TWO: LITERATURE REVIEW	
2.1. General Overview of Mineral Concentration in Fishes	4
2.2. Impact of Certain Factors on Mineral Concentration of Fishes	5
2.2.1. Intrinsic Biological Factors	5

2.2.2.	Extrinsic Biological Factor	6
2.3.	Importance of Macronutrients in Fish Physiology:	
2.3.1.	Potassium (K)	8
2.3.2.	Sodium (Na)	10
2.3.3.	Calcium (Ca)	11
2.3.4.	Magnesium (Mg)	12
2.3.5.	Phosphorus (P)	13
2.4.	Review of Mineral Composition in <i>Malapterurus electricus</i> and <i>Parachanna obscura</i>	
2.4.1.	Mineral Content in <i>Malapterurus electricus</i>	14
2.4.2.	Mineral Content in <i>Parachanna obscura</i>	16
CHAPTER THREE: MATERIALS AND METHODS		
3.1.	Study Area	17
3.1.1.	Geology	18
3.1.2.	Climate	18
3.1.3.	Vegetation	18
3.1.4.	Anthropogenic activities	18
3.2.	Sample Collection	21

3.2.1.	Fish Sampling	21
3.2.2.	Sample Handling	21
3.3.	Identification of Fish Species	
3.3.1.	<i>Malapterurus electricus</i> (Gmell, 1789)	21
3.3.2.	<i>Parachanna obscura</i> (Genther, 1861)	22
3.4.	Sample Preparation	24
3.5.	Sample Analysis	24
3.5.1.	Pre-digestion	24
3.5.2.	Digestion:	
	• Apparatus/Materials used	24
	• Precautions	25
	• Procedures	25
3.6.	Atomic Absorption Spectrophotometer (AAS)	26
3.6.1.	Working Principle of AAS	26
3.7.	Statistical Analysis	27

CHAPTER FOUR: RESULTS

4.1.	Concentration of minerals (sodium, magnesium, potassium, phosphorus and calcium) in the muscles of <i>Malapterurus electricus</i>	28
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4.2. Concentration of minerals (sodium, magnesium, potassium, phosphorus and calcium) in the muscles of <i>Parachanna obscura</i>	33
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CHAPTER FIVE: DISCUSSION

CONCLUSION	41
RECOMMENDATION	42
REFERENCES	43
APPENDIX I	51
APPENDIX II	51
APPENDIX III	52

LIST OF TABLES

PAGE TITLE	PAGE
Table 4.1: Summary table of mineral content concentrations in the muscle of <i>Malapterurus electricus</i> (May-October 2025)	28
Table 4.2: Summary of mineral content concentrations in the muscle of <i>Parachanna obscura</i> (May-October 2025)	33

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 1:	Map of Study Area	20
Figure 4.1:	Sodium Concentrations in <i>Malapterurus electricus</i> from Ikpoba River (May-October, 2025)	29
Figure 4.2:	Potassium Concentrations in <i>Malapterurus electricus</i> from Ikpoba River (May-October, 2025)	29
Figure 4.3:	Phosphorus Concentrations in <i>Malapterurus electricus</i> from Ikpoba River (May-October, 2025)	30
Figure 4.4:	Magnesium Concentrations in <i>Malapterurus electricus</i> from Ikpoba River (May-October, 2025)	30
Figure 4.5:	Calcium Concentrations in <i>Malapterurus electricus</i> from Ikpoba River (May-October, 2025)	31
Figure 4.6:	Sodium Concentrations in <i>Parachanna obscura</i> from Ikpoba River (May-October, 2025)	34
Figure 4.7:	Potassium Concentrations in <i>Parachanna obscura</i> from Ikpoba River (May-October, 2025)	34
Figure 4.8:	Phosphorus Concentrations in <i>Parachanna obscura</i> from Ikpoba River	

(May-October, 2025) 35

Figure 4.9: Magnesium Concentrations in *Parachanna obscura* from Ikpoba River

(May-October, 2025) 35

Figure 4.10: Calcium Concentrations in *Parachanna obscura* from Ikpoba River

(May-October, 2025) 36

LIST OF PLATES

PLATE TITLE	PAGE
Plate 1: A section of Ikpoba River	19
Plate 2 : <i>Malapterurus electricus</i>	23
Plate 3 : <i>Parachanna obscura</i>	23

ABSTRACT

Contamination from various pollutants has been a major threat to water bodies, resulting in the accumulation of minerals. This study evaluated and compared the concentration and distribution of minerals (Na, Mg, Ca, K, P) in two fish species (*Parachanna obscura* and *Malapterurus electricus*). Samples from both species were taken, processed and analyzed in the laboratory. The results were then presented in mean \pm standard deviation format. The mean concentration of sodium in *Parachanna obscura* was 1.75 ± 0.29 while that of *Malapterurus electricus* was 0.90 ± 0.19 , the mean concentration in *Parachanna obscura* was 18.65 ± 5.63 while that of *Malapterurus electricus* was 10.81 ± 2.42 , the mean concentration of Phosphorus in *Parachanna obscura* was 9.76 ± 2.02 while that of *Malapterurus electricus* was 8.16 ± 1.66 . In *Parachanna obscura*, magnesium mean concentration was 9.35 ± 2.24 while that of *Malapterurus electricus* was 6.45 ± 1.52 and lastly, the mean value of concentration of calcium in both species were 1.88 ± 0.62 and 1.18 ± 0.22 respectively. From the result, *Parachanna obscura* showed higher mean concentration across all measured minerals thereby indicating a greater nutritional benefit from it. This finding provides valuable insights into nutritional planning, dietary choices and fish consumption. There is need for further research to explore seasonal/environmental factors that may influence mineral levels in the species as well as the reduction of environmental pollution and preserve public health.

CHAPTER ONE

INTRODUCTION

1.1. Study Background

One of the cheapest sources of animal protein is fish. Fish contains essential nutrients needed in human diets (Sadiku and Oladimeji, 1991). Fish has also been long known for its reputation as the established health food for most of the world's population particularly developing countries in contrast to meat, poultry and eggs. The protein content in fish mostly averages from 15 to 20 percent, hence, fish provides comparatively cheap and readily available sources in complement with long chains of n-3 fatty acids, amino acids, vitamins and minerals that further contributes to healthier nutritional options for a balance dietary intake (Hajeb *et al.*, 2009; FAO, 2020; Pirestani *et al.*, 2009; Kawarazuka and Bene, 2011).

Minerals are inorganic substances in food and are needed for a wide range of functions. Those needed in the human diet are: calcium, phosphorus, magnesium, potassium and sodium (Taylor *et al.*, 1998). According to Adeyeye *et al.* (2007), these minerals are essential for muscle contractions, the maintenance of body fluid balance and activation of metabolic enzymes. Even though the requirements differ, it is also needed for body processes such as development of strong bones and teeth as well as the control of nerve signals.

Shul'man (1974) also stated that mineral contents such as calcium, potassium, sodium, magnesium and phosphorus us part of mineral analysis. Fish often have trace amount of minerals in their bodies some of which are vital elements that supports metabolic mechanisms and contributes to growth of the fish. Lack of these mineral elements causes many malfunctions by

decreasing production and resulting in disorders including anaemia, osteoporosis and blood clotting (Fawole *et al.*, 2007).

Both *Parachanna obscura* and *Malapterurus electricus* are significant and frequently consumed fish species from Ikpoba River. They are the subject of this study. It will be possible to determine their nutritional worth and how they accumulate vital minerals in the particular environment of Ikpoba River by comparing their mineral profiles from the same habitat.

They also have ecological significance respectively and are seen as predators on the food chain. *Malapterurus electricus* is a bottom dwelling nocturnal piscivore, hunting and stunning its prey using its paralyzing electric organ discharge (EOD); (Sagua, 1979). It is an opportunist feeder that feeds on the most readily available prey within its habitat. Interestingly, they are able to consume prey up to half their size (Sagua, 1979). The electric organ of *Malapterurus electricus* have been used in studies of neuronal metabolism, axonal transport (Volkandt and Zimmermann, 1986). *Parachanna obscura* on the other hand, is a top predator that occupies a higher trophic level and has been found to feed on smaller fish, shrimps, insects and other invertebrates thereby causing bioaccumulation of minerals from its prey. (Bardach *et al.*, 1972; Chen, 1976).

1.2. Justification of Study

Although macro- nutrients such as magnesium, calcium, potassium, phosphorus and sodium are vital for human health and prevention of deficiencies previously described by Fawole *et al.* (2007), the majority of current study on Ikpoba River focuses on heavy metal contamination and the health hazards that go along with it, frequently ignoring these macro-nutrients. It is challenging to establish specific dietary guidelines or track the long-term effects of river

pollution on fish quality because of this high gap, making it impossible to conduct appropriate nutritional assessments of these fish. The goal of the current study is to bridge this gap.

1.3. Aim

The study was aimed at assessing the nutritional status of two commercially important fish species (*Malapterurus electricus* and *Parachanna obscura*) in Ikpoba River, Edo State, Nigeria.

1.4. Objective

The main goal of this study is to accurately quantify the look levels of potassium (K), sodium (Na), calcium (Ca), magnesium (Mg) and phosphorus in the muscular tissues of *Parachanna obscura* and *Malapterurus electricus* that was caught from Ikpoba River in Edo State, Nigeria.

The following are the specific goals:

Measuring the levels of K, Na, Ca, Mg and P in the muscles of *Malapterurus electricus* and *Parachanna obscura* from Ikpoba River.

Comparing the levels of minerals in the two fish species to find notable differences.

Talking about the findings about nutritional implications for human consumers, taking into account how these fish contribute to essential mineral intake and help prevent deficiencies, adding current and precise information to the scientific literature regarding the mineral content of these fish in the environmental context of Ikpoba River.

CHAPTER TWO

LITERATURE REVIEW

This is a thorough analysis of research on the mineral composition of fish with an emphasis on the five key macro-elements: potassium (K), sodium (Na), calcium (Ca), magnesium (Mg) and phosphorus (P). It thoroughly explores the fundamental ideas behind mineral buildup in fish, their vital functions in human and fish physiology and a careful review of earlier studies on *Parachanna obscura* and *Malapterurus electricus*. Additionally, it incorporates current information about the Ikpoba River's natural background, highlighting the important gaps that the current study aims to fill.

2.1. General Overview of Fish Mineral Composition

Fish is commonly found in natural in natural water bodies and well known for its superior nutritional quality with a very good supply of essential minerals (Fawole *et al.*, 2007; Pirestani *et al.*, 2009; Kawarazuka and Bene, 2011). It is among the frequently traded food products globally, providing high concentrations of bioavailable minerals and vitamins, fatty acids and essential protein for over 3 billion people (Thiault *et al.*, 2019; FAO, 2020; Waterman, 1980). They are regarded as an essential part of the world's diet because it provides much more than just high-quality protein and healthy necessary fatty acids (Saba *et al.*, 2024). This resource is accessible to poor and vulnerable communities prone to nutrient deficiency diseases. Current strategies used for mitigating nutritional deficiencies are focusing on mineral supplementation and good fortication (Bhadari and Banjara, 2014).

Fish rearing requires the knowledge of the requirements in proteins, lipids, energy and vitamins of the species in order to ensure a good growth to him. These diets vary according to the species, age, size, diet, stage of life, stage of development, environment and water quality. (Reinitz, 1983; Vodounnou *et al.*, 2018; Silva and Chamul, 2000).

According to Adeyeye *et al.* (2007), minerals must be obtained through diet because they are inorganic elements that the body cannot synthesize in contrast to other elements. Their importance encompasses almost all physiological processes ranging from the basic structural stability of tissues to the complex control of cellular activities. Adeyeye *et al.* (2007) also stated that the mineral content of fish tissues is neither constant nor uniform rather it is a highly dynamic property that reflects a complex interaction between extrinsic environmental factors inherent to the fish's factor itself. Accurately evaluating the nutritional value of the fish and managing fisheries sustainably depend on an understanding of these complex impacts.

2.2. Impacts of Certain Factors on Mineral Concentration of Fishes

2.2.1. Intrinsic Biological Factors

The primary factor that determines the mineral composition of a fish is its specie. According to Window *et al.* (1987), fish species vary in their growth patterns, metabolic rates and physiological needs for particular minerals. Within the species of fish, mineral retention depends mainly on the feed and feeding rate as well as interaction with the water environment. He attributed such variations to the chemical forms of the elements and their concentrations in the environment. This report is in agreement with the one obtained by Ako and Salihu, (2004).

The trophic level of fish is also another factor that affects the mineral levels of fish. Piscivorous fish will get minerals from all their preys which reflects the mineral composition of lower trophic

levels whereas, detritivorous fish will absorb minerals from decomposing organic waste and sediments, herbivorous fish on the other hand will mostly obtain their mineral content from aquatic plants. Accordingly, the mineral profiles of the fish that live in a given aquatic ecosystem are directly impacted by the structure of the food web within the ecosystem (Abdullahi and Balogun, 2006).

2.2.2. Extrinsic Biological Factors

The physio-chemical properties of water bodies is a major important factor that impacts minerals in fishes. Parameters such as pH, temperature, salinity, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO) dramatically affects the bioavailability and uptake of minerals by aquatic organisms.

pH

In pristine waters, the pH is governed by the exchange of carbon dioxide with the atmosphere. Carbon dioxide is soluble in water and the amount of CO₂ dissolved in water is a function of temperature and concentration of CO₂ in the air. A change in pH can significantly alter the solubility of calcium and phosphorus compounds which can impact fish absorption. According to Ogbeibu and Egborge, (1995), evaporation especially in the dry season decreases water pH as a result of concentration of the ions coupled with mineralization of organic matter. Lower values of pH are indicative of higher acidity which also can be caused by the deposition of acid forming substances in precipitation. As micro-organisms breakdown organic material, the end product CO₂ dissolves and equilibrate with water forming carbonic acid (H₂CO₃). Other organic acids such as huminic and fluvic acid can also result from organic decomposition common with rivers flowing through forest areas. (Beadle, 1981).

Salinity

This is a core factor manipulating the lifespan of fish species. Its fluctuation creates an osmotic stress, which can have drastic effects on the metabolism, growth and reproduction thereby threatening species fitness and survival (Leite *et al.*, 2022). Euryhaline fishes can survive in environment with fluctuated salinity through osmoregulation strategies to maintain a virtually persistent blood osmolality. The patterns and mechanisms of osmotic and ionic regulation in euryhaline fishes have been well documented in adult fish (Mozanzadeh *et al.*, 2021); early and post embryonic stages, larval and post-larval stages (Anand *et al.*, 2023).

Ions

Aquatic organisms require several ions at minimum levels with balanced ratios to maintain normal physiological functions. Both fresh and saline groundwater may depict by imbalanced level of major ions which can be toxic. The physiological effects of rising ion concentrations on aquatic organisms are a problem of growing concern (Misha and Mahapatra, 2021) while the toxic effects of changed ionic levels and ratios on freshwater organisms have been investigated (Leite *et al.*, 2022).

Temperature

The temperature of a water body is the degree of how cold or hot the water body is and primarily governed by the local climatic conditions, volume of the water, the degree of exposure to sunlight and also anthropogenic activities. Temperature affects water chemistry and the functions of aquatic organisms. Recent air temperature from various Niger Delta streams ranged between 20°C and 32°C (Deekae, *et al.*, 2010) and most tropical freshwaters have temperature which

ranges between 20°C and 30°C (Aisien, *et al.*, 2010). Extreme cold or warm temperatures inhibit final gonad development (Akankali *et al.*, 2011)

Conductivity

According to Welcomme, (1979), conductivity is an index of fertility and productivity of aquatic ecosystem. It is the ability of water to pass on electric current. Conductivity in water increases with presence of inorganic dissolved solids such as chloride, nitrate, sulphate and phosphate anions (ions that carry a negative charge) or cations (positively charged ions) of sodium, magnesium, calcium, potassium and iron.

Turbidity

This is the measure of how suspended particles such as mud, clay, silt, in water affect clarity of a water body. They enter water body through run-offs, deposition of particles by air, birds, etc. Turbidity increases sharply during and after a rainfall. According to Chinedu *et al.*, (2011), turbidity can be caused by the presence of phytoplanktons in open water or drinking water.

Total Dissolved Solids (TDS)

Solids in water are undesirable for they degrade the quality of drinking water, inhibit photosynthetic processes and reduce the utility of water for irrigation and industrial purposes (Ogbeibu and Anagboso, 2004). Total Dissolved Solid concentration depends on the geologic material that water passes through in the saturated and unsaturated zone and the quality of the infiltrating water.

2.3. Importance of Macro-nutrients in Fish Physiology and Human Health

Understanding the specific roles of the five essential macro-nutrients examined in this study (potassium, sodium, magnesium, calcium and phosphorus), emphasizes the profound nutritional significance of fish as a dietary source.

2.3.1. Potassium (K)

Role in Human Body: Potassium is the predominant intracellular cation, meaning it is found in high concentrations inside body cells. Its primary physiological role is in maintaining cellular fluid and electrolyte balance, working in tandem with sodium. This balance is essential for cellular hydration, nutrient transport and waste removal. Potassium is essential for the nervous system's healthy operation because it makes it easier for action potentials, nerve impulses that are required for movement, sensation and brain function. Additionally, it is essential for regular muscle contraction, particularly the heart muscle's involuntary and rhythmic contractions which maintain cardiovascular health and a regular heartbeat. Moreover, enough potassium helps offset the effects of sodium, which is linked to the maintenance of healthy blood pressure levels (IOM, 2005).

Effects of Deficiency in Humans: Hypokalemia, a potassium deficiency can have a wide range of harmful health consequences. Muscle cramps and spasms are more severe symptoms that might develop from a mild deficiency's first manifestation of overall weakness and exhaustion. Importantly, if hypokalemia is severe, it can result in arrhythmias, which are irregular heartbeats that can be fatal. A higher incidence of kidney stones and higher risk of hypertension (high blood pressure) have been associated with long-term insufficient potassium intake (IOM 2005; NIH Office of Dietary Supplements, 2024; Krishna *et al.*, 1989).

Function in Fish Physiology: Potassium has an equally important role in fish physiology for osmoregulation, especially for freshwater species that inhabits hypotonic environments (lower concentrations of salt outside the body). In order to prevent constant loss to the water and preserve their internal osmotic equilibrium, these fish aggressively absorb potassium ions. Additionally, it is essential for sustaining cell membrane potential, which is essential for neuron and muscle excitability and enables fish to move in response to stimuli. Also, fish's cellular metabolism and a variety of enzymatic processes depend on potassium. (Knotchel, 1977).

According to Adeniyi *et al.* (2012), the potassium content of *Malapterurus electricus* was 126.84 ± 0.14 mg/kg while that of *Parachanna obscura* was found to be 228.03 ± 31.57 mg/kg for the male and that of female was 243.13 ± 36.19 mg/kg, according to Nurudeen *et al.* (2019).

2.3.2. Sodium (Na)

Role in Human Body: Sodium is the main extracellular cation, which means that it is present outside of human cells in large amounts, especially in interstitial fluid and blood plasma. Its most important function is to control blood volume and fluid balance which have a direct effect on blood pressure. Sodium plays a crucial part in the production and transmission of nerve impulses, making it essential for the nervous system's healthy operation. It is also necessary for the contraction and relaxation of muscles. Moreover, sodium is essential for the active absorption and passage of many nutrients into the bloodstream through the interstitial, including glucose and amino acids (IOM, 2005).

Effects of Deficiency in Humans: Although a severe deficit or hyponatremia can be fatal, excessive salt consumption is a widespread public health issue associated with hypertension thereby resulting in cellular swelling which is frequently brought on by an excessive fluid intake,

certain drugs or medical disorders. Symptoms can vary widely, from headache, nausea, and disorientation to more serious neurological symptoms like seizures and in the worst situations, coma and death from brain swelling (IOM, 2005; NIH Office of Dietary Supplements, 2024; Andreoli, 2000).

Function in Fish Physiology: Sodium is essential for osmoregulation in fish, particularly freshwater fishes. To keep their internal salt balance, freshwater fish must actively collect sodium ions from the water through their gills since they continuously lose cations. On the other hand, marine fish have to actively eliminate extra salt. Additionally, ion channels and pumps that are essential for fish neuron and muscle activity depends on sodium (IOM 2005).

According to Adeniyi *et al.* (2012), the value of sodium in *Malapterurus electricus* was

$94.67 \pm 0.02\text{mg/kg}$ while Nurudeen *et al.* (2019) found the value of calcium of male *Parachanna obscura* to be $66.34 \pm 2.83\text{mg/kg}$ and that of female *Parachanna obscura* to be

$65.78 \pm 2.18\text{mg/kg}$. Although these amounts add to the body's sodium consumption, the body usually gets enough sodium from other foods and fish doesn't usually add to an excessive sodium intake unless it is highly processed or salted.

2.3.3. Calcium (Ca)

Role in the Human Body: Calcium is the most prevalent mineral in the human body, making up an astounding 99% of its total content in teeth and bones, which give them strength and support. Calcium has a crucial role in several essential physiological functions in addition to its structural role. As a participant in the cascade that results in clot formation, it is essential component of blood coagulation. It causes the release of hormones, mediates the contraction of muscles (including smooth, skeletal and cardiac muscles), enables the transmission of nerve impulses and

aids in maintenance of a regular and healthy heartbeat. Additionally, calcium contributes to the activation of enzymes and cell signaling (NIH Office of Dietary Supplements, 2024).

Effects of Deficiency in Humans: Long-term insufficient calcium causes serious and pervasive effects, especially in bone health. It is the main cause of osteoporosis, a degenerative bone disease that results in weak, fracture-prone bones due to loss in bone mass and density. Rickets, a disorder that causes soft, fragile and malformed bones can be a sign of a severe deficit in youngsters. It can result in osteomalacia which is characterized by softening of the bones in adults. Muscle cramping, irregular heartbeats and poor blood coagulation are additional non-skeletal symptoms (NIH Office of Dietary Supplements 2024).

Function in Fish Physiology: Calcium is good for growth, maintenance of bones, teeth and muscles. Normal extracellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances (Okaka and Okaka 2001). In general, fish are great suppliers of calcium especially when eaten with their bones. According to Agali and Edema (2016), calcium levels of *Malapterurus electricus* ranged from 12.01mg/kg to 41.39mg/kg which is comparable to the findings by Mohammed *et al.* (2010). These numbers clearly highlight the value of fish as a dietary calcium source, which may help avoid disorders linked to bones.

2.3.4. Magnesium (Mg)

Role in the Human Body: Magnesium is an incredibly adaptable mineral that is involved in more than 300 enzymatic processes in the human body. Because of this, it is essential for blood glucose regulation, blood pressure regulation, muscle and neuron function and protein synthesis. Magnesium is also necessary for healthy bones because it aids in calcium absorption and contributes to the structure of the bone. It is also essential for energy metabolism since it plays a

role in the synthesis of DNA and RNA as well as the vital creation of Adenosine Triphosphate (ATP), the body's main energy molecule (NIH Office of Dietary Supplements, 2024)).

Effects of Deficiency in Humans: Magnesium deficiency can manifest with a wide range of symptoms due to its pervasive role in bodily functions. Common signs include muscle cramps and tremors, general fatigue, weakness and loss of appetite. More severe consequences can involve irregular heartbeats (arrhythmia). Chronic magnesium deficiency has been linked to an increased risk of developing high blood pressure, heart disease, type-2 diabetes and osteoporosis (NIH Office of Dietary Supplements, 2024).

Functions in Fish Physiology: In fish, magnesium contributes significantly to osmoregulation, various metabolic activities and enzyme activation, mirroring its broad roles in human physiology. It is also crucial for muscle integrity and nerve signal conduction

(Florentini *et al.*, 2021). According to Adeniyi *et al.* (2012), the magnesium content in *Malapterurus electricus* was $33.33 \pm 0.07\text{mg/kg}$ while Nurudeen *et al.* (2019) reported that the magnesium content in male *Parachanna obscura* was $60.54 \pm 2.24\text{mg/g}$ and that of female *Parachanna obscura* was $59.37 \pm 2.39\text{mg/g}$. These values highlight fish as a dietary source of magnesium.

2.3.5. Phosphorus (P)

Role in the Human Body: Phosphorus the second most common mineral in the human body, (about 85%) is mostly present in bones and teeth, where it forms important mineral complexes with calcium to greatly enhance their hardness and structural stability. Beyond its function in the skeleton, phosphorus is essential for the synthesis of cell membranes (phospholipids), nucleic acids (DNA and RNA), which contain genetic information and Adenosine Triphosphate (ATP),

the cell's energy currency. Because of this, phosphorus is extremely necessary for nerve communication, muscular contraction, energy metabolism and preserving the body's essential acid-base balance (NIH Office of Dietary Supplements, 2024).

Effects of Deficiency in Humans: Chronic low intake of phosphorus can cause a variety of problems but severe phosphorus deficiency is rather rare in healthy people who eat a balanced diet, mainly because it is present in many foods. These include impaired immunological function, disorientation, bone pain, muscle weakness, rickets (which causes soft and weakened bones in youngsters), osteomalacia (which also causes bone softening in adults), and bone pain (NIH Office of Dietary Supplements, 2024). Because of its widespread significance in almost every biological function, getting enough phosphorus is essential for good health.

Functions in Fish Physiology: Phosphorus plays a crucial role in the development of fish bones and scales, energy transfer systems and other cellular processes required for development, reproduction and general survival. With both intracellular and extracellular distribution, phosphorus also functions as structural components of bones and teeth (Calvo and Lamberg-Allardt, 2015).

Most people agree that fish is a great source of phosphorus. Agali and Edema (2016) found that the phosphorus concentration of *Malapterurus electricus* in Obueyinomo River ranged from 1.89mg/kg to 39.6mg/kg, which appears to be low when compared to the phosphorus content in ordinary fish. Nonetheless, it is well known that the majority of fish species are high in phosphorus frequently in addition to calcium.

2.4. Review of Mineral Composition in *Malapterurus electricus* and *Parachanna obscura*

Existing studies on the ranges of the mineral composition of *Malapterurus electricus* and *Parachanna obscura* from various Nigeria water bodies provide valuable comparable data, though specific comprehensive research on these species from Ikpoba River remains limited.

2.4.1. Mineral Content in *Malapterurus electricus*

Malapterurus electricus, known as the electric catfish is a fascinating species with unique bio-electric capabilities and also serves as a significant fish for consumption across many African regions. Research into its mineral composition generally underscores its nutritional value, though specific, comprehensive data from diverse researchers focusing solely on this species' precisely mineral profile can be less abundant.

Fish research generally shows potassium (K) to be major macro-nutrients. Potassium for example, was consistently shown to be the most prevalent macro-nutrients in the fish samples that Agali and Edema (2016) examined. This study has been widely supported by other studies such as those conducted by Adeyeye *et al.* (2007) and Fawole *et al.* (2007).

Alas *et al.* (2014) found that the sodium content of several fish species ranged from 22.48mg/kg to 58.35mg/kg, which is typically within the levels suggested by dietary guidelines. The significance of sodium for essential physiological processes like muscle function and electrolyte homeostasis was emphasized by Alas *et al.* (2014). Comparing the sodium concentration of fish from Osinmo Reservoir with other research such as those conducted by Adewunmi *et al.* (2014), indicates that the element's transmission and accumulation in the flesh of a fish might be affected by the ambient levels in the water body.

Fish species like *Malapterurus electricus* exhibits a wide range of calcium (Ca) concentration. Mohammed *et al.* (2010) found that the concentration of calcium varied widely among fish species, ranging from 12.01mg/kg to 881mg/kg suggesting that variables such as the age of fish play a significant role in this variation.

Adeniyi *et al.* (2012) found magnesium level to be 33.3 ± 0.07 mg/kg which is comparable with the findings by Martinez-Velverde *et al.* (2000).

The literature provided does not accurately reflect statistics regarding phosphorus particularly for *Malapterurus electricus* from different studies. However, it is expected that *Malapterurus electricus*, a bony will have high levels of phosphorus because it is essential for the production of skeleton and often correlates directly with calcium concentration.

2.4.2. Mineral Content in *Parachanna obscura*

Although *Parachanna obscura* is widely recognized as a valuable freshwater species with great nutritional and commercial importance, research focusing specifically on its mineral composition is limited. Most studies available have concentrated on other aspects such as proximate composition, physio-chemical properties of water, concentration of heavy metals and so many other aspects. Few researchers such as Agali and Edema (2016) and Nurudeen *et al.* (2019) have been able to provide a literature regarding this but none of them provided thorough and current data from Ikpoba River, Edo State. Therefore, this current work is vital for addressing this major information gap by providing up-to-date, site-specific data and nutritional assessments for this significant water body in Nigeria.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

The study was conducted in Benin City, Edo State, Nigeria, in Ikpoba River. This freshwater system is well-known for producing different species of fish. It is a fourth-order stream located in the southern Nigerian state of Edo state rainforest (Etiosa and Matthew 2006). The upper stages of the river are dendritic, and its source is located in the northern Ishan Plateau. It flows southward through a valley that is steeply carved and along sandy plains before entering Benin and joining the Ossiomo River (Atuanya *et al.*, 2012; Odigie 2015).

The latitude and longitude of the Ikpoba River are 6.5°N and 5.8°E, respectively. The muddy terrain of Ikpoba Slope encircles the Ikpoba River on both sides, according to Atuanya *et al.* (2012). The river travels 48 km across a sub-drainage catchment basin, estimated at 722 km², of which about 330 km² are within the Benin City urban area, which is 46% of the entire Ikpoba Drainage Basin. The river fluctuates between 5m and 11m and has a depth of 3 - 8m (Ikhile, 2016).

To the residents of Benin City, the Ikpoba River is especially significant. The river provides water to downstream riparian settlements for a variety of household uses. Water drainage and industrial effluent are released into the water. Variations in its physio-chemical parameters and sediment properties are also caused by runoff from agricultural regions, including fertilizers and pesticides.

3.1.1. Geology

Benin City is home to Ikpoba River. The river substratum is made up of coarse sand, humus, and fine grain soil, while the research area's flat land surface is made up of red laterite and sandy soil (Okonofua *et al.*, 2019).

3.1.2. Climate

The dry and wet seasons usually make up Nigeria's main weather patterns. The wet/rainy season typically lasts from April to October, with July and August seeing the lowest temperatures and the highest relative humidity. This study was conducted during the rainy season. The dry season, which lasts from November to March, is distinguished by high air temperatures and low relative humidity. While the annual minimum and maximum relative humidity are 69% and 96%, respectively, the mean annual temperature varies between 22°C and 31°C (Okonofua *et al.*, 2019).

3.1.3. Vegetation

Many economic trees and plant species surround the Ikpoba River namely: *Pennisetum purpureum*, *Talinum triangulate*, *Eichorrnia crassipes*, and *Chromolarian odorata* are among the species found in the region. Indian bamboo (*Bambusa spp.*), bushes, and grasses form thickets along the Ikpoba River's length (Ekhaise *et al.*, 2011).

3.1.4. Anthropogenic Activities

Car washing, laundry, farming, abattoir and animal grazing are examples of anthropogenic activities that are practiced within and near the river. The waste products from the several

brewery firms, such as 7up Bottling and Guinness Nigeria Plc, flowing into the river, (Ekhaise *et al.*, 2011).



Plate 1: A section of Ikpoba River.

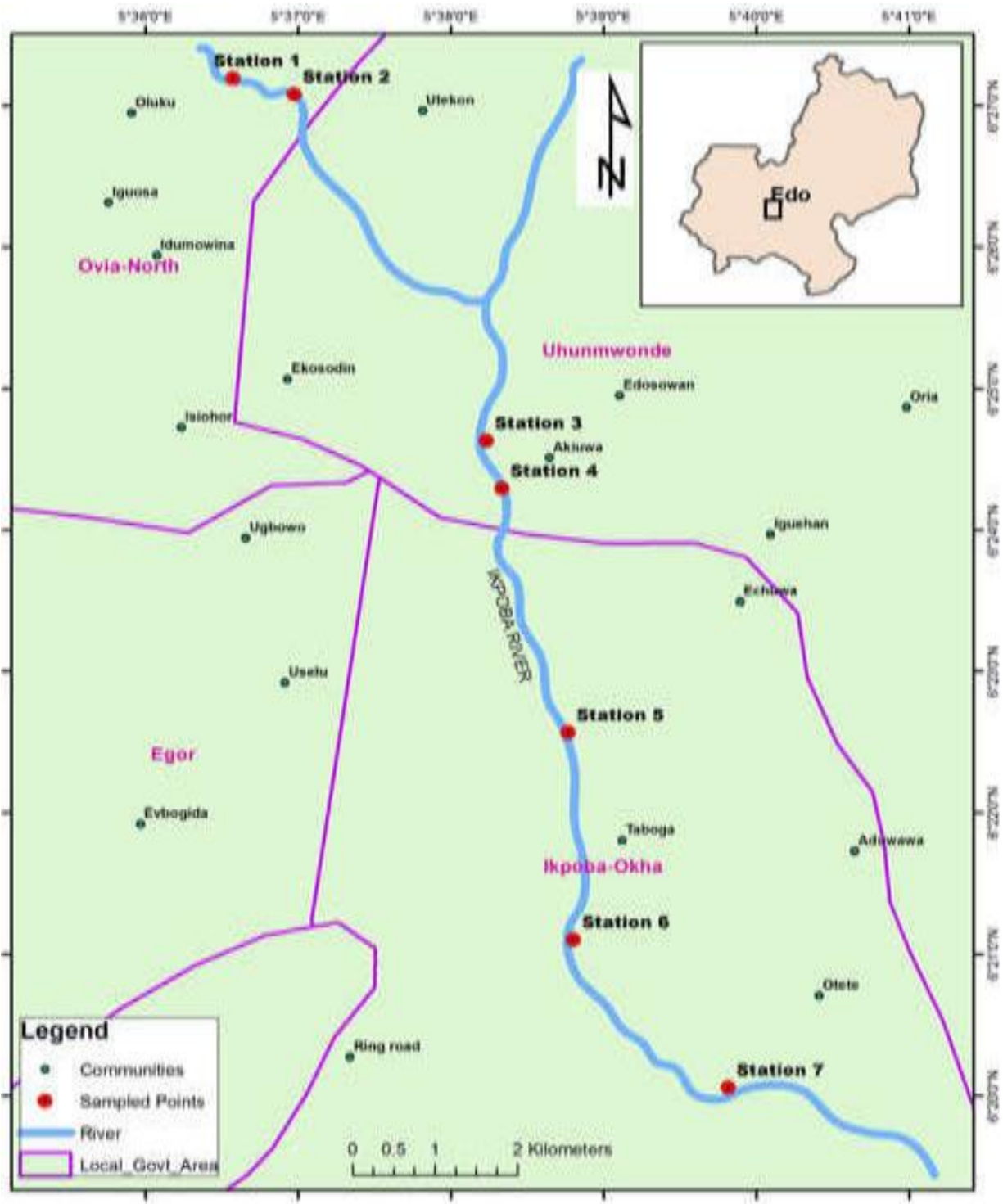


Figure 1: Map of Study Area

3.2. SAMPLE COLLECTION

The two fish species (*Parachanna obscura* and *Malapterurus electricus*) were captured by artisanal fishermen working together.

3.2.1. Fish Sampling

Fish samples were collected at random without the use of a sampling station. Sampling was carried out for six months, from May 2025 to October 2025. Since it was within a specific season (the wet/rainy season), there was no need for seasonal variety. A variety of fishing tools majorly fishing nets and fishing wire were used to catch fish by the fishers.

3.2.2. Sample Handling

After the samples have been caught, it is then placed in a bucket or sometimes polythene bag with little water in it to keep it alive.

3.3. IDENTIFICATION OF FISH SPECIES

Fishes were identified in the laboratory with Idodo-Umeh (2003).

3.3.1. *Malapterus electricus* (Gmel, 1789)

- **Kingdom:** Animalia
- **Phylum:** Chordata
- **Class:** Actinopterygii
- **Order:** Siluriformes
- **Family:** Malapteruridae

- **Genus:** *Malapterurus*
- **Species:** *Malapterurus electricus*

3.3.2. *PARACHANNA OBSCURA* (Genther 1861)

- **Kingdom:** Animalia
- **Phylum:** Chordata
- **Class:** Actinopterygii
- **Order:** Anabantiformes
- **Family:** Channidae
- **Genus:** *Parachanna*
- **Species:** *Parachanna obscura*



Plate 2: *Malapterurus electricus*



Plate 3: *Parachanna obscura*

3.4. SAMPLE PREPARATION

After being cleaned upon arrival, the fish specimen was taken to the laboratory for examination after the muscle was removed using a scalpel.

3.5. SAMPLE ANALYSIS

To guarantee quality control and adherence to established protocols, the sample analysis was conducted at the University of Benin's Owena Laboratory.

3.5.1. Pre-digestion

Before digestion, the samples were dehydrated in an oven at 105°C for 48hrs until it reached a consistent dry weight of 1.0g. It is then ground to create more homogeneous powder that allows for reduced sample sizes and higher surface area.

3.5.2. Digestion.

The digestion is strictly a Nitric-Perchloric Acid mixture in the ratio, 2:1 and a Nitric Acid-water mixture in the ratio 1:1 and an Atomic Absorption Spectrophotometer (AAS) instrumentation was chosen because of its sensitivity.

APPARATUS/MATERIALS USED

- Fish sample (dried and powdered)
- 100ml digestion tube (Kjeldahl flask)
- Heating mantle
- Funnels
- 100ml volumetric flask
- Filter Paper

- Beakers.
- Deionized water
- Concentrated Nitric Acid (HNO_3)
- Concentrated Perchloric Acid (HClO_4)
- Atomic Absorption Spectrophotometer (AAS)
- Fume cupboard
- Measuring cylinder
- Analytical balance

PRECAUTIONS

- Acid purity is paramount to ensure that contaminants are not introduced into the sample
- The type of vessels used must be compatible with the acid digestion process to avoid potential leaching of contaminants into samples
- Ensuring that there was proper ventilation to prevent hazardous vapours
- When heating, heat gently and never seal digestion tubes tightly
- Personal Protective Equipment (PPE) was always worn which includes: lab coats and gloves

PROCEDURES

- The dried weighted fish sample was placed into a clean digestion tube
- 10ml of the aqua regia was introduced to the sample
- The mixture was allowed to stand for 30minutes at room temperature to Pre-digestion (this reduces frothing and violent reactions).

- The mixture was heated gently on a heating mantle and then increases the temperature gradually to avoid splattering inside a fume cupboard.
- The digestion was maintained until the solution becomes clear or light yellow indicating the organic matter has been disintegrated.
- Overheating was avoided to prevent loss of volatile elements. This whole process of digestion takes 30 minutes to 1 hour.
- Whenever the sample is not clear add small drops of acid mixture and then continue digestion.
- The digested sample was then allowed to cool.
- The digest is then transferred into a 100ml volumetric flask.
- If the solution contains particulates, filter through Whatman filter paper to obtain a clear solution.

3.6. ATOMIC ABSORPTION SPECTROPHOTOMETER (AAS)

Atomic Absorption Spectrophotometer (AAS), is a commonly used analytical technique for the quantitative confirmation of elements in various samples and is known for its high sensitivity. This report aims to give an overview of the working principles of AAS, highlighting its importance in analytic chemistry.

3.6.1. WORKING PRINCIPLE OF AAS

AAS operates on the absorption spectroscopy principle which measures the intake of electromagnetic radiation by atoms. AAS an instrument is made up of several components which are: radiation source, atomization system, a monochromator, a detector and a data processing unit. The source of radiation for an AAS is commonly a hollow cathode lamp (HCL). In

correspondence to the analyte elements, there is emission of light with specific wavelength. The radiation emitted is then focused onto the sample solution.

The sample goes through a process of thermal or non-thermal atomization process when brought into an atomization system to convert the analyte atoms into free gaseous atoms or ions. This step ensures efficient interaction between the sample and the incident radiation.

The radiation that passes through the sample is directed through a monochromator after atomization. The monochromator ensures that only desired wavelength gets to the detector by selecting a particular wavelength of light relating to the absorption line of the analyte elements.

The quantification of the intensity of the transferred radiation after interaction with the sample is done by the detector. A photomultiplier tube (PMT) or a photodiode is commonly used as a detector in AAS instruments. The detector also turns the optical signal into an electrical signal, which is in direct relation to the concentration of the analyte elements.

The electric signal generated by the detector is processed by a computer or dedicated electronics. The signal is compared to calibration curves or standards to ascertain the concentration of the analyte in the sample.

3.7. STATISTICAL ANALYSIS

All statistical analysis was computed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 21. The data gotten from the laboratory analysis were analyzed for their range values, mean and standard errors.

CHAPTER FOUR

RESULTS

Concentration of minerals - potassium, sodium, calcium, phosphorus and magnesium in the muscles of *Malapterurus electricus* and *Parachanna obscura* from Ikpoba River

4.1. *Malapterurus electricus*

Table 4.1: Summary Table of mineral content concentration in the muscle of *Malapterurus electricus* (May -October 2025)

Minerals(mg/kg)	Mean \pm S. D	Minimum	Maximum
Sodium	0.90 \pm 0.19	1.36	2.11
Potassium	10.81 \pm 2.42	10.22	24.26
Phosphorus	8.16 \pm 1.66	7.65	13.54
Magnesium	6.45 \pm 1.52	8.75	11.38
Calcium	1.18 \pm 0.22	1.07	2.57

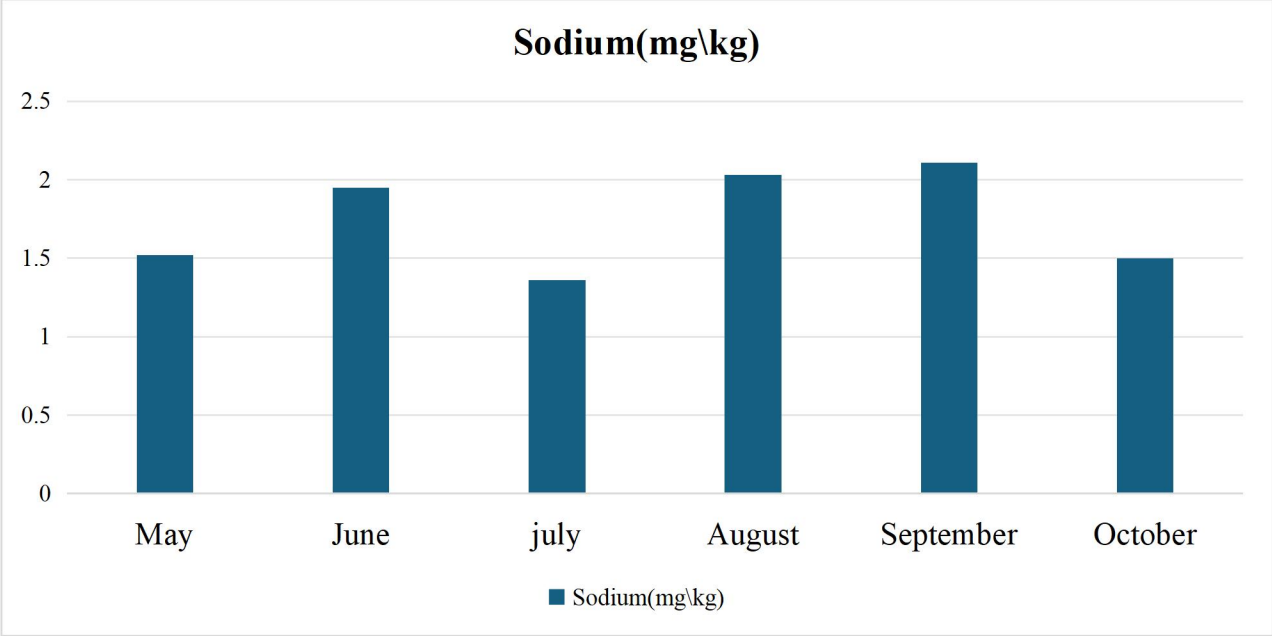


Figure 4.1: Sodium concentrations in *Malapterurus electricus* from Ikpoba River (May -October 2025)

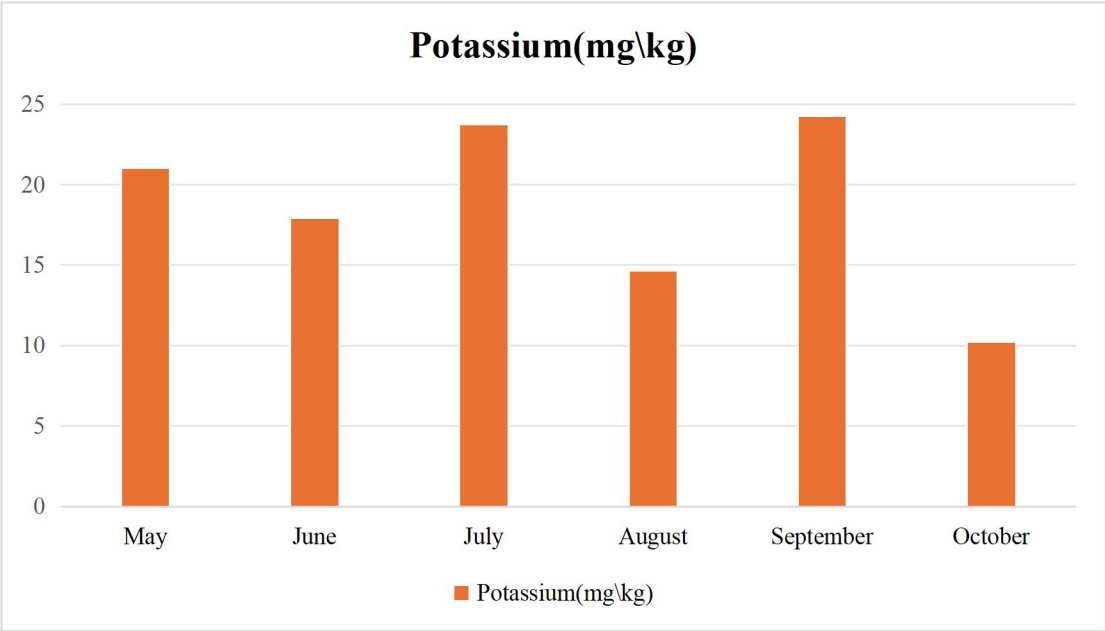


Figure 4.2: Potassium concentrations in *Malapterurus electricus* from Ikpoba River (May -October 2025)

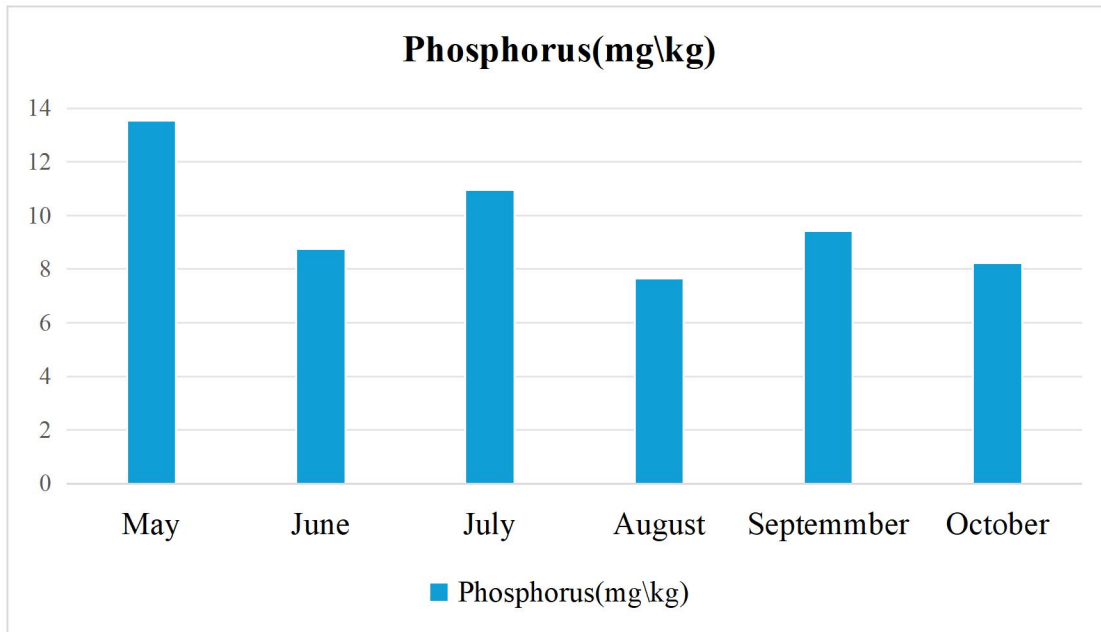


Figure 4.3: Phosphorus concentrations in *Malapterurus electricus* from Ikpoba River (May -October 2025)

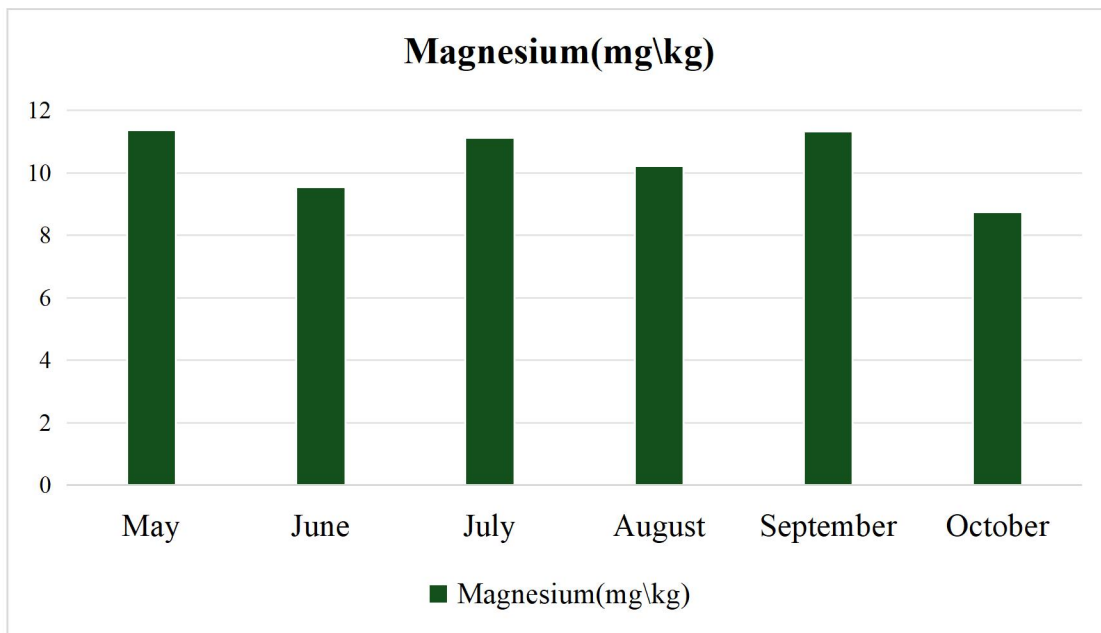


Figure 4.4: Magnesium concentrations in *Malapterurus electricus* from Ikpoba River (May -October 2025)

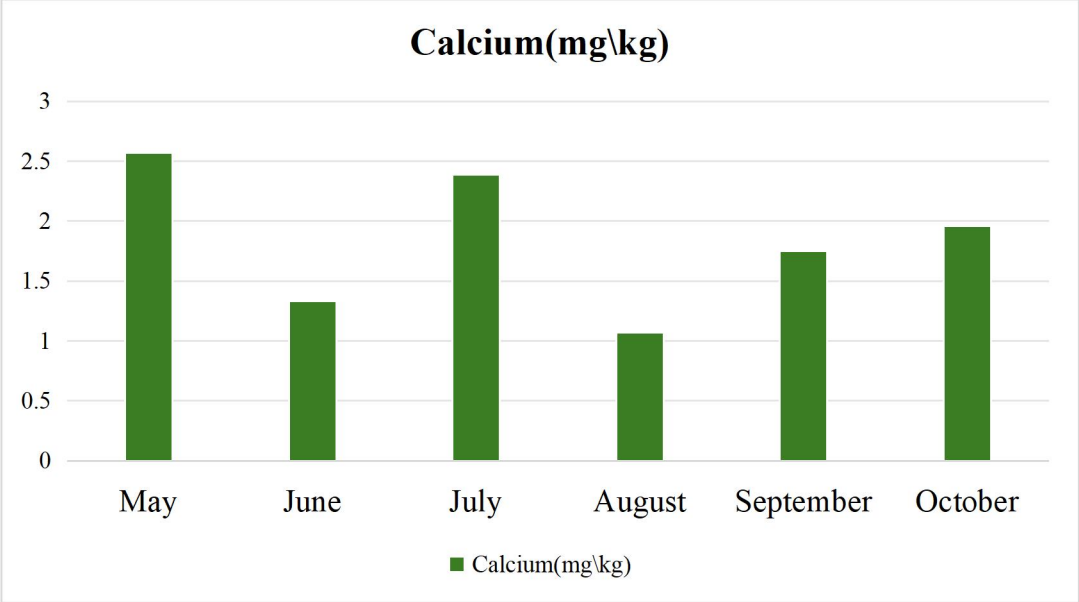


Figure 4.5: Calcium concentrations in *Malapterurus electricus* from Ikpoba River (May -October 2025)

Table 4.1 and Figures 4.1 to 4.5 show the levels of sodium, potassium, phosphorus, magnesium and calcium in the muscles of *Malapterurus electricus* from Ikpoba River.

Sodium concentration in the muscle of *Malapterurus electricus* ranged from 1.36mg/kg to 2.11mg/kg with a mean value of 0.90 ± 0.19 mg/kg. The highest value was recorded in the month of September and the lowest value of 1.36mg/kg was recorded in the month of July.

The concentration of potassium in the muscle of *Malapterurus electricus* ranged from 10.22mg/kg to 24.26mg/kg with a mean value of 10.81 ± 2.42 mg/kg. The highest value of 24.26mg/kg was recorded in the month of September while the lowest value of 10.22mg/kg was recorded in the month of October.

Also, the range of the concentration of Phosphorus in *Malapterurus electricus* was found to be 7.65mg/kg to 13.54mg/kg with a mean value of 8.16 ± 1.66 mg/kg. In the Month of May, the highest value of 13.54mg/kg was recorded while the lowest value of 7.65mg/kg was recorded in the month of August.

Malapterurus electricus was found to have a magnesium range of 8.75mg/kg to 11.38mg/kg with a mean value of 6.45 ± 1.52 mg/kg. The highest value of 11.38mg/kg was recorded in the month of May while the lowest value of 8.75mg/kg was recorded in October.

Lastly, the concentration of calcium in *Malapterurus electricus* ranged from 1.07mg/kg to 2.57mg/kg with a mean value of 6.45 ± 1.52 mg/kg. The highest value of 2.57mg/kg was recorded in the month of May while the lowest value of 1.07mg/kg was recorded in the month of August.

Overall, the order of mineral content concentration in the muscles of *Malapterurus electricus* from this study was $K > P > Mg > Ca > Na$.

4.2 *Parachanna obscura*

Table 4.2 and Figures 4.6 to 4.10 also reveal the levels of sodium, potassium, phosphorus, magnesium and calcium in the muscles of *Parachanna obscura*.

Table 4.2. Summary of mineral content concentrations in the muscle of *Parachanna obscura* (May - October, 2025)

Minerals (mg/kg)	Mean \pm S. D	Minimum	Maximum
Sodium	1.75 \pm 0.29	0.64	1.22
Potassium	18.65 \pm 5.63	7.25	13.58
Phosphorus	9.76 \pm 2.02	7.14	10.03
Magnesium	9.35 \pm 2.24	4.98	9.54
Calcium	1.88 \pm 0.62	0.88	1.49

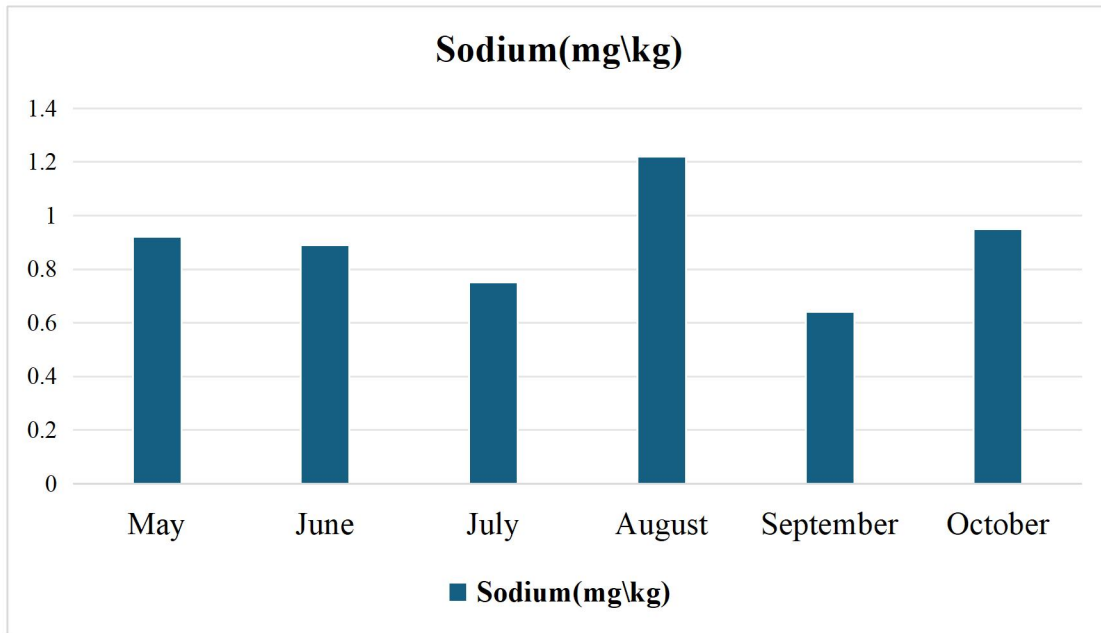


Figure 4.6: Sodium concentrations in *Parachanna obscura* from Ikpoba River (May -October 2025)

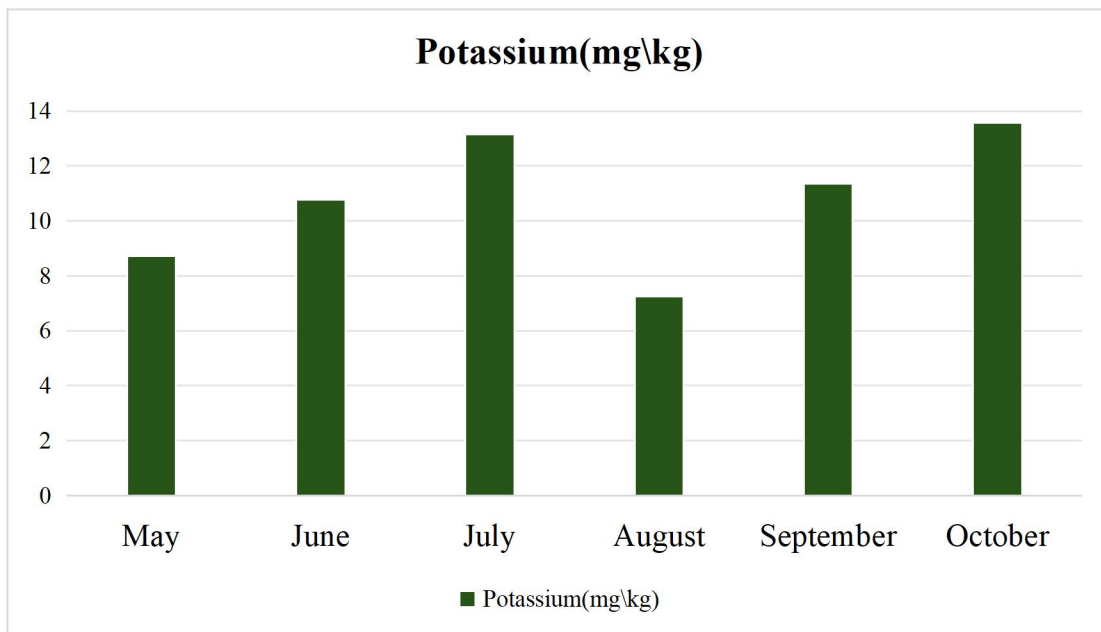


Figure 4.7: Potassium concentrations in *Parachanna obscura* from Ikpoba River (May -October 2025)

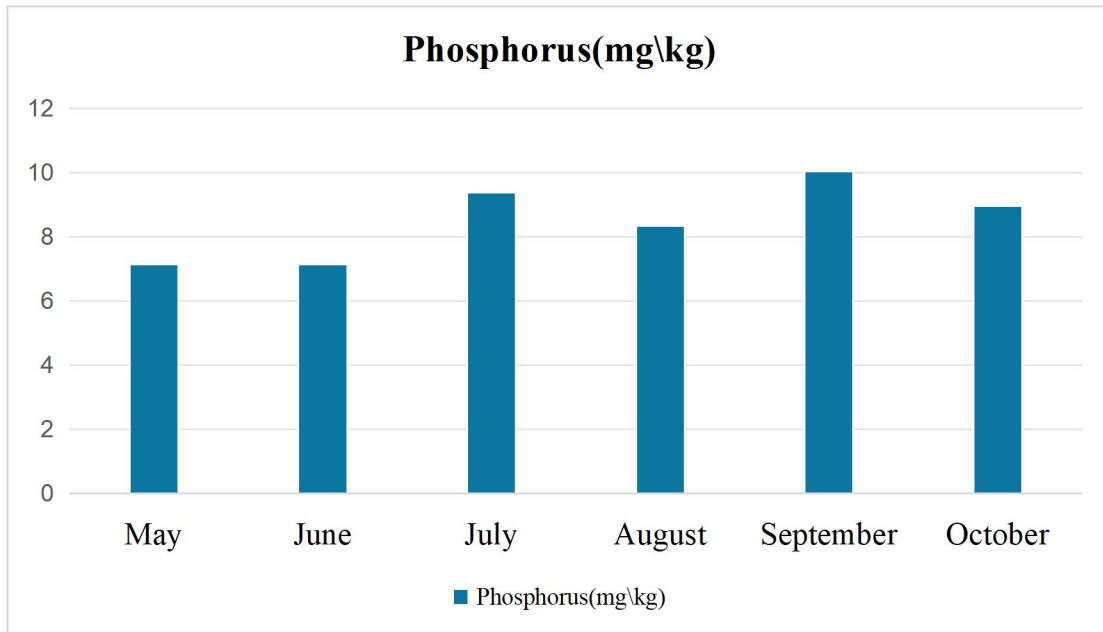


Figure 4.8: Phosphorus concentrations in *Parachanna obscura* from Ikpoba River (May -October 2025)

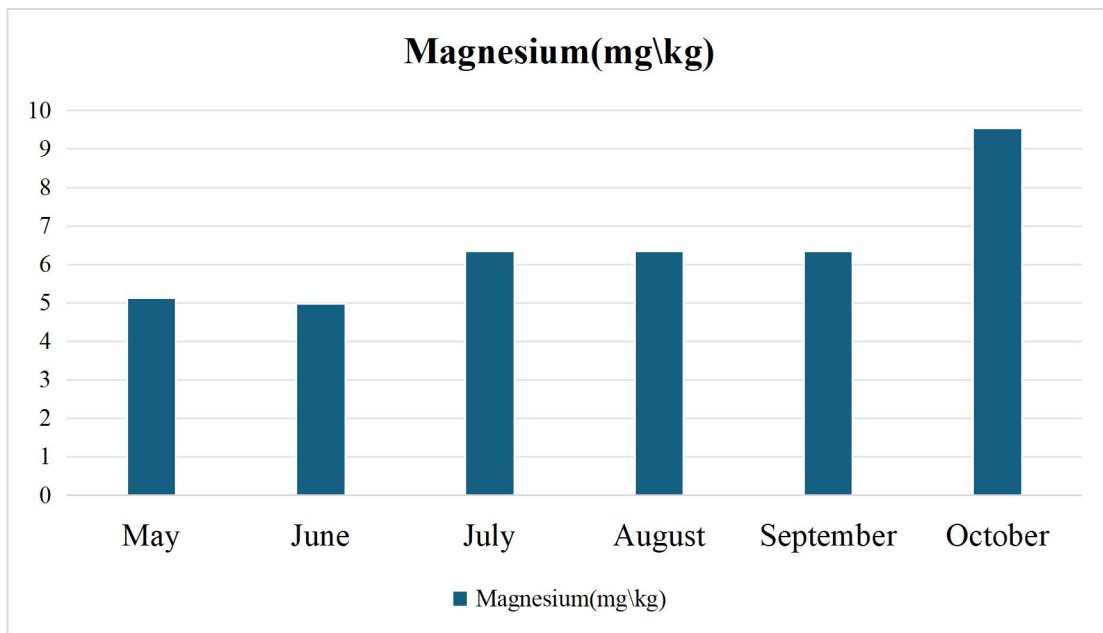


Figure 4.9: Magnesium concentrations in *Parachanna obscura* from Ikpoba River (May -October 2025)

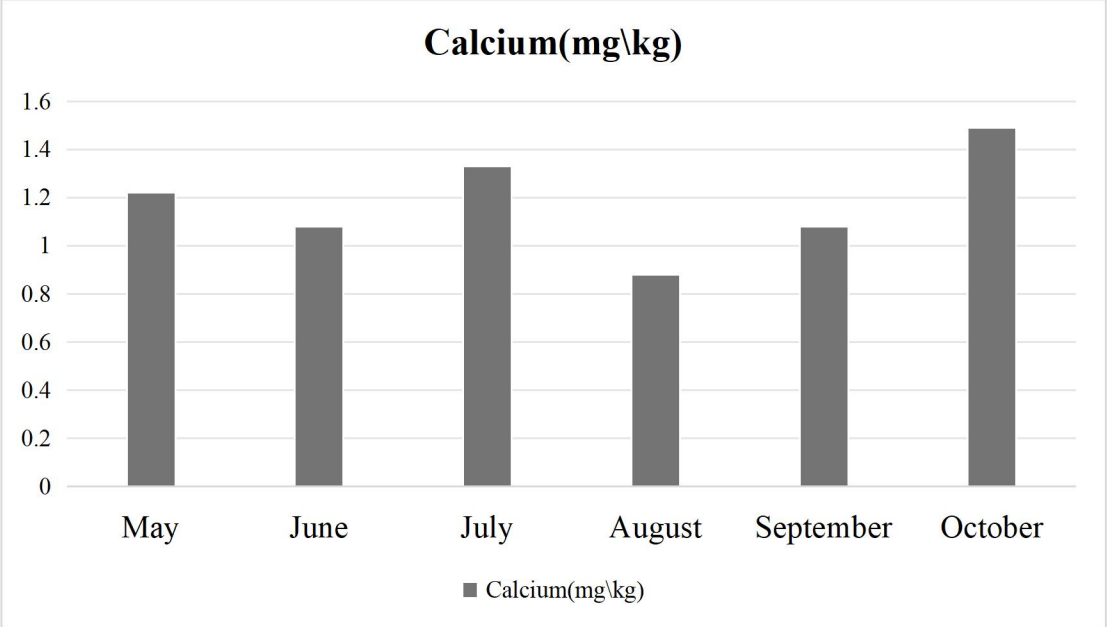


Figure 4.10: Calcium concentrations in *Parachanna obscura* from Ikpoba River (May -October 2025)

Sodium concentration ranged from 0.64mg/kg to 1.22mg/kg with a mean value of 1.75 ± 0.29 mg/kg. The highest value of 1.22mg/kg was recorded in the month of August while the lowest values of 0.64mg/kg was also recorded in the month of September.

The concentration of potassium in *Parachanna obscura* ranged from 7.25mg/kg to 13.58mg/kg with a mean value of 18.65 ± 5.63 mg/kg. The highest value of 13.58mg/kg was recorded in the month of October while the lowest value of 7.25mg/kg was recorded in the month of August.

Also, the range of the concentration of phosphorus in *Parachanna obscura* was found to be 7.14 to 10.03mg/kg with a mean value of 9.76 ± 2.02 mg/kg. In the month of September, the highest value of 10.03mg/kg was recorded while the lowest value of 7.14mg/kg was recorded in the month of May.

Parachanna obscura was found to have a magnesium range of 4.98 to 9.54mg/kg with a mean value of 9.35 ± 2.24 mg/kg. The highest value of 9.54mg/kg was recorded in the month of October while the lowest value of 4.98mg/kg was recorded in the month of June.

Lastly, the concentration of calcium in *Parachanna obscura* ranged from 0.88 to 1.49mg/kg with a mean value of 1.88 ± 0.62 mg/kg. The highest value of 1.49mg/kg was recorded in the month of October while the lowest concentration of 0.88mg/kg was recorded in the month of August.

Overall, the order of mineral content in the muscles of *Parachanna obscura* from this study was $K > P > Mg > Ca > Na$.

CHAPTER FIVE

DISCUSSION

Fish is a highly proteinous food consumed by a large population. It is an aquatic animal that is found in almost every water body across the globe. A large percentage of consumers do not eat fish because of its availability, flavours, palatability (Foran *et al.*, 2005). A fewer percentage do so because of its nutritional value. Therefore, studies on the mineral composition of the freshwater bodies have not really caught attention of researchers in fisheries. Hence, the consumers and fishery workers are left with limited information on the importance of a particular fish species in their daily diets.

In developing countries, fish is one of the potential sources of animal protein and essential nutrients for the maintenance of a healthy body (Fawole *et al.*, 2007). The importance of fish in developing countries increased greatly after the Sahelian drought of 1971-1964 which greatly decreased the cattle population, made the price of livestock virtually prohibitive to the majority of Nigerians; a trend which triggered a corresponding increase in the demand for fish which then was the alternative animal protein source (Ladipo *et al.*, 1982).

The study of mineral elements present in living organism is of biological importance since many of such elements take part in some metabolic processes and are known to be indispensable to all living things (Shul'man, 1974). The body usually contains small amounts of these minerals, some of which are essential nutrients being components of many enzyme system and metabolic mechanisms and as such contributes to the growth of the fish. The most important mineral elements induce a lot of malfunctioning; as it reduces productivity and causes diseases such as osteoporosis, anaemia etc. (Fawole *et al.*, 2007); (Adewumi *et al.*, 2014). This study measured

the levels of calcium, sodium, potassium, phosphorus and magnesium in *Malapterurus electricus* and *Parachanna obscura* from Ikpoba River. The results of this investigation of these two fish species from Ikpoba River offers fresh perspectives on the nutritional significance of these species as well as the impact of their immediate surrounding. All the fish samples examined showed appreciable concentrations of the macro elements suggesting that these fishes could be a good source of minerals.

The variations recorded in the concentration of different nutritional components in the fish examined could have been as a result of the rate in which these components are available in the water body (Yeannes and Almandos, 2003) and the ability of the fish to absorb and convert the essential nutrients from the diet or the water bodies where they live. This is supported by the findings of Fawole *et al.* (2007).

Potassium was found to dominate other minerals in all the fish samples. This also corresponds with the findings by Agali and Edema (2009). High concentrations of potassium in fish have also been confirmed by other researchers including Adeyeye *et al.* (2007) and Fawole *et al.*, (2007), who have connected them to essential like sugar metabolism, muscle contraction and nerve impulse transmission (Alas *et al.*, 2014). The high concentration of potassium in the fish species is probably due to its richness in Ikpoba River from which the fishes eat and drink. The value of potassium in *Malapterurus electricus* ranged between 10.22mg/kg to 24.26mg/kg and that of *Parachanna obscura* ranged between 7.25mg/kg to 13.58mg/kg which is within FAO (2003) limits of 30mg/kg to 134mg/kg.

Phosphorus is a major constituent of bones. The values of phosphorus in *Malapterurus electricus* ranged between 7.65mg/kg to 13.54mg/kg while that of *Parachanna obscura* ranged between

7.14mg/kg to 10.03mg/kg which was within FAO (2001) range of 6.8mg/kg to 550mg/kg. The results obtained was higher than the findings of Fawole *et al.* (2007).

Just as potassium and phosphorus, the magnesium content recorded in *Malapterurus electricus* which ranged between 8.75mg/kg to 11.38mg/kg while that of *Parachanna obscura* was lower which ranged between 4.98mg/kg to 9.54mg/kg which are within the FAO range of 4.3mg/kg to 452mg/kg and are comparable with Martinez-Velverde *et al.* (2000). The fishes in the river area are good source of magnesium since it is a component of bone.

Calcium is also important for bone and teeth formation and fish is also known to be a good source of this mineral. In this study, calcium ranged between 1.07mg/kg to 2.57mg/kg in *Malapterurus electricus* and 0.88mg/kg to 1.49mg/kg which was within FAO (2003) mean values of 19mg/kg to 881mg/kg and comparable to the values obtained by Mohammed *et al.* (2010). The concentration of calcium observed in the fishes may be due to a major deposit of calcium in bones in the species. The findings suggests that fish bones could be a veritable source of calcium to reduce the risk of osteoporosis in adults (Adeyemi *et al.*, 2013).

According to Alas *et al.* (2014), sodium is good for muscle functioning and electrolyte balance. Sodium values in *Malapterurus electricus* ranged between 1.36mg/kg to 12.11mg/kg while that of *Parachanna obscura* was 0.64mg/kg to 1.22mg/kg which was within FAO (2003) recommended limit of 30mg/kg to 134mg/kg comparable to the values by some researchers. Sodium had the least concentration among the macro nutrients. The low sodium content could be due to low levels of sodium in water, less trophic transfer and its accumulation in fish flesh.

CONCLUSION

According to the study's finding, both *Parachanna obscura* and *Malapterurus electricus* from Ikpoba River are beneficial dietary sources of necessary macro-elements. It also showed that fresh water fishes are good sources of minerals. This, it is right to say that the mineral elemental contents of species is a function of the availability of these elements in their local environment, diet absorptive capability as well as their preferential accumulation.

RECOMMENDATION

Both *Parachanna obscura* and *Malapterurus electricus* from the Ikpoba River are beneficial dietary sources of necessary macro-elements, according to the study's findings. But the potassium, sodium, calcium, phosphorus and magnesium content of *Malapterurus electricus* is much higher. A possible environmental factor influencing mineral availability in the Ikpoba River is highlighted by the observed low concentrations of all minerals when compared to other research. The following suggestions are offered for further study in order to resolve the disparities discovered and offer a more thorough understanding:

- To evaluate seasonal differences in mineral concentrations, carry out longitudinal research that spans the wet and dry seasons.
- To create a clear connection between the environment, diet, and mineral accumulation, examine the mineral content of the water and sediment of the Ikpoba River as well as the fish's stomach contents.
- Extend the analysis to include trace minerals and heavy metals to give a more comprehensive nutritional and safety profile of these significant food sources.

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APPENDIX I

Table Showing the Concentration of Minerals in the muscles of *Malapterurus electricus* (Sodium, Potassium, Phosphorus, Magnesium, Calcium)

Months	Sodium (mg/Kg)	Potassium (mg/Kg)	Phosphorus (mg/kg)	Magnesium (mg/kg)	Calcium (mg/kg)
May	1.52	21.04	13.54	11.38	2.57
June	1.95	17.93	8.75	9.54	1.33
July	1.36	23.75	10.95	11.13	2.39
August	2.03	14.67	7.65	10.22	1.07
September	2.11	24.26	9.43	11.34	1.75
October	1.50	10.22	8.23	8.75	1.96

APPENDIX II

Table Showing the Results of the Concentrations in the Muscles *Parachanna obscura* (Sodium, Potassium, Phosphorus, Magnesium, and Calcium)

Months	Sodium (mg/Kg)	Potassium (mg/Kg)	Phosphorus (mg/kg)	Magnesium (mg/kg)	Calcium (mg/kg)
May	0.92	8.73	7.14	5.13	1.22
June	0.89	10.77	7.15	4.98	1.08
July	0.75	13.15	9.38	6.35	1.33
August	1.22	7.25	8.33	6.35	0.88
September	0.64	11.35	10.03	6.35	1.08
October	0.95	13.58	8.96	9.54	1.49

APPENDIX III

Table Showing the Maximum Tolerable Limits of Sodium, Potassium, Phosphorus, Magnesium and Calcium

Minerals	Tolerable Limits (mg/kg)	References
Sodium	39.50-57.8	FAO (2003)
Potassium	30-134	FAO (2003)
Phosphorus	6.8-550	FAO (2001)
Magnesium	4.5-452	FAO (2003)
Calcium	19-881	FAO (2003)