

**ASSESSMENT OF HEAVY METALS, PHYSICOCHEMICAL
PROPERTIES IN WATER AND PROXIMATE COMPOSITION
OF FISH FROM OYAN AND ASEJIRE DAMS**

BY

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CERTIFICATION

This is to certify that **AGBOJO, ODUNAYO CHRISTIAN** with the matriculation number **(210531010)**, Department of Chemistry, faculty of science, Lagos State University, Ojo compiled this project report under the supervision of **Prof. Majolagbe, A.O.**

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DEDICATION

I dedicate this project to GOD ALMIGHTY for his guidance, wisdom, and strength throughout this academic journey. To my beloved parents, pastor Mr and Mrs Agbojo and family members whose unwavering support, sacrifices and encouragement have been my driving force. To my project supervisor, Prof. Majolagbe, A.O and coordinators Mr. Adejare Adeniyi and Miss Anko whose dedication to knowledge and excellence has shaped my academic and professional growth. To my colleagues, who have worked with me through challenges and triumphs, this work is a testament to our shared aspirations and relentless pursuit of success.

ABSTRACT

The bioaccumulation of nutrients and contaminants in fish and water indicates environmental conditions and seasonal changes that directly affects food quality and public health. This study evaluated seasonal changes in water quality and heavy metal contamination in Oyan and Asejire Dams, Nigeria, focusing on environmental health and food safety. Water and fish samples (tilapia from Oyan, catfish from Asejire) were collected in wet and dry seasons and analyzed for physicochemical parameters (pH, EC, TDS, alkalinity, hardness), nutrients (nitrate, phosphate, sulfate), proximate composition (protein, ash, fat, moisture and carbohydrate) and selected heavy metals using standard methods. Statistical tools (descriptive stats, Pearson correlations, PCA) were used to interpret results. Marked seasonal differences were observed. Oyan Dam was acidic in the wet season (mean pH 5.66), with high nitrate (up to 39.26 mg/L) and phosphate (mean 1.01 mg/L), while dry season pH rose to 7.87. Asejire Dam had higher ionic strength and elevated nitrate (mean 13.8 mg/L) in the dry season. Notably, iron levels in Oyan's wet-season water (mean 2.60 mg/L; max 10.38 mg/L) exceeded safety guidelines, though other metal concentrations remained low. Fish showed substantial protein, ash, and lipid contents, though clarification is needed on whether values are wet or dry weight. Most heavy metal residues in fish were within safe limits, except for lead in wet season tilapia (0.215 mg/kg), which exceeded FAO's 0.2 mg/kg limit but stayed below WHO's 0.5 mg/kg guideline. The study emphasizes the role of seasonal variation in influencing nutrient levels and metal bioaccumulation, highlighting the need for ongoing monitoring, pollution source control, and ecological risk assessments to protect aquatic life and public health.

Keywords: Proximate composition, Oyan Dam, Asejire Dam, Bioaccumulation, Biomagnification, Metals.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

One of the most important natural resources in the world is water, making Aquatic ecosystems serve as essential resources for drinking, fishing, agriculture, recreation, and industrial activities. However, in recent decades, increasing levels of pollution particularly from heavy metals and other pollutants have raised significant concerns regarding water quality and ecological health (Bănăduc *et al.*, 2022).

According to Awoyemi, 2024, heavy metals including lead (Pb), cadmium (Cd), and chromium (Cr) even at low concentrations are especially dangerous because of their toxicity, persistence, and propensity to bioaccumulate in aquatic creatures like fish. When these metals are above allowable limits, they can cause major health problems such as neurotoxicity, renal damage, and developmental issue (Lawal *et al.*, 2021).

In Nigeria, many surface water bodies including lakes, rivers, and dams are vulnerable to contamination due to rapid urbanization, industrial effluents, agricultural runoff, and poor waste management practices (Omokaro *et al.*, 2024). The Oyan and Asejire Dams, situated in Ogun and Oyo States respectively, are important water reservoirs used for municipal supply, irrigation, and fishery (Akinyemi *et al.*, 2025). Despite their importance, these dams may be exposed to pollution from human settlements, farming activities, and industrial sites surrounding their catchment areas (Alla & Liu., 2021).

Fish are essential component of human diets and excellent bioindicators of aquatic pollution, particularly for monitoring heavy metals due to their capacity for bioaccumulation in tissues such

as the liver and muscle (Agbugui & Abe., 2022). studying the proximate composition such as moisture, protein, lipid, carbohydrate and ash content of fish is equally important to evaluate nutritional quality and safety for consumption (Birie *et al.*, 2025).

Furthermore, physicochemical parameters of water such as pH, temperature, dissolved oxygen (DO), turbidity, total dissolved solids (TDS), and conductivity are critical indicators of water quality (Jaffar *et al.*, 2020). These parameters not only influence aquatic life but also affect the solubility and mobility of heavy metals (Miranda *et al.*, 2021). Therefore, a combined analysis of heavy metals, water quality, and fish nutrition provides a holistic assessment of the safety and sustainability of dam water usage.



Fig. 1: Oreochromis niloticus (Tilapia)

1.2 STATEMENT OF PROBLEM

Despite the critical role of the Oyan and Asejire dams in regional water supply and aquaculture, limited comprehensive studies have assessed both the metal contamination levels and the nutritional integrity of aquatic organisms from these reservoirs. With increasing human activity and potential sources of pollution in their catchment areas, the possibility of bioaccumulation and biomagnification of toxic metals in fish, and contamination of water used by surrounding communities, poses a serious environmental and public health concern. There is a growing need for updated and integrated studies that evaluate both water and fish quality to inform proper monitoring, regulation, and policy intervention.

1.3 AIM AND OBJECTIVES OF THE STUDY

AIM

To assess heavy metals concentration, physicochemical properties of water, and the proximate composition of fish from Oyan and Asejire dams.

OBJECTIVES

1. Collection of fish and water samples from Oyan and Asejire Dams.
2. Metal analysis of fish and water samples (Pb, Zn, Ca) and quantification using Atomic Absorption Spectrophotometer (AAS).
3. Assessment of physicochemical properties such as pH, temperature, turbidity, dissolved oxygen, electrical conductivity, total dissolved solids of the selected dam sites.

4. Evaluation of proximate composition (moisture, protein, fat, carbohydrate, ash content) of fish samples obtained from both dams.

5. Statistical analysis of the data generated (Descriptive analysis, Pearson correlations and Principal component analysis).

1.4 SIGNIFICANCE OF STUDY

Findings from this research will provide valuable information on the environmental health of two key dams in southwestern Nigeria. The study will help inform local authorities, environmental agencies, and public health institutions on possible contamination risks and also guide future monitoring strategies. Additionally, the results will be useful to consumers, fishermen, and policymakers for ensuring food safety and ecological sustainability.

1.5 SCOPE OF THE STUDY

This study focuses on water and fish samples obtained from Oyan and Asejire dams in southwestern Nigeria. The following metals (Ca, Na, K, Cu, Mg, Zn, Fe, Pb) and selected physicochemical parameters will be examined. Proximate analysis will cover major nutrients in fish including protein, lipid, carbohydrate, ash, and moisture content. The study does not include sediment or microbiological analysis.

CHAPTER TWO

LITERATURE REVIEW

2.1 CONCEPT OF WATER POLLUTION IN FRESHWATER ECOSYSTEM

Water is the foundation of life on Earth and completely controls the chemical makeup of all living things. Its unique physical and chemical qualities make it the center of biological metabolism in all living things (Adesina *et al.*, 2024). Among the most significant resources that nature has given the earth are water ecosystems, particularly freshwater ecosystems. It is estimated that 15% of the world's continental surface is made up of freshwater ecosystems, including lakes, ponds, rivers, streams, and wetlands (Chung *et al.*, 2021).

About 10% of all animals and one-third of all vertebrate species live in these inland bodies of water, making them strongholds of biodiversity, one of our most prized natural resources is the water found in freshwater habitats, which are highly prized for its recreational, aesthetic, and scenic features (Majeed *et al.*, 2025). A major hazard to freshwater biodiversity is the contamination of water bodies with numerous kinds of pollutants (chemical, physical, radioactive, and pathogens) from various sources (industrial effluents, agricultural runoff, domestic sewage, construction, and mining operations) (Chawla *et al.*, 2024). Globally, it is a major cause of illnesses and fatalities, primarily in Asia and Africa (Liu *et al.*, 2024). Visual water pollution is caused by physical pollutants (such as temperature changes and big objects), such as plastic bags that are discharged into water bodies by human activity. Urban runoff also contributes to water pollution, which includes pollutants from the land, pollutants from the streets, soil, trash, pesticides, and car adulterants (Gunasekara *et al.*, 2025).

2.2 HEAVY METALS IN AQUATIC ENVIRONMENT

Naturally occurring elements that have high atomic weights and densities at least five times larger than water with atomic number greater than 20 are known as heavy metals (Jagaba *et al.*, 2024). These metals are also referred to as transition metals such as zinc (Zn), copper (Cu), iron (Fe), lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As). Heavy metals are toxic even at low concentrations. The presence of heavy metals in freshwater ecosystems is a major environmental concern due to their persistence, bioaccumulation, and toxic effects on aquatic life and human health (Edo *et al.*, 2024).

2.2.1 SOURCES, PERSISTENCE AND TRANSPORT MECHANISMS OF HEAVY METALS

A major worldwide environmental concern nowadays is the pollution of seas and marine habitats by heavy metals. Indeed, exposure to heavy metals can have serious implications for the wellbeing of the ocean ecosystem and marine life. Heavy metals pollution comes from a variety of sources, including human activity like industrial and urban waste water and natural processes such as the breakdown of rocks due to physical, chemical, and biological stresses (Butnariu, 2022).

Anthropogenic (Human-Induced) Sources include industrial effluents, Industries such as mining, metal plating, battery manufacturing, textiles, and tanneries discharge high levels of heavy metals into freshwater bodies (Shah, 2021). runoffs from agricultural farmlands, The over use of pesticides, fertilizers, and herbicides that include heavy metals such as cadmium in phosphate fertilizers and arsenic in insecticides contaminates rivers, lakes, and dams (Muhsin *et al.*, 2021). Petroleum products and spills of oil, Fossil fuel combustion and unintentional spills release heavy metals into the environment, including nickel (Ni), lead, and vanadium (V) (Jagaba *et al.*, 2024).

Heavy metals travel through a number of transit modes after being discharged into aquatic systems, such as sedimentation, particle adsorption, and aquatic creature ingestion (Mansor *et al.*, 2024).

2.2.2 ENVIRONMENTAL FATE AND BIOAVAILABILITY OF HEAVY METALS

Heavy metals undergo physical, chemical, and biological changes that impact their toxicity and bioavailability rather than degrading in the environment. These metals can be found in a variety of forms, such as dissolved ions in water that aquatic life can directly absorb. Particulate-bound metals that adhere to sediments and suspended solids, complexes, both chemical and inorganic, that affect toxicity and mobility (Angon *et al.*, 2024). The main controlling factors include pH, redox potential (Eh), ionic strength/hardness, dissolved organic matter (DOM), particulate matter and sediments, as well as temperature. For instance, reduced pH levels (acidic environments) typically enhance the solubility of numerous cationic metals (such as Cd^{2+} , Pb^{2+}), which increases their dissolved amounts and immediate availability to aquatic life. On the other hand, waters high in carbonate or with elevated pH tend to promote precipitation or sorption, resulting in decreased dissolved concentrations (Wang *et al.*, 2024). Under reducing conditions (low Eh), metals like chromium and arsenic can change oxidation state ($\text{Cr}^{6+} \leftrightarrow \text{Cr}^{3+}$, and $\text{As}^{5+} \leftrightarrow \text{As}^{3+}$, resulting in different solubility and toxicity profiles (Alam, 2024). Dissolved organic matter and particulate organic carbon act as complexing agents, binding metals to form soluble organo-metal complexes (increasing transport) or facilitating adsorption to particles and sediments (decreasing immediate dissolved bioavailability but establishing long-term sinks and potential secondary sources if conditions change). Water hardness (high $\text{Ca}^{2+}/\text{Mg}^{2+}$) and ionic composition can lower the bioavailability and immediate toxicity of some metals (such as Pb and Cd) by making it harder for living things to take them up (Allahkarami & Allahkarami., 2025).

2.2.3 TOXICOLOGICAL EFFECTS OF HEAVY METALS ON AQUATIC LIFE AND HUMANS

Heavy metals have a diverse spectrum of harmful effects on aquatic life, depending on the metal, its chemical form, exposure dose, duration, and species susceptibility (Zaynab *et al.*, 2022). Metals can disrupt respiration (gill damage), osmoregulation, growth, reproduction, and behavior. they can cause oxidative stress (increased reactive oxygen species), damage membranes and DNA, and cause histopathological lesions in target organs (liver, kidney, gill, gonads) (Menon *et al.*, 2023). Minor effects are ecologically significant because they diminish wellness, predator evasion, and reproductive success, altering population structure and community dynamics long before outright mortality is observed (Satkar *et al.*, 2024). Low-level metal stress in fish and invertebrates is widely detected using biomarkers such as hepatic metallothionein induction, antioxidant enzyme responses (SOD, CAT, GPx), lipid peroxidation products, and histopathology. Humans are exposed to aquatic heavy metals largely through drinking water and food sources (Raeeszadeh *et al.*, 2023). The toxicological effects depend on the metal, Lead impairs neurological development in children and affects cardiovascular and renal systems in adults, cadmium is carcinogenic and targets kidneys and bone (Itai-Itai disease historically) mercury, particularly methylmercury, is a potent neurotoxin that affects fetal neurodevelopment; and arsenic (inorganic) increases cancer risk and causes skin, cardiovascular, and endocrine effects. The public-health significance of fish borne metals is exacerbated in communities that rely heavily on local fisheries for protein. Chronic low-level exposure through diet can accumulate over time, resulting in negative outcomes (Mengistu, 2021). As a result, risk assessment takes into account consumption rates, metal concentrations in edible tissues, and vulnerable groups (children, pregnant women). International guidelines (WHO, FAO) set maximum residue limits for certain

metals in fish and drinking water, monitoring and enforcement shortcomings, particularly in low-resource locations, imply human exposure is a significant problem (Mengistu, 2021).

2.3 BIOACCUMULATION AND BIOMAGNIFICATION OF POLLUTANTS IN FISH

Bioaccumulation means the total build-up of substances (such as metals) within an organism from various exposure pathways (including water, diet, and contact with sediment) as time progresses. Biomagnification refers to the rise in concentration of a substance within organisms at higher trophic levels as a result of dietary transfer (Ray & Shaju., 2023). The degree and distribution of accumulation vary depending on the species and the specific tissue: organs that are metabolically active (such as the liver, kidney, and gill) typically exhibit greater metal levels compared to muscle, yet muscle is critical for human exposure as a result of dietary consumption (El-Agri, 2021). According to (Gora *et al.*, 2025), absorption, detoxification, retention, and elimination are influenced by lipid content, metabolic rate, and metal-binding proteins (metallothioneins). As previously mentioned, bioavailability is determined by water chemistry and speciation. Dissolved free ionic forms are generally more bioavailable than firmly bound particle forms. Certain metals, such as methylmercury, which are poorly depurated or bind strongly to soft tissues, biomagnify more easily and concentrate in top predators, while other metals with effective excretion might not biomagnify as much (Singh & Sharma., 2024). Recent studies confirm that biomagnification of mercury and certain persistent organic pollutants is well documented, whereas biomagnification of numerous inorganic metals is more variable and dependent on metal chemistry and food chain structure (Kumar *et al.*, 2023). Empirical studies typically show orders-of-magnitude differences in metal concentrations between organs (gut > liver > muscle) and between species at different trophic levels (Cui *et al.*, 2015). pH, redox, organic matter, sediments, and water chemistry all influence metal fate and bioavailability, hence speciation and bioavailable fractions provide more

information than total concentrations. Heavy metals induce a wide range of harmful consequences in aquatic creatures (oxidative stress, histopathology, reproductive impairments) and serious chronic human health outcomes through dietary exposure (Linnik *et al.*, 2023). Bioaccumulation and biomagnification are particular to species, tissues, and metals, mercury and certain persistent chemicals exhibit significant biomagnification, but inorganic metal biomagnification varies. Monitoring should encompass several tissues and trophic levels (Edo *et al.*, 2024).

2.4 NUTRITIONAL AND HEALTH IMPLICATIONS OF PROXIMATE COMPOSITION IN FISH

Fish is a major source of high-quality protein, essential fatty acids, vitamins, and minerals, making it an important part of a healthy diet. Proximate analysis of fish typically involves determining moisture content, crude protein, lipid, ash, fiber, and carbohydrate levels each of which reflects the nutritional value of the fish (Phogat *et al.*, 2022). These parameters not only guide dietary recommendations but also provide insights into the health and ecological status of fish populations.

The nutritional composition of fish can vary widely depending on species, age, diet, habitat, and environmental conditions such as water temperature and quality (Ahmed *et al.*, 2022). For example, the protein content of freshwater fish generally ranges from 15% to 24%, while fat content may vary from 0.5% to 20% depending on the species and season (Rasul *et al.*, 2021). Lipid content is of particular interest due to the presence of polyunsaturated fatty acids (PUFAs), which have been linked to reduced risks of heart disease (Kapoor *et al.*, 2021).

However, environmental stressors, including heavy metal contamination, can compromise the nutritional quality of fish. Several studies have shown that exposure to pollutants can lead to reduced protein synthesis, increased lipid peroxidation, and alterations in ash and moisture content

(Xu *et al.*, 2021). Consequently, assessing both the proximate composition and metal levels in fish offers a holistic view of their health status and suitability for human consumption (Ahmed *et al.*, 2022).

2.5 PHYSICOCHEMICAL PARAMETERS; ENVIRONMENTAL INDICATORS OF WATER QUALITY

Physicochemical parameters play a crucial role in determining the overall quality and ecological integrity of aquatic systems. Common parameters include pH, dissolved oxygen (DO), temperature, electrical conductivity (EC), turbidity, total dissolved solids (TDS), biochemical oxygen demand (BOD), nitrate, sulphate, phosphate levels (Menon *et al.*, 2023). These indicators affect metal solubility, biological activity, and the survival of aquatic organisms (Banaee *et al.*, 2024).

For instance, pH influences the speciation and mobility of metals acidic conditions enhance the solubility and bioavailability of toxic metals such as cadmium and lead (Peana *et al.*, 2021). Dissolved oxygen (DO) levels reflect the water's ability to support aerobic organisms; low DO often indicates organic pollution or eutrophication. High turbidity reduces light penetration, affecting photosynthesis and disrupting food chains (Rodrigues *et al.* 2023).

Physicochemical parameters are often influenced by human activities such as agriculture, deforestation, and waste disposal. In Nigeria, water quality monitoring studies of rivers and reservoirs (e.g., Ogun River, Asejire Reservoir, and Oyan Dam) have recorded seasonal fluctuations in temperature, turbidity, and dissolved oxygen linked to rainfall patterns and anthropogenic input (Omokaro *et al.* 2024). Monitoring these parameters is essential not only for

detecting pollution but also for establishing baseline data that guide water management, fish farming, and public health protection.

2.6 REGULATORY STANDARDS AND GUIDELINES

To protect aquatic ecosystems and human health, various international organizations have established regulatory guidelines and permissible limits for contaminants such as heavy metals in water and fish. These guidelines help monitor pollution levels, prevent excessive contamination, and ensure safe consumption of aquatic resources (Ahmad *et al.* 2021).

2.6.1 INTERNATIONAL REGULATORY GUIDELINES FOR WATER AND FISH SAFETY

Several global agencies, including the World Health Organization (WHO), United States Environmental Protection Agency (USEPA), Food and Agriculture Organization (FAO), and National Environmental Standards and Regulations Enforcement Agency (NESREA) in Nigeria, have set specific permissible limits for these pollutants (Ogbeide & Henry 2024).

Table 1: heavy metals in drinking water and fish

Heavy metals	WHO limit for drinking water (mg/L)	USEPA limit in fish (mg/kg)	FAO/WHO recommended limit in fish (mg/kg)
Lead Pb	0.01 mg/L	0.3 mg/kg	0.2 mg/kg
Cadmium Cd	0.003 mg/L	0.1 mg/kg	0.05 mg/kg

Mercury Hg	0.001 mg/L	0.5 mg/kg	0.5 mg/kg
Chromium Cr	0.05 mg/L	0.15 mg/kg	0.1 mg/kg
Arsenic As	0.01 mg/L	1.0 mg/kg	1.0 mg/kg

These standards provide a benchmark for assessing pollutant levels in water and fish to ensure they remain within safe consumption limits. However, many developing countries, including Nigeria, struggle with enforcing these regulations due to inadequate monitoring and weak policy implementation. For instance, some rural communities lack access to routine water testing, making them vulnerable to chronic exposure through both drinking water and fish consumption (Obialor 2023).

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS AND CHEMICALS

The materials used for the experiments are as follows;

- Measuring cylinder
- Conical flask
- Portable PH meter, conductivity meter, DO meter
- Sample bottles (150cl and 75cl)
- Amber bottle
- 25ml and 50ml standard flask
- Filter paper
- Beaker
- Fume cupboard
- Gloves
- Plastic funnel
- Hot plate
- Soxhlet extractor apparatus
- Extraction thimbles
- Reflux condenser
- Water bath
- Kjeldahl apparatus

- Desiccator
- Hot air oven
- Weigh balance
- Burette and titration set up

Reagents used for the experiments are;

- Nitric acid
- Hydrochloric acid
- Distilled water
- Sulfuric acid
- Normal hexane
- Ammonium molybdate
- Barium chloride
- EDTA
- Ammonia buffer

Equipment used for analysis

- Atomic Absorption Spectroscopy (AAS)
- UV Spectrophotometer

3.2 STUDY AREA

This research study is conducted in two major dam sites which are Oyan and Asejire dams respectively for their differing hydrological characteristics and environmental impacts. These sites were selected to provide a comprehensive understanding of dam activities changes or dynamics in aquatic environment.

OYAN DAM

Oyan Dam is located in Ogun State, Southwestern Nigeria, at approximately 7°15'N latitude and 3°10'E longitude. It was constructed in 1983 by the Ogun-Osun River Basin Development Authority (OORBDA) for multipurpose water resource management. The dam is fed by the Oyan River, a tributary of the Ogun River, and has a surface area of about 4,000 hectares with a maximum storage capacity of 270 million cubic (Akinyemi, Mobolaji *et al.* 2025).



Fig 2: Oyan Dam

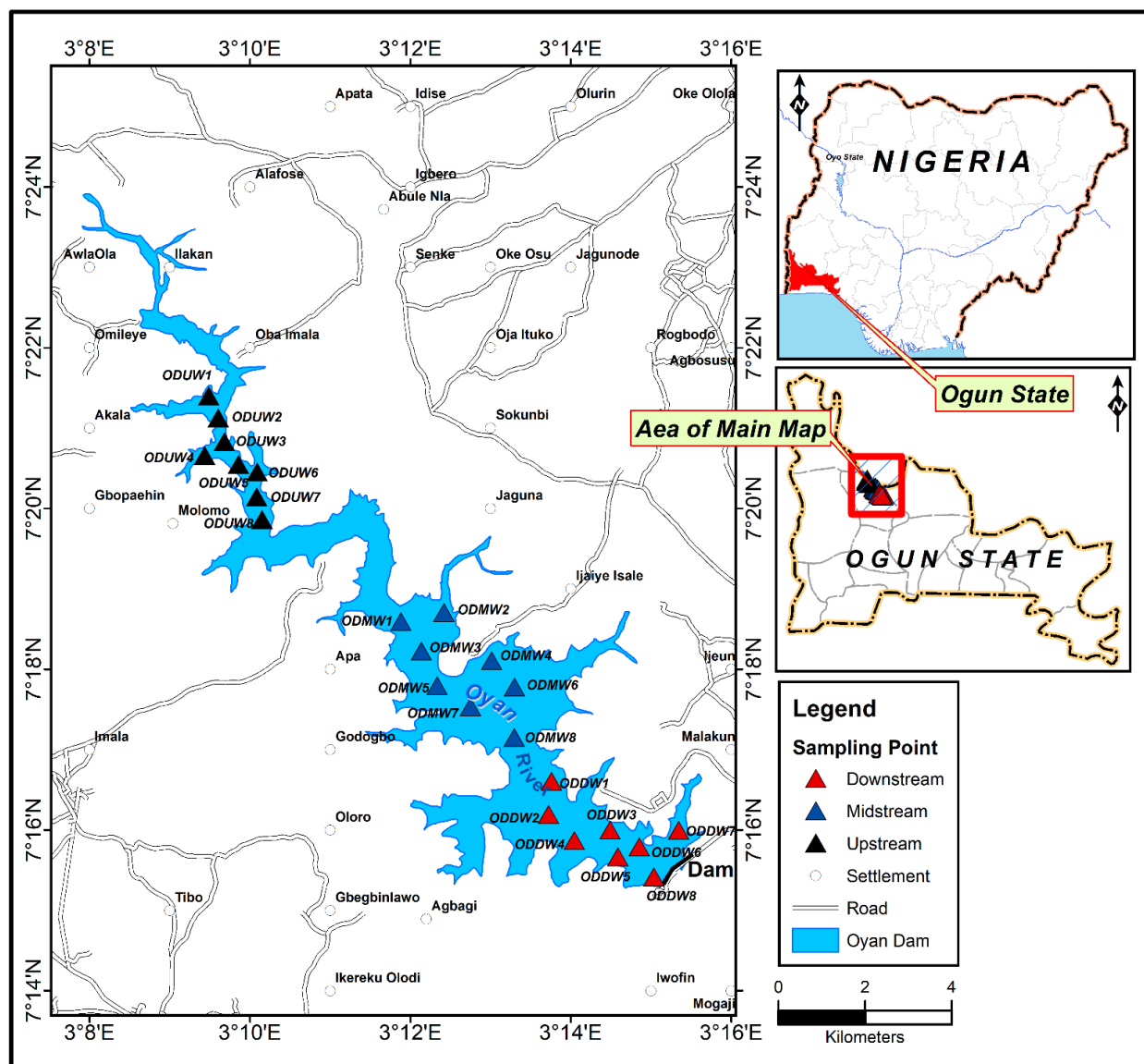


Figure 3: Map of Oyan Dam showing Sampling Points

ASEJIRE DAM

Asejire Dam is situated in Oyo State, Southwestern Nigeria, at approximately 7°25'N latitude and 4°5'E longitude. The dam was built on the Osun River in the 1970's as a major water supply project for Ibadan, the capital of Oyo State. The dam has a storage capacity of about 250 million cubic meters (m³) and a surface area of approximately 2,300 hectares (KAREEM, OLUWALE *et al.* 2024).



Fig 4: Asejire Dam

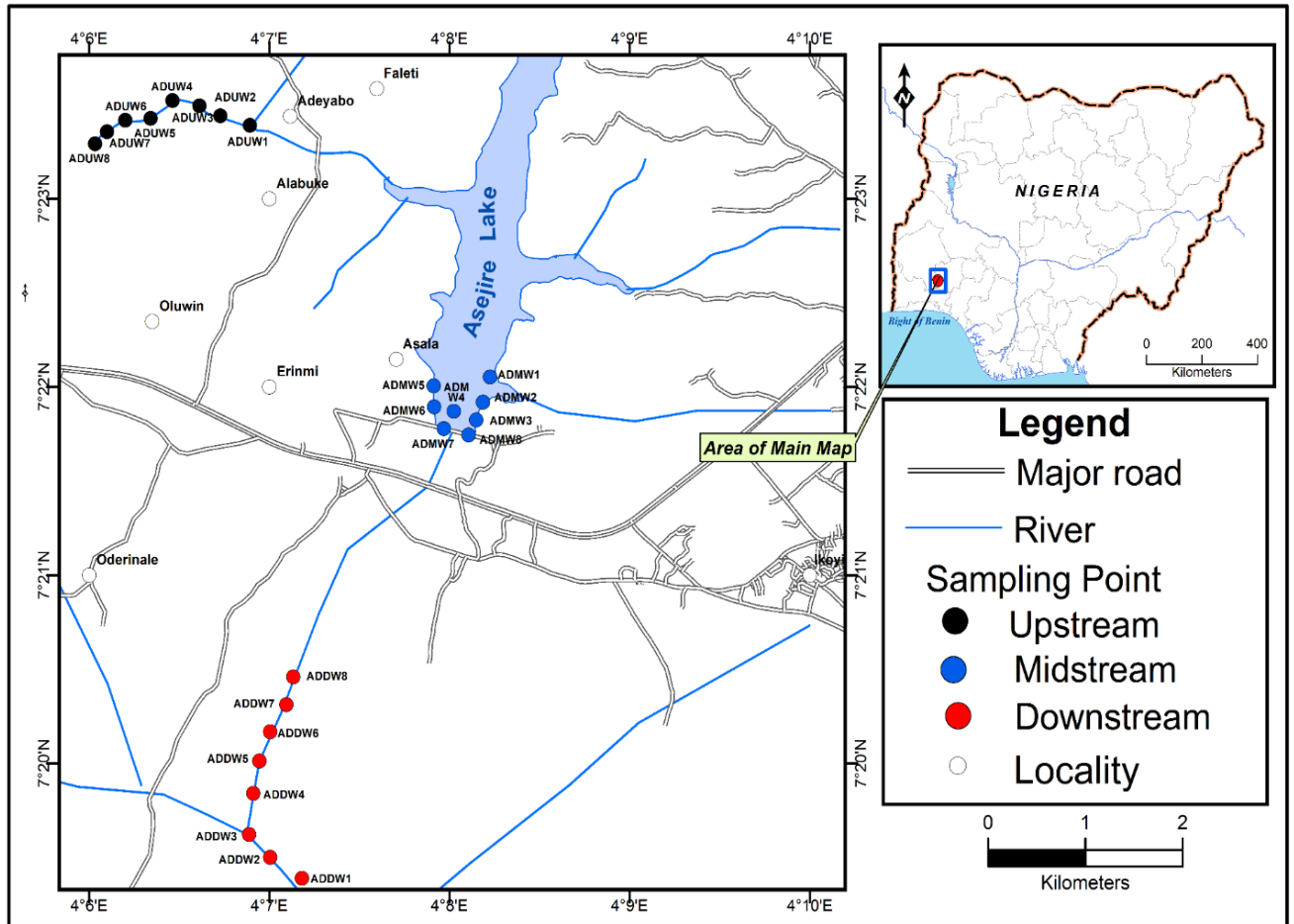


Fig 5: Map of Asejire Dam Showing Sampling Points

3.3 METHODS

3.3.1 WATER SAMPLING

Water samples were collected from different locations within each dam which include upstream, midstream and down-stream areas. At each area, eight samples were collected to ensure accuracy and representativeness with strict labelling. Collection was done using 150cl and 75 cl polyethylene bottles, previously rinsed with nitric acid and distilled water to prevent contamination. Physicochemical parameters such as pH, electrical conductivity (EC), temperature, Total Dissolved Solids (TDS), dissolved oxygen (DO) were measured immediately using a multi-parameter digital meter during sampling.

3.3.2 FISH SAMPLING

Fish samples were collected using gill nets by fishermen operating within the dam areas. Dominant species were selected, Tilapia (*Oreochromis niloticus*) and Catfish from oyan and asejire dams respectively. At least four samples of each species were collected from each dam and preserved in ice packed coolers before being transported to the laboratory for analyses.

3.3.3 PHYSICOCHEMICAL ANALYSIS OF WATER

Physicochemical parameters such as pH, electrical conductivity (EC), temperature, Total Dissolved Solids (TDS), dissolved oxygen (DO) were measured using a multi-parameter digital meter during water sampling while the analyses involved: Nitrate Analysis, Sulphate Analysis, Chloride Test, Hardness Test, Acidity and Alkalinity Test.

TOTAL ALKALINITY BY TITRIMETRY (APHA/AWWA, 1998)

Apparatus: Pyrex glass/Conical flask, burette, pipette and wash bottle.

Reagents: 0.05M Sodium carbonate, 0.02M Sulphuric acid, mixed bromocresol/methyl red indicator, phenolphthalein indicator.

Standardisation of Sulphuric acid

0.02M Sulphuric acid was standardised with 0.05M standard Sodium carbonate solution.

$$\text{Molarity of H}_2\text{SO}_4 = \frac{A \times B}{53.00 \times C}$$

Where A = g of carbonate in 1 L flask

B = mL of Na₂CO₃ used

C = mL of acid used

Procedure

50 mL of the water samples were measured into 250 mL conical flasks, 2 – 3 drops of phenolphthalein indicator were added and then titrated against standardised 0.02M Sulphuric acid, until a pink colour was observed, which accounts for phenolphthalein alkalinity. Total alkalinity was determined by running the titration above with 3 drops of bromocresol methyl red indicator until a pink colour appeared.

Calculation

1 mL of 0.02M H₂SO₄ = 1 mg CaCO₃

$$\text{Phenolphthalein alkalinity (mg CaCO}_3) = \frac{A \times M \times 50000}{\text{mL of sample}}$$

Where A = mL standard acid used

M = Molarity of standard acid

$$\text{Total alkalinity (mg CaCO}_3\text{)} = \frac{(2B - C) \times M \times 50000}{\text{mL of sample}}$$

Where B = mL of titrant at first end point with phenolphthalein indicator

C = mL of titrant at second end point with bromocresol methyl red indicator

ACIDITY BY TITRIMETRY (APHA/AWWA, 1998)

Apparatus: Glassware conical flask, burette and funnel.

Reagents: Standard 0.02 M sodium hydroxide, phenolphthalein indicator, 0.05 M potassium hydrogen phthalate solution.

Standardisation of Sodium hydroxide

The 0.02 M Sodium hydroxide solution was standardised against 15 ml of 0.05 M standard solution of potassium hydrogen phthalate.

$$\text{Molarity of NaOH} = \frac{A \times B}{204.2 \times C}$$

Where A = g KHC₈H₄O₄/1 L flask

B = mL of KHC₈H₄O₄ used

C = mL of NaOH used

Procedure

50 mL each of the water samples were measured into conical flasks, 2 – drops of phenolphthalein were added, and titrated against the 0.02 M NaOH until a pink colour appeared.

Calculation

$$\text{Acidity} = \frac{A \times M \times 50000}{\text{Vol. of Sample}}$$

Where A = mL of NaOH

M = Molarity of NaOH used

TOTAL HARDNESS BY COMPLEXOMETRIC TITRATION METHOD (APHA/AWWA, 1998)

Apparatus: 250 mL beaker, 250 mL conical flasks, burette and funnel.

Reagents: Buffer solution $\text{NH}_4\text{-NH}_3\text{OH}$ (Ammonia ammonium hydroxide), 0.28 M sodium sulfide, 0.01 M Calcium carbonate, 0.01 M EDTA solution, and Erichrome Black T indicator.

Procedure

0.01 M EDTA was freshly prepared, standardized and titrated against 0.01M calcium carbonate with Eriochrome Black T as indicator. 50 ml of the water sample was measured accurately into a 250 mL conical flask. 1 mL of the buffer solution (Ammonia-ammonium hydroxide) was added to give a pH of 10, followed by 1 mL of masking agent (0.28 M sodium sulfide), and the solution was thoroughly mixed. 1 mL of Eriochrome Black T was thereafter added. The standard EDTA (titrant) was then slowly added into the conical flask containing the sample with continuous stirring

until a blue color was observed marking the end point. Blank titration using distilled water was also carried out in the same way.

Calculation

$$\text{Hardness mg CaCO}_3/\text{L} = \frac{A \times B \times 1000}{\text{Vol. of Sample}}$$

Where A = mL titration for sample

B = mg CaCO₃ equivalent to 1.0 mL EDTA

DETERMINATION OF CHLORIDE BY ARGENTOMETRIC METHOD (APHA/AWWA, 1998)

Apparatus: Pyrex glass, beaker, burette and funnel.

Reagents: 0.0141 M Silver nitrate, 1 N Potassium chromate indicator.

Standardisation of Silver nitrate

0.0141 M Silver nitrate was first standardised against Sodium chloride, with potassium chromate as indicator.

Procedure

50 mL each of the water samples were measured into a 250 mL conical flask, then potassium chromate was added, and titrated against 0.0141 M Silver nitrate. The mixture was constantly stirred until a red colour appeared, marking the end point. Blank titration was done using the same procedure as those of the water samples.

Calculation

$$\text{mg Cl}^-/\text{L} = \frac{(A - B) \times M \times 35450}{\text{Vol. of Sample (mL)}}$$

Where A = mL titration for sample

B = mL titration for blank

M = Molarity of AgNO₃

DETERMINATION OF NITRATE BY ULTRAVIOLET SPECTROPHOTOMETRIC SCREENING METHOD (APHA/AWWA, 1998)

Apparatus:

Reagents: Potassium Nitrate (KNO₃), Chloroform (CHCl₃), Hydrochloric acid (HCl).

Procedure

A stock nitrate solution was prepared by drying potassium nitrate (KNO₃) in an oven at 105°C for 24 hrs. 0.7218 g of KNO₃ was dissolved in water, and diluted to 1000 mL. The salt solution was preserved with 2 mL of chloroform (CHCl₃), which makes the solution stable for at least 6 months. An intermediate nitrate solution was then prepared by diluting 100 mL stock nitrate solution to 1000 mL with water, and preserved with 2 mL CHCl₃.

Procedure

50 mL of each clear water sample was poured into a beaker, 1 mL of HCl was added and the solution was mixed thoroughly. Calibration standards for NO₃⁻ was prepared in the range 0 to 7 mg NO₃⁻ by diluting to 50 mL, the following volumes of intermediate nitrate solution: 0, 1.00, 2.00, 4.00, 7.00 . . . 35.0 mL. NO₃⁻ standards were treated in the same manner as the water samples.

The absorbance was read at a wavelength of 220 nm to obtain the NO_3^- reading, and at a wavelength of 275 nm to determine interference due to dissolved organic matter.

$$\text{mg/L NO}_3^- = \frac{\text{mg NO}_3^- \times 1000}{\text{Sample Volume}}$$

DETERMINATION OF SULPHATE BY TURBIDIMETRY (APHA/AWWA, 1998)

Apparatus: Analytical balance, hotplate with magnetic stirrer, micropipette, spectrophotometer, and stopwatch.

Reagents: Buffer solution, Barium chloride crystals, standard sulphate solution.

Preparation of buffer solution: 30 g Magnesium chloride ($\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$), 5 g sodium acetate, 1 g potassium nitrate and 20 ml acetic acid were dissolved in distilled water and made up to 1 L.

Procedure

100 mL each of the water samples were accurately measured into a conical flask (250 mL), then 20 mL of the buffer solution was added and mixed with stirring apparatus. While stirring, a spoonful of BaCl_2 crystals was added and stirred on a magnetic stirrer for 60 seconds. It was thereafter poured into the absorption cell of the spectrophotometer, and its absorbance read at 420 nm. Blank titration was carried out with the same procedure as that of the water samples. The SO_4^{2-} concentration of the sample was estimated by extrapolation from the calibration curve which was obtained from spectrophotometric analysis of standard sulphate solution.

$$\text{mg/L SO}_4^{2-} = \frac{\text{mg SO}_4^{2-} \times 1000}{\text{Sample Volume (ml)}}$$

DETERMINATION OF PHOSPHATE BY COLORIMETRIC METHOD (APHA/AWWA, 1998)

Apparatus: Analytical balance, Hot plate, Glassware, and Spectrophotometer.

Instrumentation: Ammonium molybdate solution, 0.1 M Ascorbic acid solution, Potassium antimony tartarate.

Preparation of reducing agent: 250 mL of 5 M H₂SO₄, 75 mL Ammonium molybdate, 150 mL Ascorbic acid, and 25 mL Potassium antimony tartarate were dissolved in 5 M Sulphuric acid.

Procedure

40 mL each of the water samples were measured into a 50 mL standard volumetric flask, and 8 mL of reducing agent was added, and thereafter, made up to the 50 mL mark with distilled water. The solution was allowed to stand for 10 minutes, and its absorbance measured spectrophotometrically at 880 nm. Blank titration was carried out in the same way as that of the water samples. The PO₄³⁻ concentration of sample was estimated by extrapolation from the titration curve which was obtained from spectrophotometric analysis of standard PO₄³⁻ solutions.

$$\text{mg/L PO}_4^{3-} = \frac{\text{mg PO}_4^{3-} \times 1000}{\text{Sample Volume}}$$

DETERMINATION OF SALINITY

Salinity was determined from its relationship to chloride (Cl⁻) concentration.

$$\text{Salinity (ppt)} = 0.00180665 \times \text{Cl}^- \text{ (mg/L)}$$

HEAVY METALS ANALYSES

DETERMINATION OF METALS BY SPECTROPHOTOMETRIC METHOD (APHA/AWWA, 1998)

Apparatus: 250 mL beakers, Hot plate, 50 mL volumetric flasks.

Instrumentation: Flame Atomic Absorption Spectrophotometer.

Reagents: Concentrated Nitric acid (analar grade).

Procedure

50 mL each of the water samples were measured into a clean 250 mL beaker, and 5 mL of concentrated Nitric acid (analar grade) was added. This was evaporated to near dryness (about 3 mL) over a hot plate. It was then cooled, quantitatively transferred to a 50 mL volumetric flask, and made up to mark with distilled water. The digested sample was stored in an acid-washed, well-labelled, and secured plastic bottle. Eight metals (Zn, Fe, Cu, Pb, Mg, Ca, Na. and K) were determined employing a Flame Atomic Absorption Spectrophotometer (FAAS). Procedural blanks were prepared with distilled water and done with the same procedure.

3.3.4 DIGESTION OF WATER SAMPLES

50ml of water samples was measured with the addition of 5ml nitric acid in a beaker. The mixture was heated for about 10 minutes gently in a water bath. The digested samples was filtered into a 50ml volumetric flask and a 50ml sampling bottle for metal analysis using Atomic Absorption Spectrophotometer (AAS).

3.3.5 DIGESTION OF FISH SAMPLES

1g of dried fish samples was weighed in duplicate with the addition of 20ml aqua regia solution (HCL: HNO₃, 3:1) in a beaker. The mixture was heated for about 10 minutes gently in a water bath until the fish sample was completely broken down. The digested samples was filtered into a 50ml volumetric flask and a 50ml sampling bottle for metal analysis using Atomic Absorption Spectrophotometer (AAS).

PROXIMATE ANALYSES OF FISH

DETERMINATION OF MOISTURE CONTENT

The method described by AOAC (2010) was adopted. A clean crucible was dried to constant weight in an air oven at 105oC, cooled in a desiccator and weighed (W1). Two grams of sample were accurately weighed into the previously labeled crucible and reweighed (W2). The crucible was dried in oven to a constant weight (W3). The percentage moisture content was calculated thus:

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} \times 100$$

$$W2-W1$$

DETERMINATION OF ASH CONTENT

Ash content was determined according to AOAC (2010) method where porcelain crucible was dried in an oven at 100oC for 10 minutes, cooled in a desiccator and weighed (W1). Two grams of the sample was placed into the previously weighed porcelain crucible and weighed (W2). The sample was first ignited and transferred into a furnace, which was then set at 550oC. The sample was left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was

then removed, cooled in the desiccator and weighed W3. The percentage ash content was calculated as: % Ash content = $\frac{W3-W1}{W2-W1} \times 100$

$$W2-W1$$

DETERMINATION OF CRUDE FAT

The fat content was determined according to the method described by AOAC (2010). A clean, dried 500ml round bottom flask, containing few anti-bumping granules was weighed (W1) and 300ml of Petroleum ether (40-60 oC) for extraction was poured into the flask fitted with soxhlet extraction unit. The extractor thimble containing twenty grams of the sample was fixed into the soxhlet extraction unit. The round bottom flask and a condenser were connected to the soxhlet extractor and cold water circulation was put on. The heating mantle was switched on and the heating rate was adjusted until the solvent was refluxing at a steady rate. Extraction was carried out for six hours. The solvent was recovered and the oil was dried in the oven at 70 oC for one hour. The round bottom flask containing the oil was cooled in the desiccator and then weighed W2. The lipid content was calculated thus;

$$\% \text{ Crude Fat Content} = \frac{W2-W1}{\text{Weight of sample}} \times 100$$

Weight of sample

DETERMINATION OF CRUDE PROTEIN

Determination of nitrogen and crude protein were done according to the method of AOAC (2010). Exactly 1.5g of the defatted sample in an ashless filter paper was dropped into 300ml Kjeldahl flask. Twenty five milliliters of H₂SO₄ and 3g of digesting mixed catalyst (weighed separately into an ashless filter paper) was dropped into the Kjeldahl flask. The flask was then transferred to

the Kjeldahl digestion apparatus. The sample was digested until a clear green colour was obtained. The digest was cooled and diluted to 100ml with distilled water. Distillation of the Digest 20ml of the diluted digest was measured into a 500ml Kjeldahl flask containing anti-bumping chips and 40ml of 40% NaOH was slowly added by the side of the flask. A 250ml conical flask containing a mixture of 50ml of 2% Boric acid and 4 drops of mixed indicator was used to trap the ammonia liberated. The conical flask and the Kjeldahl flask were then placed on the Kjeldahl distillation apparatus, with the tubes inserted into the conical flask and the Kjeldahl flask. The flask was heated to distill out NH₃ evolved. The distillate was collected into the boric acid solution. From the point when the boric acid turned green, 10 minutes were allowed for complete distillation of the ammonia present in the digest. The distillate was the titrated with 0.1M HCl.

Calculated thus:

$$\% N = 14 \times M \times V_t \times T_v \text{ Weight of sample (g)} \times V_a \times 100 \%$$

$$\text{Crude protein} = \% \text{ Nitrogen} \times 6.25$$

CARBOHYDRATE CONTENT

Percentage carbohydrate was calculated thus;

$$\% \text{Carbohydrate} = 100 - (\% \text{ Moisture} + \% \text{ Ash} + \% \text{ Fat} + \% \text{ Protein})$$

3.4 DATA ANALYSIS

Data obtained were analyzed using SPPSS (version 25), descriptive statistics (mean, standard deviation, range), Correlation, Component Matrix and Dendrogram were used to summarize the results. Results were compared with FAO and WHO Limits.

CHAPTER FOUR

RESULTS AND DISCUSSION

Result shows proximate composition, metals concentration and physicochemical properties of fish and water samples from Oyan and Asejire Dams for both dry and wet seasons.

4.1 PROXIMATE COMPOSITION AND METAL CONCENTRATION (DRY SEASON)

OYAN TILAPIA

Table 2:Proximate Composition (Dry Season) Tilapia Oyan Dam

Parameter	Tilapia (%)	WHO (%)	FAO limit (%)
Ash	14.78	1.35	1.6
Protein	12.25	18.5	22
Crude Fat	26.15	7.6	8.55
Moisture	26.15	73.5	73.5
Carbohydrate	15.68	35	35

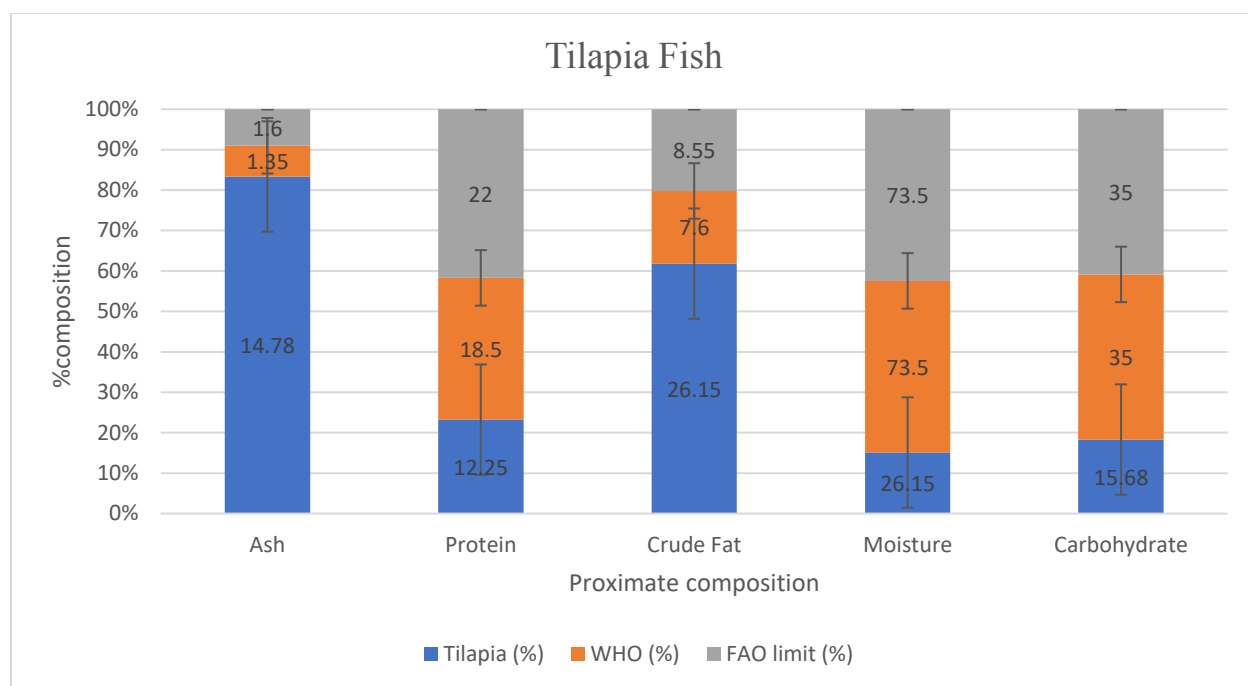


Fig 6: Graphical representation of proximate composition (Dry season) Tilapia

In table 2 (figure 6), the result shows that Ash content (14.78%) far exceeded the WHO (1.35%) and FAO (1.6%) limits, suggesting mineral deposition. Protein (12.25%) fell below the WHO (18.5%) and FAO (22%) standards, reflecting low nutritional quality. Crude fat (26.15%) was substantially higher than the recommended range (7.6–8.55%). Moisture (26.15%) was far below the expected 73.5%, while carbohydrate (15.68%) was lower than 35%. The fish in the dry season contained excessive ash and fat but impoverished protein and carbohydrate.

Table 3: Metals concentration (Dry Season) Tilapia Oyan Dam

Parameter	Tilapia(mg/kg)	Who limits(mg/kg)	FAO limits (mg/kg)
CU	0.004	30	30
Fe	0.16	100	100
Zn	0.032	1.5	30
Pb	0.032	0.5	0.2
Cd	0	0.5	0.05
Cr	0.03	0.575	0.575
Ni	0	32.5	80

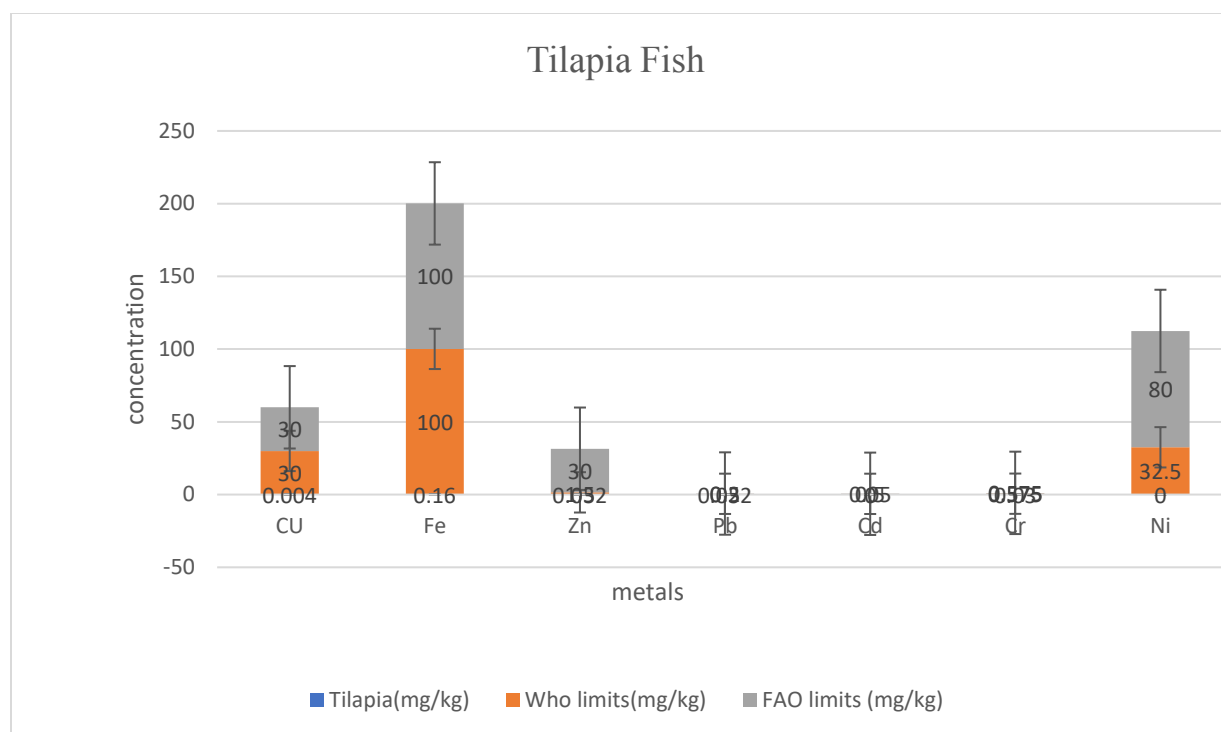


Fig 7: Graphical representation of Metals concentration (dry season) Tilapia

This result (Table 3 and Fig 7) shows that Cu (0.004 mg/kg), Fe (0.16 mg/kg), Zn (0.032 mg/kg) were far below permissible limits. Pb (0.032 mg/kg) exceeded FAO (0.2 mg/kg) but remained within WHO (0.5mg/kg). Cd was absent, Cr (0.03 mg/kg) and Ni (0.0) were within safe ranges. Fish were mostly safe, but Pb poses a potential concern.

4.2 PROXIMATE COMPOSTION AND METALS CONCENTRATION (WET SEASON) TILAPIA OYAN

Table 4: Proximate Composition (Wet Season) Tilapia Oyan Dam

Parameter	Tilapia(%)	WHO(%)	FAO limit (%)
% Ash	14.78	1.35	1.6
% Protein	25.26	18.5	22
% Crude Fat	12.615	7.6	8.55
% Moisture	10.49	73.5	73.5
%Carbohydrate	27.925	35	35

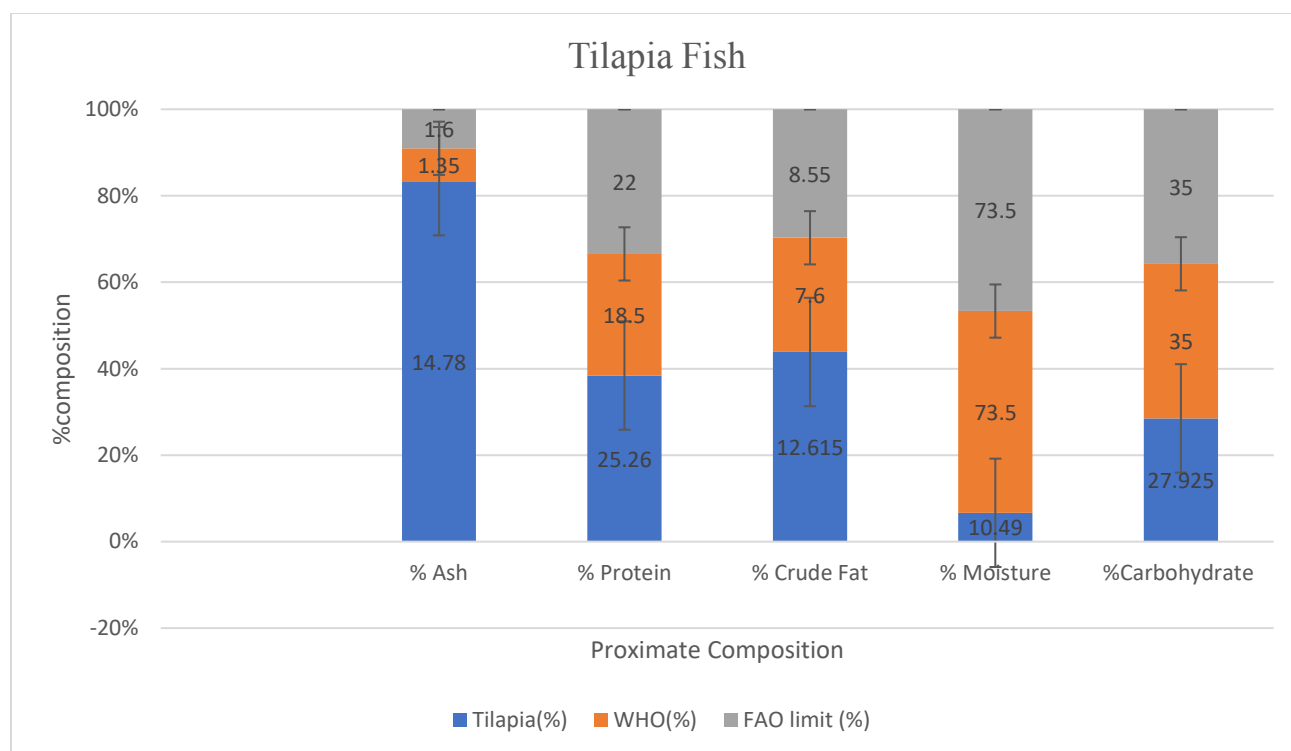


Fig 8: Graphical representation of proximate composition (wet season) Tilapia

In table 4 (figure 8) The result shows that Protein (25.26%) exceeded WHO (18.5%) and FAO (22%) values, indicating improvement in nutritional quality. Crude fat (12.62%) approached recommended levels but remained slightly high. Ash remained high (14.78%) and moisture (10.49%) was critically below 73.5%. Carbohydrate (27.93%) was still below 35%. The Protein improved in the wet season, but high ash and low moisture persisted.

Table 5: Metals Concentration (Wet Season) Tilapia Oyan

Parameter	Tilapia(mg/kg)	WHO(mg/kg)	FAO limit (mg/kg)
Ca	34.076	900	900
Mg	0.05	387.5	387.5
Cu	0.02	30	30
Zn	0.001	1.5	30
Fe	0.026	100	100
Na	1.345	225	225
K	2.435	480	480
Pb	0.215	0.5	0.2
Cd	0	0.5	0.05
Cr	0.03	0.575	0.575
Ni	0	32.5	80

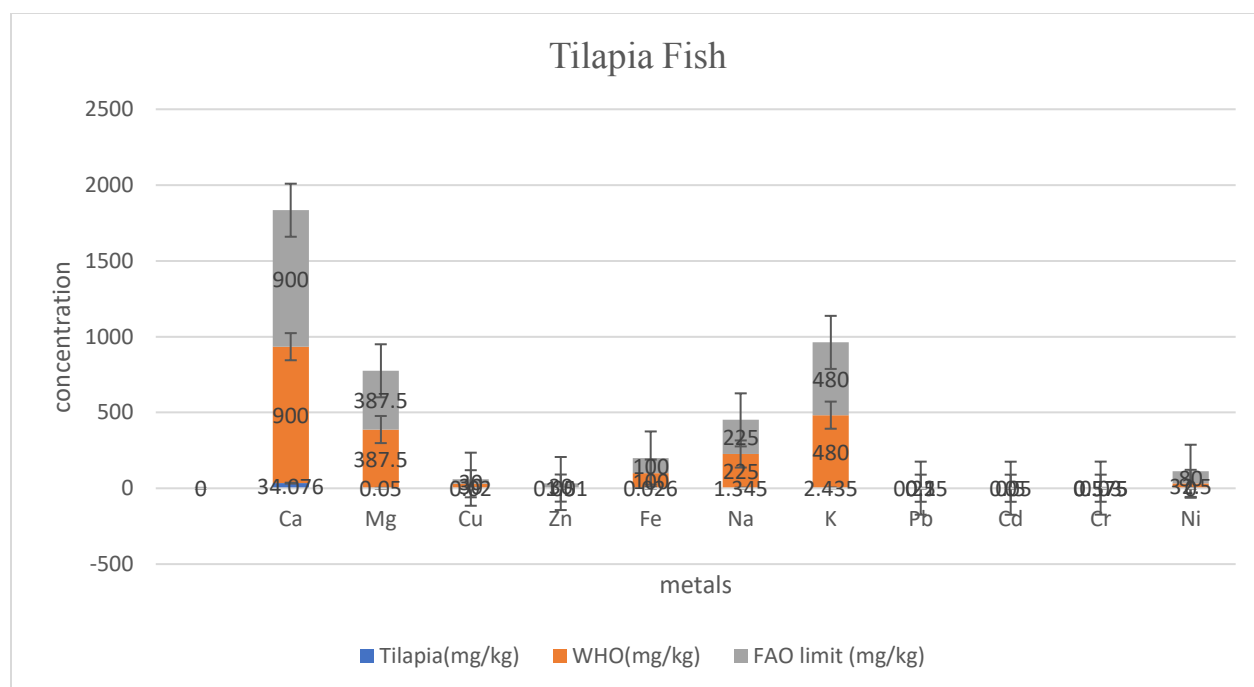


Fig 9: Graphical representation of Metals Concentration (dry season) Tilapia

In table 5 (figure 9) the result shows that Major minerals (Ca 34.08 mg/kg, Na 1.345 mg/kg, K 2.435 mg/kg) were below permissible thresholds. Pb (0.215 mg/kg) exceeded FAO (0.2 mg/kg) and approached WHO (0.5mg/kg). Other metals remained safe. Pb pollution persisted across wet season fish samples.

4.3 PROXIMATE COMPOSTION AND METALS CONCENTRATION (DRY SEASON) CATFISH OYAN

Table 6: Proximate Composition (Dry Season) Catfish Asejire Dam

Parameter	Catfish(mg/kg)	WHO(mg/kg)	FAO limit (%)
% Ash	37.58	1.35	1.6
% Protein	15.167	18.5	22
% Crude Fat	3.58	7.6	8.55
% Moisture	17.883	73.5	73.5
%carbohydrate	25.79	35	35

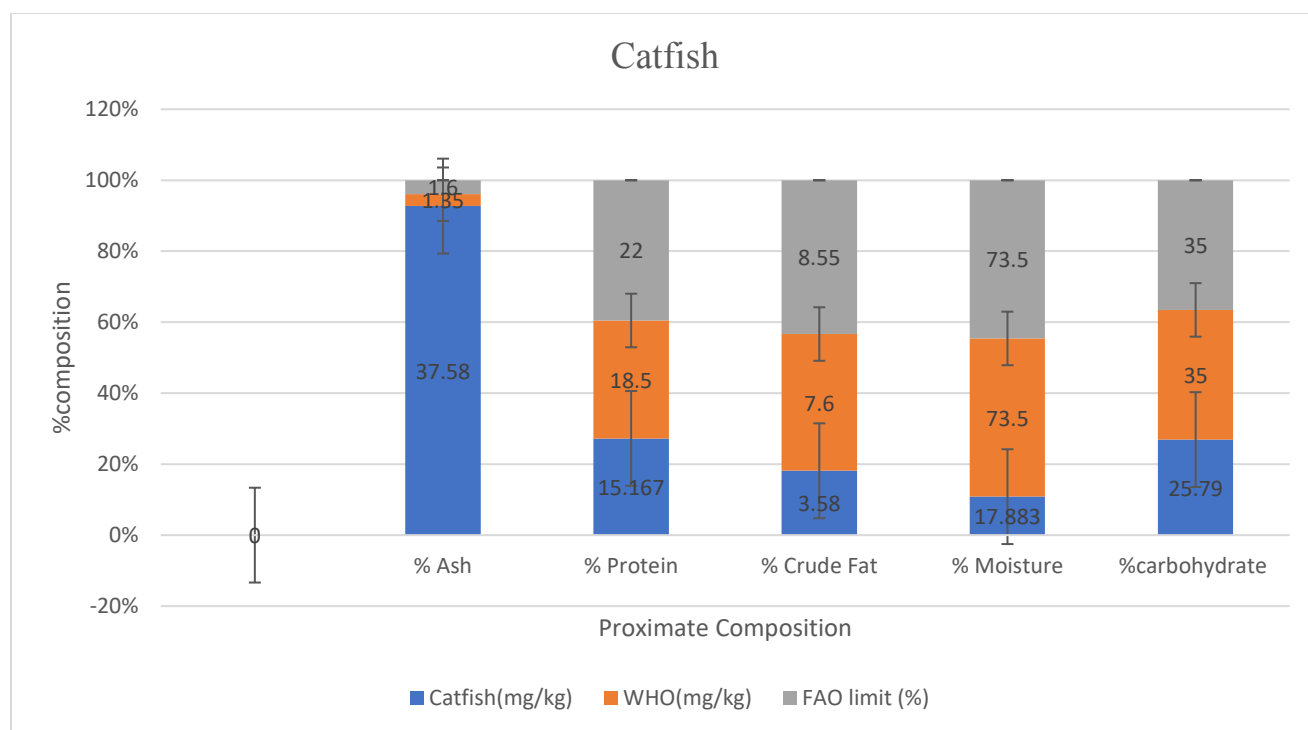


Fig 10: Graphical representation of proximate composition (dry season) Catfish Asejire

Result in (table 6 and figure 10) shows that Ash (37.58%) was extremely high as compared to the WHO/FAO limit (1.6%). Protein (15.17%) was below WHO (18.5%) and FAO (22%). Crude fat (3.58%) was far lower than standards. Moisture (17.88%) was drastically below 73.5%. Carbohydrate (25.79%) was below 35%. Catfish from Asejire were mineral-heavy but nutritionally poor.

Table 7: Metals Concentration Table (Dry Season) Catfish Asejire Dam

Metals	Catfish(mg/kg)	Who limits(mg/kg)	FAO (mg/kg)
Ca (mg kg)	0.44	900	900
Mg (mg/kg)	0.01306	387.5	387.5
Cu (mg/kg)	0.00132	30	30
Zn (mg/kg)	0.02242	1.5	30
Fe (mg kg)	0.0231	100	100
Pb (mg/kg)	0	0.5	0.2
Na (mg/kg)	0.9963	225	225
K (mg/kg)	1.1398	480	480

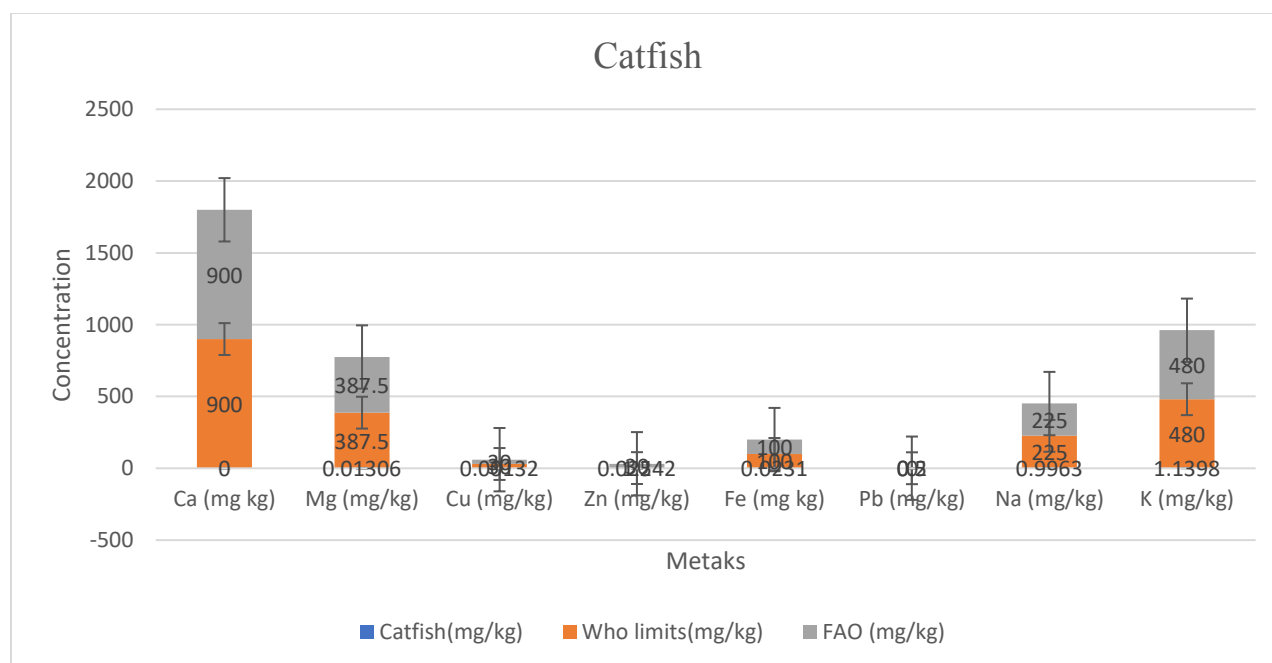


Fig 11: Graphical representation of Metals Concentration (dry season) Catfish

Result (table 7 and figure 11) shows that Ca (0.44 mg/kg), Mg (0.013 mg/kg), Cu (0.0013 mg/kg), Zn (0.022 mg/kg), Fe (0.023 mg/kg), Na (0.996 mg/kg), and K (1.14 mg/kg) were all very low while Pb was absent. The Heavy metal contamination was negligible, showing safer fish compared to Oyan Tilapia.

4.4 PHYSICOCHEMICAL PARAMETERS AND METALS CONCENTRATION (WET SEASON) OYAN DAM

Table 8: Descriptive statistics (Wet Season) Oyan Dam

Parameters	Min	Max	Mean	SEM	SD	Exceedance	WHO
pH	5.07	6.51	5.66	0.09	0.45	0.75466	6.5-8.5
Temp. (oC)	26.40	31.70	28.77	0.29	1.42	N/A	N/A
EC (uS/cm)	95.00	130.00	107.13	1.25	6.13	0.3571	300
TDS (mg/L)	51.00	60.00	53.46	0.41	2.00	0.05346	1000
ALK (mg/L)	17.40	28.00	23.53	0.55	2.68	0.2139	20-200
ACD (mg/L)	10.00	29.40	16.67	1.15	5.66	2.2226	6.5-8.5
TH (mg/L)	0.00	0.59	0.49	0.02	0.11	0.00098	500
Cl (mg/L)	-11.50	15.20	6.45	0.89	4.35	0.0258	250
NO ₃ (mg/L)	0.62	39.26	4.34	1.56	7.65	0.00868	500
PO ₄ (mg/L)	0.67	1.27	1.01	0.04	0.19	0.00404	250
SO ₄ (mg/L)	17.24	19.33	18.07	0.14	0.68	0.07228	250
Ca (mg/L)	0.00	7.03	2.20	0.29	1.42	0.0293	75
Mg (mg/L)	0.00	0.53	0.22	0.02	0.11	0.0044	50
Cu (mg/L)	0.00	0.06	0.01	0.00	0.01	0.005	2
Zn (mg/L)	0.00	0.50	0.16	0.02	0.12	0.0533	3
Fe (mg/L)	0.00	10.38	2.60	0.50	2.45	8.666	0.3
Pb (mg/L)	0.00	0.00	0.00	0.00	0.00	0	0.01
Na (mg/L)	0.00	18.63	14.72	0.71	3.48	0.0736	200
K (mg/L)	0.00	16.40	7.82	0.64	3.14	0.6516	12

In (table 8), the result shows that pH (5.07–6.51, mean 5.66) indicated acidic water, below WHO 6.5–8.5 standard. Nitrate (up to 39.26 mg/L) exceeded WHO (10 mg/L) in several sites. EC, TDS, sulphate, and phosphate remained within limits.

Fe (mean 2.6 mg/L) exceeded WHO's 0.3 mg/L guideline nearly nine-fold, suggesting severe iron contamination. Pb was undetected.

Table 9: Correlation Data (wet season) Oyan Dam

Parameters	pH	Temp. (oC)	EC (uS/cm)	TDS (mg/L)	ALK (mg/L)	ACD (mg/L)	TH (mg/L)	Cl (mg/L)	NO3 (mg/L)	PO4 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	Cu (mg/L)	Zn (mg/L)	Fe (mg/L)	Pb (mg/L)	Na (mg/L)	K (mg/L)
pH	1																		
Temp. (oC)	.028	1																	
EC (uS/cm)	.324	.319	1																
TDS (mg/L)	.475*	.409*	.935**	1															
ALK (mg/L)	.525**	.334	.042	.212	1														
ACD (mg/L)	-.450*	.124	-.113	-.174	-.108	1													
TH (mg/L)	-.200	-.031	-.074	-.107	.007	.033	1												
Cl (mg/L)	.237	.070	.499*	.520**	.101	-.152	.020	1											
NO3 (mg/L)	-.370	.070	-.049	-.022	-.556**	.437*	.005	-.032	1										
PO4 (mg/L)	-.738**	-.116	-.569**	-.653**	-.279	.341	-.013	-.540**	.171	1									
SO4 (mg/L)	.428*	-.137	.199	.309	-.075	-.508*	-.009	.268	-.190	-.465*	1								
Ca (mg/L)	.076	-.143	.203	.236	-.145	.169	.077	.181	.161	-.165	.221	1							
Mg (mg/L)	-.012	-.329	.041	.060	-.418*	-.074	-.111	-.080	.160	.183	.205	.372	1						
Cu (mg/L)	.364	-.261	.004	.104	-.049	-.315	-.284	.084	-.111	-.175	.192	.174	.551**	1					
Zn (mg/L)	.545**	.201	.461*	.474*	.082	-.303	-.271	.206	-.135	-.416*	.230	.092	.265	.421*	1				
Fe (mg/L)	-.348	-.460*	-.264	-.328	-.480*	-.049	.004	-.296	.043	.497*	-.021	-.025	.788**	.376	-.055	1			
Pb (mg/L)	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c		
Na (mg/L)	-.193	.012	-.011	-.019	-.280	.165	-.207	-.052	.140	.273	.027	.437*	.696**	.338	.409*	.438*	. ^c	1	
K (mg/L)	-.300	-.320	-.123	-.181	-.448*	.031	-.104	-.213	.039	.435*	.013	.201	.869**	.433*	.207	.901**	. ^c	.749**	1

Result (table 9) shows a Strong positive correlation between TDS and EC ($r = 0.935$) suggested conductivity was mainly due to dissolved solids. A strong negative correlation between pH and phosphate ($r = -0.738$) suggested that increasing phosphate load may contribute to acidity.

Table 10: Component Matrix (wet season) Oyan Dam

Parameters	Components					
	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
pH	.709	.392	-.356	.095	.134	-.235
Temp. (oC)	.405	-.198	.437	.518	-.056	.277
EC (uS/cm)	.603	.398	.474	-.014	-.190	.278
TDS (mg/L)	.698	.439	.418	.025	-.111	.191
ALK (mg/L)	.579	-.218	-.314	.415	.461	.106
ACD (mg/L)	-.337	-.358	.612	.164	.286	-.200
TH (mg/L)	-.030	-.270	.041	-.517	.341	.556
Cl (mg/L)	.525	.257	.260	-.312	-.037	.037
NO ₃ (mg/L)	-.317	-.075	.653	-.189	-.287	-.372
PO ₄ (mg/L)	-.826	-.304	-.002	.242	-.007	.132
SO ₄ (mg/L)	.324	.481	-.235	-.464	-.057	-.006
Ca (mg/L)	-.028	.430	.404	-.308	.619	-.225
Mg (mg/L)	-.515	.793	.046	-.036	.044	.076
Cu (mg/L)	-.078	.707	-.308	.129	.019	-.265
Zn (mg/L)	.348	.666	.045	.393	-.087	.012
Fe (mg/L)	-.772	.435	-.206	-.048	-.140	.259
Na (mg/L)	-.463	.614	.298	.304	.258	.031
K (mg/L)	-.714	.627	-.009	.118	.023	.227
Eigen Values	4.844	3.903	2.135	1.527	1.047	1.010
TV%	26.912	21.684	11.863	8.484	5.816	5.612
CV%	26.912	48.596	60.459	68.943	74.759	80.371

In (Table 10), the result shows Four principal components explained ~76% of the variance. PC1 was linked to ionic strength (EC, TDS, Cl, SO₄), while PC2 represented nutrient enrichment (NO₃, acidity).

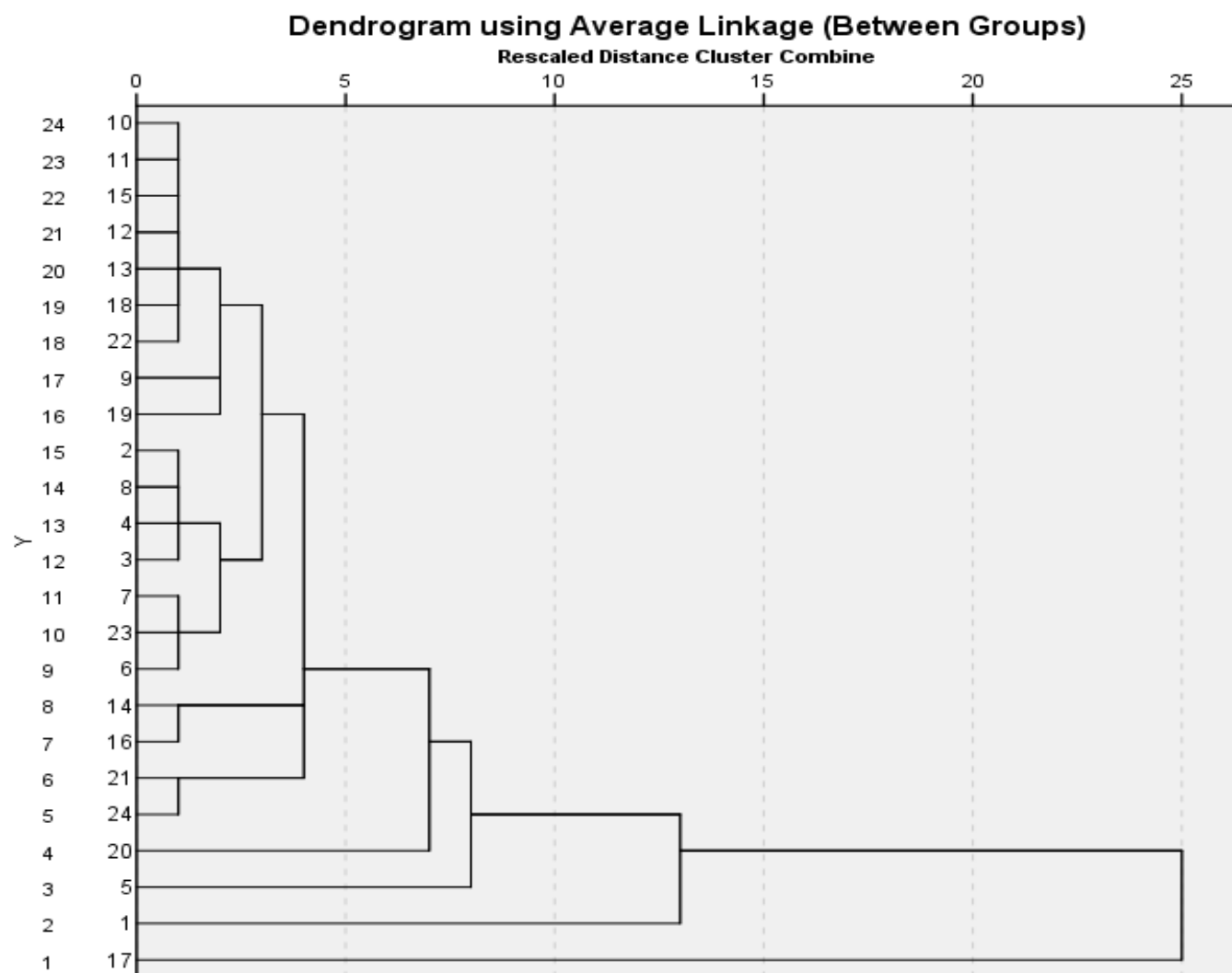


Fig 12: Dendrogram using average linkage

Figure.12 shows that Cluster analysis grouped sites into nutrient-enriched vs. acidic clusters, reflecting localized agricultural inputs.

4.5 PHYSICOCHEMICAL PARAMETERS AND METALS CONCENTRATION (DRY SEASON) OYAN DAM

Table 11: Descriptive Statistic (dry season) Oyan Dam

Parameters	Min	Max	Mean	SEM	SD	Exceedance	WHO
pH	7.02	8.38	7.87	0.11	0.54	1.049	6.5-8.5
Temp. (oC)	20.20	33.50	30.42	0.49	2.42	N/A	N/A
EC (uS/cm)	63.00	107.00	91.17	3.91	19.13	0.3039	300
TDS (mg/L)	32.00	53.00	45.63	1.92	9.43	0.04563	1000
ALK (mg/L)	0.00	37.40	22.61	1.49	7.31	4.8651	20-200
ACD (mg/L)	0.00	10.00	5.84	0.44	2.15	0.7786	6.5-8.5
TH (mg/L)	0.26	0.51	0.34	0.01	0.05	0.00068	500
Cl (mg/L)	2.30	6.60	4.01	0.23	1.15	0.01604	250
SO4 (mg/L)	17.18	18.97	17.74	0.10	0.51	0.07096	250
Ca (mg/L)	0.03	8.24	2.71	0.62	3.05	0.03613	75
Mg (mg/L)	0.11	0.93	0.33	0.05	0.27	0.006	50
Cu (mg/L)	0.00	0.19	0.02	0.01	0.04	0.01	2
Zn (mg/L)	0.01	0.17	0.06	0.01	0.05	0.02	3
Fe (mg/L)	0.00	2.56	0.70	0.12	0.57	2.33	0.3
Pb (mg/L)	0.00	0.00	0.00	0.00	0.00	0	0.05
Na (mg/L)	8.91	21.87	15.63	0.70	3.41	0.07815	200
K (mg/L)	3.28	7.38	5.06	0.21	1.04	0.4216	12

In (table 10) the result shows that pH (7.02–8.38, mean 7.87) was within WHO standards. EC and TDS were safe. Alkalinity ranged widely (0–37.4 mg/L). Cu (0.004 mg/kg), Fe (0.16 mg/kg), Zn (0.032 mg/kg) were far below permissible limits.

Fe (0.70 mg/L) still exceeded WHO but at lower levels compared to the wet season. Other metals (Cu, Zn, Mg, Ca) remained within safe limits.

Table 12: Correlation Data (Dry Season) Oyan Dam

Parameters	pH	Temp. (oC)	EC (uS/cm)	TDS (mg/L)	ALK (mg/L)	ACD (mg/L)	TH (mg/L)	Cl (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	Cu (mg/L)	Zn (mg/L)	Fe (mg/L)	Pb (mg/L)	Na (mg/L)	K (mg/L)
pH	1																
Temp. (oC)	-.385	1															
EC (uS/cm)	.961**	-.457*	1														
TDS (mg/L)	.970**	-.449*	.998**	1													
ALK (mg/L)	.520**	-.346	.591**	.554**	1												
ACD (mg/L)	.136	-.009	.125	.113	.275	1											
TH (mg/L)	-.023	.262	-.022	-.018	-.218	-.490*	1										
Cl (mg/L)	.255	-.325	.306	.293	.333	.241	-.549**	1									
SO4 (mg/L)	.068	.105	.085	.085	-.079	.212	.056	-.093	1								
Ca (mg/L)	.542**	-.317	.587**	.574**	.341	.400	-.493*	.609**	-.145	1							
Mg (mg/L)	-.901**	.461*	-.950**	-.947**	-.573**	-.191	.066	-.398	-.082	-.583**	1						
Cu (mg/L)	.288	-.080	.256	.244	.093	.361	-.023	.005	-.035	.371	-.268	1					
Zn (mg/L)	-.377	.184	-.357	-.370	-.081	-.047	-.004	-.107	.343	-.238	.300	.044	1				
Fe (mg/L)	-.655**	.409*	-.680**	-.690**	-.369	.007	-.062	-.405*	.023	-.263	.797**	-.010	.103	1			
Pb (mg/L)	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b	. ^b		
Na (mg/L)	.733**	-.247	.801**	.788**	.655**	.354	-.302	.440*	.090	.617**	-.801**	.191	-.244	-.486*	. ^b	1	
K (mg/L)	-.721**	.437*	-.682**	-.704**	-.205	.045	-.091	-.171	-.119	-.294	.765**	.010	.270	.765**	. ^b	-.391	1

Table 12 shows that EC and TDS showed near-perfect correlation ($r = 0.998$), confirming their interdependence. pH positively correlated with alkalinity, indicating higher alkalinity buffers acidity.

Table 13: Component Matrix (Dry Season) Oyan Dam

Parameters	Components			
	PC 1	PC 2	PC 3	PC 4
Ph	.923	-.205	.108	.145
Temp. (oC)	-.531	-.011	.345	.219
EC (uS/cm)	.958	-.179	.093	.090
TDS (mg/L)	.954	-.203	.085	.089
ALK (mg/L)	.633	.191	.017	-.073
ACD (mg/L)	.261	.676	.389	.102
TH (mg/L)	-.211	-.815	.188	.261
Cl (mg/L)	.493	.507	-.326	-.365
SO4 (mg/L)	.018	-.078	.766	-.435
Ca (mg/L)	.686	.497	-.094	.162
Mg (mg/L)	-.970	.144	-.087	.014
Cu (mg/L)	.264	.260	.408	.593
Zn (mg/L)	-.356	.108	.488	-.489
Fe (mg/L)	-.739	.332	.085	.307
Na (mg/L)	.837	.202	.144	.009
K (mg/L)	-.713	.456	.034	.190
Eigen Values	7.081	2.242	1.477	1.239
TV%	44.256	14.014	9.230	7.744
CV%	44.256	58.270	67.500	75.244

Table 13 shows Three components explained ~76% variance. PC1 indicated ionic balance, PC2 alkalinity–acidity, PC3 chloride, sulphate.

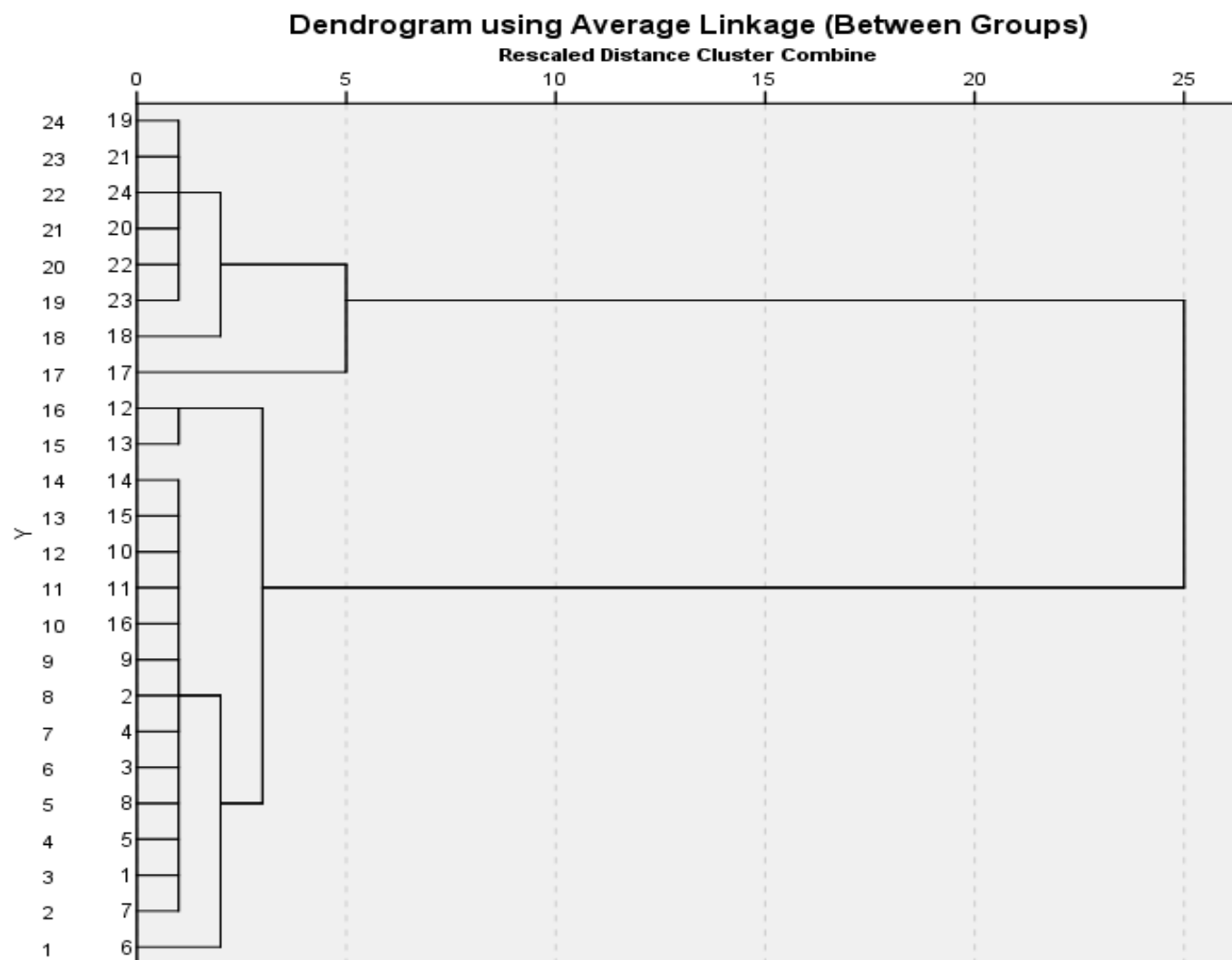


Fig 13: Dendrogram using average linkage

Figure 13 shows sites clustered into low alkalinity vs. high alkalinity groups, reflecting spatial heterogeneity in water chemistry.

4.6 PHYSICOCHEMICAL PARAMETERS AND METALS CONCENTRATION (DRY SEASON) ASEJIRE DAM

Table 14: Descriptive Statistics (Dry Season) Asejire Dam

Parameters	Min	Max	Mean	SEM	SD	Exceedance	WHO
pH	6.69	7.55	7.14	0.06	0.30	0.952	6.5-8.5
Temp. (oC)	27.20	34.40	29.63	0.37	1.82	N/A	N/A
EC (uS/cm)	117.00	154.00	138.25	2.70	13.22	0.4608	300
TDS (mg/L)	60.00	76.00	69.75	1.11	5.44	0.06975	1000
ALK (mg/L)	26.00	42.60	31.07	0.95	4.68	0.2824	20-200
ACD (mg/L)	4.00	12.00	7.31	0.57	2.81	0.9746	6.5-8.5
TH (mg/L)	0.47	0.67	0.54	0.01	0.06	0.00108	500
Cl (mg/L)	-0.20	3.20	1.59	0.20	0.99	0.00636	250
NO ₃ (mg/L)	11.01	16.57	13.77	0.27	1.31	0.02754	500
SO ₄ (mg/L)	16.73	18.08	17.58	0.05	0.27	0.07032	250
Ca (mg/L)	3.81	9.06	5.84	0.27	1.34	0.7786	75
Mg (mg/L)	0.12	0.28	0.17	0.01	0.04	0.0034	50
Cu (mg/L)	0.00	0.07	0.02	0.00	0.02	0.01	2
Zn (mg/L)	0.00	0.16	0.04	0.01	0.04	0.013	3
Fe (mg/L)	0.00	0.96	0.33	0.07	0.33	1.1	0.3
Pb (mg/L)	0.00	0.00	0.00	0.00	0.00	0	0.05
Na (mg/L)	12.96	18.63	15.86	0.27	1.33	0.0793	200
K (mg/L)	4.92	7.38	6.12	0.11	0.54	0.51	12

In (table 14), the result shows that pH (6.69–7.55, mean 7.14) fell within WHO standards. EC (117–154 μ S/cm) and TDS (60–76 mg/L) were very low compared to permissible limits. Nitrate (11–16.57 mg/L) exceeded WHO (10mg/L).

Fe (0.33 mg/L) slightly exceeded WHO (0.3 mg/L). Cu, Zn, Mg, Ca were all very low while Pb absent. Iron and nitrate contamination were the main issues in Asejire Dam.

Table 15: Correlation Data (Dry Season) Asejire Dam

Parameters	pH	Temp. (oC)	EC (uS/cm)	TDS (mg/L)	ALK (mg/L)	ACD (mg/L)	TH (mg/L)	Cl (mg/L)	NO3 (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	Cu (mg/L)	Zn (mg/ L)	Fe (mg/L)	Pb (mg/ L)	Na (mg/ L)	K (mg/L)
pH	1																	
Temp. (oC)	.230	1																
EC (uS/cm)	-.273	.624**	1															
TDS (mg/L)	-.279	.618**	.995**	1														
ALK (mg/L)	-.629**	.096	.513*	.517**	1													
ACD (mg/L)	-.759**	.209	.745**	.743**	.663**	1												
TH (mg/L)	.486*	.162	-.344	-.340	-.533**	-.548**	1											
Cl (mg/L)	-.271	.457*	.650**	.647**	.368	.605**	-.478*	1										
NO3 (mg/L)	.222	.107	-.182	-.199	-.157	-.360	.037	-.020	1									
SO4 (mg/L)	.220	.061	-.055	-.080	.078	-.045	-.308	.135	.179	1								
Ca (mg/L)	.390	-.119	-.495*	-.481*	-.642**	-.557**	.283	-.268	.074	-.112	1							
Mg (mg/L)	-.036	-.400	-.410*	-.387	-.233	-.215	.147	-.472*	-.074	-.185	.587**	1						
Cu (mg/L)	.227	.362	.177	.157	-.192	-.048	.454*	-.040	-.302	-.261	.041	-.151	1					
Zn (mg/L)	.335	.518**	.104	.096	-.232	-.085	.256	.135	-.019	.220	.162	-.070	.602**	1				
Fe (mg/L)	-.782**	.158	.726**	.727**	.697**	.933**	-.532**	.517**	-.290	-.179	-.549**	-.130	-.013	-.084	1			
Pb (mg/L)	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c	. ^c		
Na (mg/L)	-.151	-.015	.011	.012	-.179	.112	-.087	.042	.011	-.190	.489*	.667**	-.010	.187	.226	. ^c	1	
K (mg/L)	-.009	.385	.376	.398	.072	.207	-.373	.431*	.210	-.099	.098	.071	-.123	.216	.339	. ^c	.386	1

Table 15 shows that EC–TDS showed strong correlation ($r = 0.995$). Alkalinity was negatively correlated with pH ($r = -0.629$). Acidity correlated strongly with EC and TDS ($r > 0.74$).

Table 16: Component Matrix (Dry Season) Asejire Dam

Parameters	Components				
	PC 1	PC 2	PC 3	PC 4	PC 5
pH	-.620	.587	-.167	.229	-.027
Temp. (oC)	.384	.812	.022	.124	-.133
EC (uS/cm)	.875	.344	.053	-.037	-.115
TDS (mg/L)	.873	.333	.073	-.041	-.131
ALK (mg/L)	.756	-.313	-.189	-.038	.059
ACD (mg/L)	.921	-.160	.129	-.157	.129
TH (mg/L)	-.601	.426	-.053	-.454	-.248
Cl (mg/L)	.723	.248	.044	.316	.042
NO3 (mg/L)	-.223	.074	-.098	.670	-.421
SO4 (mg/L)	-.002	.052	-.381	.572	.666
Ca (mg/L)	-.654	.104	.566	.136	.062
Mg (mg/L)	-.422	-.353	.714	-.076	.118
Cu (mg/L)	-.036	.667	.060	-.602	.139
Zn (mg/L)	-.049	.764	.194	.000	.451
Fe (mg/L)	.905	-.186	.252	-.172	.015
Na (mg/L)	-.022	-.046	.917	.093	.119
K (mg/L)	.355	.245	.539	.502	-.226
Eigen Values	5.967	2.869	2.315	1.856	1.060
TV%	35.102	16.876	13.618	10.917	6.233
CV%	35.102	51.978	65.596	76.513	82.747

In (table 16) Three principal components explained ~78% variance. PC1: ionic balance, PC2: alkalinity/temperature, PC3: nutrients.

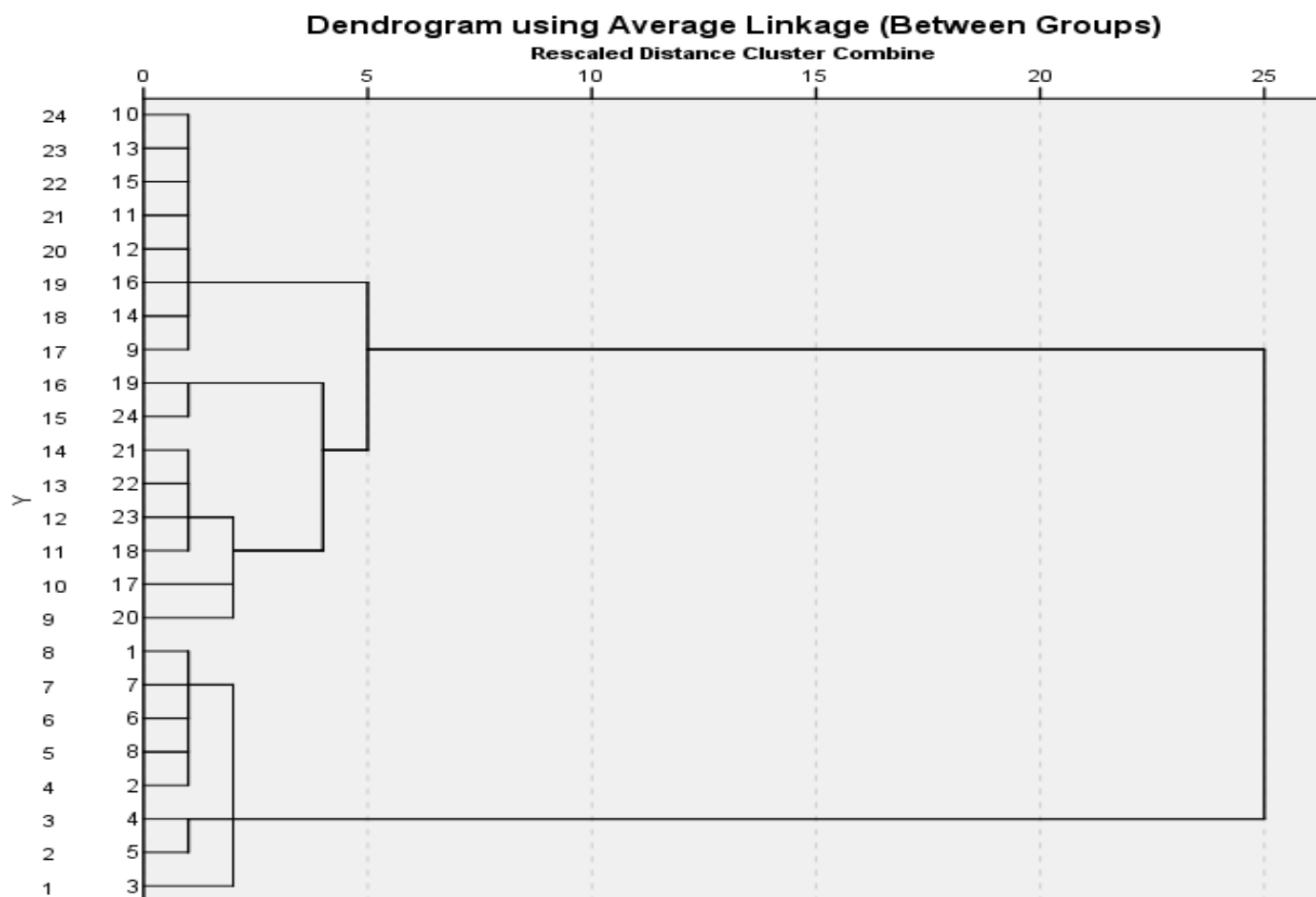


Fig 14: Dendrogram using average linkage

(Figure 14) shows sites clustered into nutrient-polluted vs non-polluted groups, confirming localized nutrient inputs.

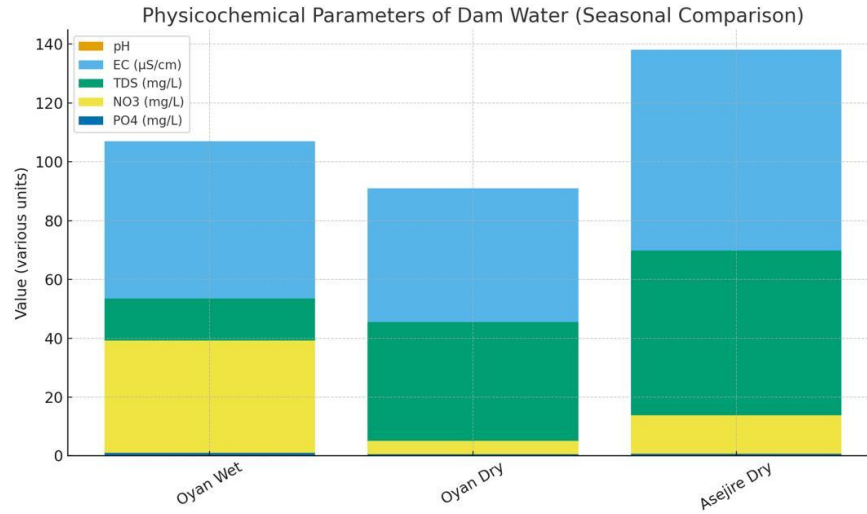


Fig 15: Physicochemical Parameters (pH, EC, TDS, NO₃, PO₄) showing seasonal changes at Oyan (wet/dry) and Asejire (dry).

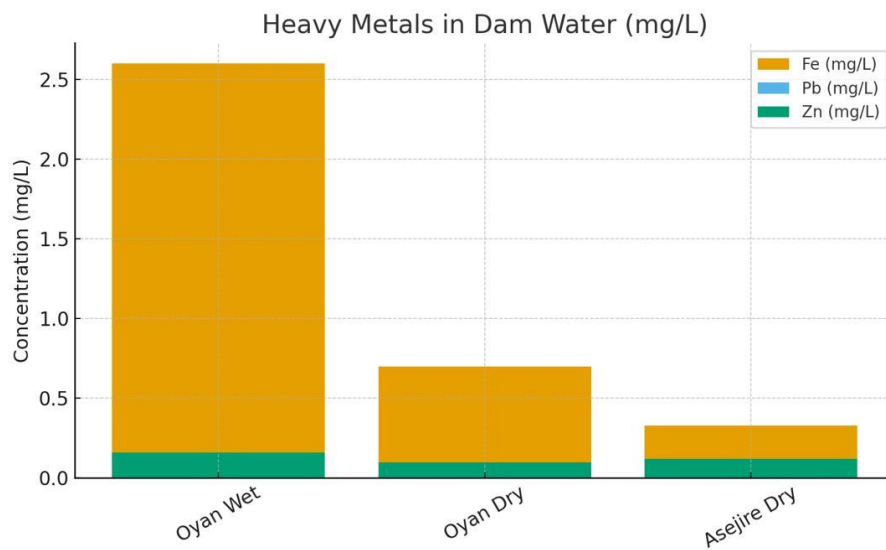


Fig 16: Heavy Metals in Dam Water (Fe, Pb, Zn) highlighting high Fe during the Oyan wet season.

Figure 16 shows how Oyan Dam wet season shows the highest Fe concentration (mean is approximately 2.60 mg/L, with maxima >10 mg/L). This is several-fold above the WHO guideline of 0.3 mg/L. In contrast, dry season Fe dropped significantly in Oyan (≈ 0.70 mg/L) and was lowest in Asejire (≈ 0.33 mg/L). This pattern suggests wet-season mobilization of Fe which is likely from sediment resuspension, soil erosion, or redox cycling during high inflows.

Pb concentrations in the dam water were consistently below detection (0 mg/L reported) across both dams and both seasons. This might suggest negligible Pb inputs directly into the water column.

Zn levels were generally low (<0.2 mg/L across all sites and seasons), well below guideline thresholds. Slight seasonal variation was noted, but Zn does not appear to be a significant pollutant in these waters.

The water chemistry in this result indicates that Fe is the main fluctuating heavy metal in the dam waters, with a sharp wet-season increase at Oyan, while Pb and Zn remain low. This indicates that seasonal hydrology and catchment geology drive Fe mobilization, whereas Pb sources are not apparent in the water itself.

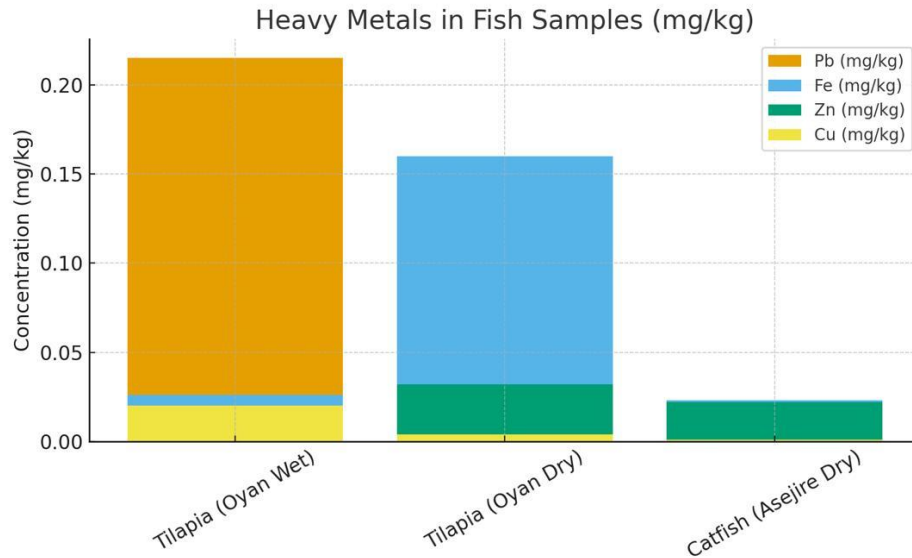


Fig 17: Heavy Metals in Fish (Tilapia & Catfish) comparing tissue burdens across species, dams, and seasons (noting Pb exceedance in wet-season tilapia).

In (Figure 17) result shows In sharp contrast to water, Pb was detected in fish tissues especially wet-season tilapia at Oyan (0.215 mg/kg). This value is slightly above FAO's permissible limit (0.2 mg/kg), though still below WHO's (0.5 mg/kg). Dry-season tilapia had much lower Pb (0.032 mg/kg), and catfish from Asejire had undetectable Pb.

Although Pb was absent in water, it accumulated in fish during the wet season. This suggests Pb entry through sediment ingestion, food-chain transfer, or adsorbed particles, which fish can uptake more readily than dissolved Pb.

Fish Fe concentrations were low overall (≤ 0.16 mg/kg in tilapia, ≤ 0.023 mg/kg in catfish), and far lower than water concentrations. This reflects Fe is low bioaccumulation potential: although abundant in water, Fe is strongly bound to particulates and sediments and is regulated physiologically by fish.

Zn (0.001–0.032 mg/kg) and Cu (0.001–0.020 mg/kg) levels in fish were very low, well within safe dietary thresholds. These essential trace elements showed no seasonal risk signal, confirming their natural regulation in aquatic organisms.

4.7 PCA BILOT OF HEAVY METALS IN FISH AND DAM WATER

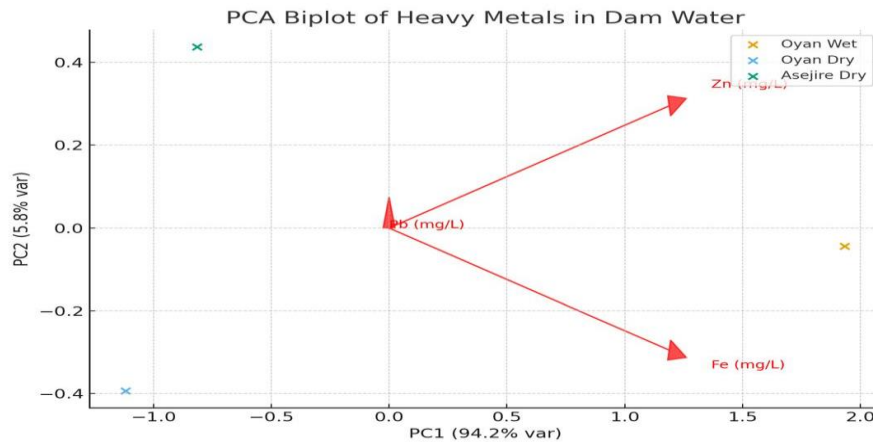


Fig 18: PCA Biplot for heavy metals in dam water

Figure 18 shows how Heavy Metals in Dam Water (Fe, Pb, Zn) Shows how Oyan (wet/dry) and Asejire (dry) cluster differently, with Fe driving much of the wet-season variability.

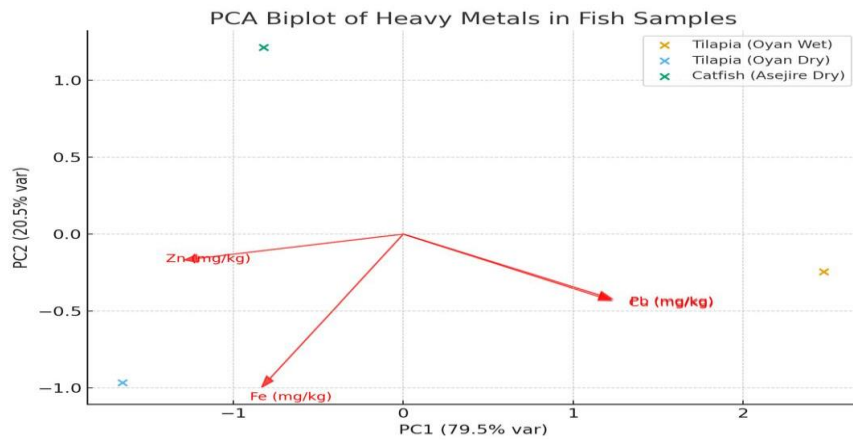


Fig 19: PCA Biplot for heavy metals in fish samples

Figure 19 shows that Heavy Metals in Fish (Tilapia & Catfish) Illustrates how Pb separates wet-season tilapia (Oyan) from other fish samples, while Fe, Zn, and Cu contribute smaller but distinct directions of variation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study assessed the seasonal dynamics of physicochemical parameters, heavy metals, and proximate composition in Tilapia (*Oreochromis niloticus*) and Catfish (*Clarias gariepinus*) from Oyan and Asejire Dams. While water quality largely met WHO/FAO standards, Oyan exhibited acidity and recurrent nitrate and iron pollution during the wet season, while sodium levels in Asejire approached threshold limits. Fish analysis revealed seasonal nutritional shifts, with Tilapia showing higher protein in the wet season but lead concentrations above FAO limits, posing public health risks, whereas Catfish exhibited safer metal levels but nutritional imbalances. Statistical tools (PCA, correlation, clustering) highlighted seasonal variability shaped by hydrology and anthropogenic inputs. This research advances knowledge by linking dam water quality, seasonal nutrient loading, and fish bioaccumulation to public health and ecosystem sustainability. It identifies fish as bioindicators of contamination, demonstrates the influence of runoff on pollution, and underscores nutritional-health interconnections, aligning with SDGs on clean water, food safety, and climate resilience.

5.2 RECOMMENDATIONS

This study highlights the urgent need for improved water and food safety in Oyan and Asejire Dams. Oyan's acidic pH and high iron levels require treatment and stabilization, while elevated nitrates in both dams call for better watershed management. Fish quality also raised concerns, as Tilapia from Oyan Dam showed lead contamination above FAO limits, while Catfish from Asejire Dam, though safer, had nutritional imbalances. To address these challenges, regular biomonitoring

using fish as bioindicators, stricter enforcement of agricultural and waste regulations, and community-based monitoring are recommended. Further research on seasonal metal bioaccumulation, sediment-bound metals, and fish nutrition will help strengthen management strategies and protect both ecosystem and public health.

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