ASSESSMENT OF ZOOPLANKTON COMMUNITY STRUCTURE, PHYSICOCHEMICAL CHARACTERISTICS AND WATER QUALITY OF OBAZUWA LAKE, EDO STATE, NIGERIA.

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DECEMBER, 2025

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A THESIS WRITTEN IN THE DEPARTMENT OF ANIMAL AND ENVIRONMENTAL BIOLOGY, AND SUBMITTED TO THE COLEGE OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF (MASTER OF SCIENCE, HYDROBIOLOGY AND FISH BIOLOGY) OF THE UNIVERSITY OF BENIN, BENIN CITY.

DECEMBER, 2025

CERTIFICATION

We certify that this work was carried out by Mr. George Idemudia AIDEYAN in the Department of Animal and Environmental Biology, University of Benin, Benin City.

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CERTIFICATION OF THESIS

We the undersigned attest and declare that the thesis of Mr. George Idemudia AIDEYAN Titled: Assessment of Zooplankton Community Structure, Physicochemical Characteristics and Water Quality of Obazuwa Lake, Edo State, Nigeria, has successfully passed the anti-plagiarism test and does not violate any copyright regulations.

Prof. J. O. Olomukoro **Date**

Project Supervisor

Prof. (Mrs.) I. Tongo **Date**

Head of Department

DEDICATION

To future works this study will inspire and all who will build upon its findings.

ACKNOWLEDGEMENTS

Writing this thesis has been made possible by the grace endowed upon me by the Almighty God and the invaluable support and contributions of those around me.

To begin with, I am profoundly grateful to my supervisor and academic mentor, Prof. J. O. Olomukoro, for his encouragement, support, and guidance throughout my project work and in writing this dissertation. His consistent advice, collaborative critique, and heartfelt assurances have been invaluable.

In addition, I wish to extend my sincere appreciation to Prof. (Mrs.) I. Tongo, the current Head of Department, who also served as the departmental and faculty postgraduate coordinator during my program. Her prompt feedback, timely paperwork, and patient mentorship provided an excellent academic experience throughout my master's program, seminar and examination sessions.

I am also deeply thankful to the former Head of Department, Prof. M.O. Omoigberale whose leadership was instrumental in the progress of this program. His consistent words of advice and professional excellence remain a source of pride and inspiration.

Furthermore, my sincere appreciation goes to Prof. (Mrs.) I. P. Oboh, who doubles as my Fish Biology professor and Director of the TETFUND Centre for Aquaculture and Food Technology. I am grateful for sponsoring our trip to ARAC (African Regional Aquaculture Centre), Port Harcourt, and for partially supporting the funding of this project by nominating me through my supervisor for the TETFUND Grant. Thank you for the invitation to Freshwater Biological Association of Nigeria (FBAN) conference (2024) and lots more. Your contributions are too numerous to list, Thank you, Ma.

I am equally thankful to the Dean of Life Sciences, Prof. I. O. T. Imoobe, for his immense support and guidance during this academic journey. Your encouragement has been truly impactful, especially in helping out with identification guides for zooplankton taxa used for the completion of this dissertation. Thank you Sir, I will always appreciate your kindness and understanding.

I want to appreciate Prof. A.E Ogbeibu, who's mannerism of teaching Biostatistics contributed to the newly found interest I have today in statistics and data science.

To my senior colleague turned friend, Mr. Clinton Enabulele, who has been acting as a pseudo assistant supervisor for his constant advice, help and support in my seminar presentation, FBAN presentation, Exams and in writing this thesis. You are truly a friend who stands out amongst brothers.

I would also like to specially acknowledge Mr. Festus Arijode for his invaluable assistance in the course of my seven months’ field sampling.

Special thanks also goes to Dr. Kingsley Egun, Dr. Erhunwunse Nosakhare, Dr. Osaro Asemota, Mr. Cyril Olowo, Mr Alari Eghosa and other academic and non-academic staff of the Department of Animal and Environmental Biology.

Memorable thanks also to, the Director of National Centre for Energy and Environment (NCEE), Dr. Emmanuel Ogbomida and the Head of Laboratory Departments (NCEE), Mr. Otobo for granting access to essential facilities and laboratory support during this project. To the staffs of NCEE, Mrs Rita, Dr. (Mrs.) Maureen and Mr. Akin thank you so much for your contributions.

To my colleagues who’ve supported through this journey, Success Uhwueseba, Godsgift Emmanuel, Aliyu Mohamed and Mrs. Dorcas Onomor. You made this journey fun. Thank you for being a part of this journey.

To my family, thank you for the assistance, support and contributions throughout this program.

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LIST OF ABBREVIATIONS

DO	Dissolved Oxygen
BOD	Biological Oxygen Demand
EC	Electrical conductivity
TSS	Total suspended solids
$P > 0.05$	Probability coefficient (not statistical significant)
Sig. 2 tailed	Significance at 2 tails of normal distribution
TS	Total solids
TDS	Total dissolved solids
r	Correlation coefficient
WHO	World Health Organization
APHA	American Public Health Association
UNESCO	United Nations Education, Scientific and Community Organization
WQI	Water Quality Index
CCME	Canadian council of Ministers of the Environment
F-value	Fisher value (used in ANOVA statistical test)
FMEnV	Federal Ministry of Environment
et al.	Et alii (Latin for “and others”)

ABSTRACT

Lentic water bodies in Nigeria are often neglected in favour of flowing systems making them prone to pollution, nutrient enrichment and ecological degradation. This study assessed the zooplankton community structure, physical and chemical characteristics, and water quality of Obazuwa Lake, Edo State, Nigeria.

Water and zooplankton samples were collected monthly from May to November, 2024 at three sampling stations. Temperature, pH, and dissolved oxygen (DO) were measured *in situ,* while other physicochemical parameters were analyzed in the laboratory using standard procedures. Zooplankton specimens were identified using recognized taxonomic keys. Data was analyzed using descriptive statistics, one-way Analysis of variance (ANOVA) to test for spatial variation and Pearson's correlation to assess relationships between biotic and abiotic components. Water quality index (WQI) was computed to classify lake water quality. Multivariate analysis such as Canonical Correspondence Analysis (CCA), Principal component analysis (PCA) and Redundancy Analysis (RDA) was also used to identify community patterns.

Results revealed no significant spatial and temporal variation between water parameters recorded. Physicochemical characteristics measured were within permissible limits (World Health Organization (WHO), UNESCO, and Federal Ministry of Environment (FMEnV), except for Total suspended solids (TSS), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Manganese, Iron, Total solids, and Dissolved oxygen (DO). A total of 3771 individual zooplankton representing 9 orders, 18 families and 48 species were recorded. Copepoda was the dominant group, followed by Cladocera and Rotifera. The most abundant species were *Eudiaptomus gracilis* (1239 individuals), *Thermodiaptomus incognitus* (933 individuals), and *Thermodiaptomus galebi* (871 individuals). *Moinodaphnia macleayi* was the most dominant cladoceran encountered while *Proales decipens,* and *Platyias leloupi* were the most occurring rotifers. Diversity indices indicated moderate richness and evenness, with Shannon-Wiener values ranging from 1.79 to 2.60 across stations. Pearson's correlation revealed that nitrate, BOD, COD, and Total Hardness were the main drivers of ecological variations among zooplankton. CCA analysis showed that dissolved oxygen and alkalinity were key factors in zooplankton distribution. RDA and PCA analysis indicated weak to moderate association of water characteristics and zooplankton. WQI values above 100 recorded in the study, suggested that although the lake supported moderate diversity, it was unsuitable for domestic use without proper treatment. Overall, the study concludes that zooplankton distribution of Obazuwa Lake is primarily influenced by water temperature, COD, BOD and nutrient input. Continuous monitoring is recommended to preserve the lake's integrity and prevent further eutrophication**.**

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND KNOWLEDGE

Water has been described as the most essential and universally relevant resources for all living organisms (Adakole *et al*., 2008). Life is believed to have originated in an aquatic environment, making water a fundamental component of all living things. The quality of water is therefore a key indicator of its suitability for various uses and for sustaining aquatic life (Omowaye *et al.,* 2011; Elovaara *et al*., 2020; Ibemenuga, 2020)

Natural freshwater storage such as lakes, serve as a living space for a range of aquatic organisms (Ogidi, 2022). They support biodiversity, supply drinking and cooking water to households and are used in numerous agricultural activities as natural supplement for rainfall (Fabian *et al.,* 2025). Both rural and urban settlements in developing countries continually face threats of aquatic degradation due to industrial effluent discharge, domestic wastes and agricultural runoffs. (Dauda *et al.* 2021; Lekwot *et al.* 2012). Freshwater sources like lakes and ponds are crucial for human activities such as cooking, washing, domestic consumption, manufacturing, irrigation and tourism. However, the deterioration of water quality caused by untreated effluents may introduce harmful contaminants into aquatic environments, posing serious risks to human health, aquaculture and overall ecosystem integrity (Abubakar *et al.* 2025).

Tropical ecosystems are undergoing continual transformations as a result of ongoing climatic variations, which significantly influence the distribution and overall productivity of aquatic species (Zingel *et al*., 2018). On a global scale, more than 250 million individuals are affected by illnesses linked to contaminated water, with an approximately 5% of related fatalities attributed to unsafe water sources. (Ogidi, 2024). The rapid decline of aquatic wildlife and deterioration of freshwater quality are results of, increasing industrial development, rapid urban expansion, and intensive application of synthetic fertilizers in agriculture (Iyiola, 2023; Ogidi and Richard-Nwachukwu, 2024).

These shifts in ecological balance and composition of tropical ecosystems often result in extinction of certain native species or, in some cases, favour the proliferation of alien species tolerant of pollution (Edward and Ugwumba, 2010). According to Cordy (2001), water quality availability and usage are influenced by physicochemical and biological properties of the ecosystem. Alterations within these properties in these characteristics can lead to social, economic, and environmental stress with a lake. Chemical contamination of water, whether natural or anthropogenic poses a burden globally (Łuczkiewicz *et al.,* 2010). Such stress invariably results in water quality deterioration, which further exacerbates the community and aquatic ecosystem stress threshold (Taminu *et al*. 2023).

Lakes serves as hotspots of diversity, supporting a multiplicity of zooplanktonic flora and fauna. In recent years, however, these freshwater bodies notably lakes and ponds have been exposed to significant human-induced pressures that have compromised both their water quality and ecological balance (Ateba *et al.,* 2008). The condition of aquatic systems and its influence on biological assemblages are typically mirrored through physicochemical parameters (EPA, 2002). Water is vital for drinking, fishery, bathing, recreation and domestic uses. The quality of freshwater, is however limited by zooplankton abundance resulting from algal blooms and fluctuations in physicochemical characteristics of water. These fluctuations restrict zooplankton productivity and contribute to stratification and instability of lake ecosystem (Ibrahim, 2009; Sharma, 2013; Sarwade and Kamble, 2014).

Zooplankton are famously regarded as “floaters” of the aquatic world due to their limited locomotion abilities. These planktonic organisms otherwise regarded as “drifters or drifting animals", consist of minute, nearly motionless organisms with limited capacity to move through the water column (Ateba *et al.,* 2008). They respond rapidly to even minimal variations in environmental conditions and serve as essential function in shaping aquatic biodiversity (Goswami, 2004). They regulate phytoplankton blooms and act as energy transfer for larvae and fish juveniles (Sati and Paliwal, 2008). Zooplankton constitute the animal component of most freshwater, brackish and marine bodies They are found in lakes, rivers, ponds, streams, rice-fields, reservoirs and irrigation canals (Thankgod, 2023). Tropical freshwater ecosystem is typically dominated by Protozoa, Rotifers, Cladocerans, Copepods and Ostracods., though the composition varies depending on the ecological composition of the river, lake or stream.

Zooplankton serves as effective bioindicators for monitoring water integrity (Kumari *et al*., 2004; Ogbeibu *et al.* 2013). Their diversity, density and variability provide valuable insights regarding the condition and purity of aquatic environments (Ferdouz *et al*., 2009; Gansfort *et al*., 2020). Bioindicators are communities of organisms whose reaction to environmental conditions reveals the general ecological wellbeing of aquatic systems (Taminu *et al.*, 2023). Negative impacts of industrial and human activities on aquatic environments are often detected through changes in zooplankton composition (Gerhardt, 2007). In aquaculture, zooplankton plays a significant role in fish nutrition (Kadiri, 2006) According to Arimoro and Ofojekwu, (2004), zooplankton function as natural dietary source for developing fish larvae. Ornamental fish such as (*Hemichromis bimaculatus* and *Poecilia reticulata*) have been recorded to survive mainly on plankton (Oyedapo *et al.,* 2023). Heterotrophic filter feeding zooplankton control excessive algal growth and help maintain ecological balance by sustaining a lake's food chain and supporting the productivity of commercial fisheries (Turkur and Danyaya, 2025). By protecting these non-motile weak swimmers, we unconsciously protect higher trophic state organisms (Gibbon, 2022).

Statistical tools have been effectively employed to analyse biodiversity in natural lakes and ponds. These methods help to characterize species abundance, relationships and interactions while accounting for the ecological conditions that shape the communities. (Ogbeibu, 2014).

According to Magurran, (2004), the simplest diversity metric used to express richness is the overall species count whereas Das (2021) and Mulya *et al*., (2021) reported that the Shannon-Weiner and Margalef's indices are among the best suited metrics for assessing diversity respectively. The application of these indices serves as indicators for assessing environmental contamination (Chariton *et al.*,2016).

Recently, increasing attention has been directed toward the widespread pollution of Nigeria's aquatic ecosystem and this had led to the reduction of quality surface water across Nigeria. These pollution stress have been linked with anthropogenic activities causing serious health risks (Ighalo and Adeniyi, 2020). These have also led to, increased eutrophication and large scale alterations in physicochemical characteristics and zooplankton community (Chapman and Romberg, 2008). This study therefore is intending to contribute knowledge to the underlying problem of lake eutrophication and neglected study gaps.

1.2 JUSTIFICATION OF THE STUDY

Lentic water bodies such as lakes and ponds have received comparatively lesser research attention in terms of their zoological composition, diversity and ecological health, compared to flowing waters (rivers, streams and dame). Yet, the biodiversity of lakes represents an essential component of freshwater ecology (Morris *et al*., 2014) and has become increasingly important due to global climatic influences (Hofer *et al*., 2001).

Nigerian waterways face a number of threats from extensive organic loading, surface runoffs alongside various human-driven activities such as sand excavation, domestic sewage and religious practices, all of which limits the existing short supply of freshwater, available for use by humans.

Obazuwa lake has become a hotspot for aquatic biodiversity studies, however, most of the existing research focuses on bottom dwelling macroinvertebrates, leading to the neglect of zooplankton components. As a result, limited research has been conducted in the last ten years to examine the ecological condition of zooplankton populations within the lake.

Zooplankton is one of the most reliable biological indicators of freshwater health. (Mauskar, 2008) and their study offers a simple, cost-effective and rapid method for predicting water quality particularly in developing countries (U.S. Geological Survey (2007). Factors such as absence or presence of suitable lifeforms, abundance and species distribution patterns converge to give detailed information of the ecological health status of freshwater bodies (Wokoma *et al.* 2021). It is important therefore, to assess the water quality, zooplankton community structure and physicochemical characteristic of Obazuwa Lake, Edo state, Nigeria.

1.3 AIM AND OBJECTIVES

The study was aimed to assess the zooplankton community structure, physicochemical characteristics, and water quality of Obazuwa Lake, Edo State, Nigeria.

The objectives of the study were to:

1. determine the physicochemical characteristics of Obazuwa Lake and their spatial-temporal variations,
2. evaluate the abundance, composition, community structure and dominance of zooplankton communities in the lake,
3. estimate the richness, evenness and diversity of the zooplankton species,

4. establish correlation and multivariate relationships between zooplankton taxa and physicochemical characteristics of the Lake.
5. ascertain the Water Quality Index (WQI) of the Lake

CHAPTER TWO

LITERATURE REVIEW

2.1 Physical and Chemical Characteristic of Freshwater bodies

Vandi *et al.* (2023) in their study of Lake Geriyo in Yola, reported that zooplankton distribution and abundance were significantly influenced by physicochemical parameters. In the dry season, pH values varied between 7.38 to 7.51, whereas in the rainy season, higher pH levels of up to 8,20 were observed. Temperature readings ranged from 20.23 °C to 20.63 °C in humid season and increased to 27.51 °C to 27.73 °C in rainy season. Electrical conductivity values in the dry season fluctuated between 315.71 to 383.33 µS/cm and from 341.51 to 344.85 µS/cm in the wet season. Dissolved oxygen (DO) concentration increased from 2.71–3.46 in the dry months to 4.31–4.58 during onset of rains. Both BOD and COD increased in the wet season. Ammonia concentrations decreased from dry season levels of 0.88 – 0.97 to 0.31– 0.33 mg/L in rainy months.

Rabiu *et al.* (2025) in the study on River Rima in Sokoto State, reported significant variation in all measured physicochemical parameters. Water temperature ranged from 22.8 ± 0.57 °C in the early dry season to 30.2 ± 0.23 °C in the early wet season. Dissolved oxygen (DO) values fluctuated between 3.45 ± 0.40 mg/L during the latter part of the dry season to 5.25 ± 0.33 in the late wet period. Electrical conductivity (EC) values shifted from 94.5 ± 2.91 µS/cm during the rainy period to 161 ± 26.92 µS/cm in the dry season, while total dissolved solids (TDS) remained relatively low (5.23–6.66 mg L^{-1}). Nitrate concentrations were modest, ranging from 0.89 ± 0.37 in months occasioned by excess rainfall to 1.08 ± 0.41 mg/L in hot months, and phosphate values were consistently low (0.18–0.20 mg/L). pH fluctuated from 6.54 ± 0.49 to 7.08 ± 0.08, indicating slightly acidic to near-neutral conditions.

Obhahie *et al.* (2025) evaluated the comparative effects of inorganic and organic fertilizers application on zooplankton production in concrete tanks at Federal University Oye-Ekiti. Results showed that temperature, biochemical oxygen demand, pH, and phosphate concentrations showed no significant differences between the tanks, whereas EC, TDS, total alkalinity (TA), DO, CO_2, transparency, nitrate, and potassium levels differed significantly. Tank-A (inorganic fertilizer) recorded higher mean temperature (25.19 °C), EC (443.66 µs cm^{-1}), transparency (25.34 cm), DO (7.80 ppm), nitrate (4.62 ppm), phosphate (2.47 ppm) and potassium (11.49 ppm) compared to Tank-B (organic fertilizer), which showed higher pH (7.40), TDS (209.68 ppm), TA (150.98 ppm), BOD (2.42 ppm), and CO_2 (31.0 ppm).

Similarly, Jokthan *et al.* (2023) in their investigation of Kaltungo Dam revealed that physicochemical parameters studied were within ranges suitable for sustaining aquatic life. Dissolved oxygen (DO) values fluctuated between 1.7 mg/l in November and.18 mg/l in October, December, and January–March, as a result of rainfall, runoff, and photosynthetic activity. Biochemical oxygen demand (BOD) ranged between 1.13 mg/l and 5.18 mg/l generally within limits of unpolluted water. Water temperature ranged between 25.5 °C and 34.75°C. pH values remained stable between 8.18 and 8.33. Electrical conductivity (94–156 µS cm^{-1}) and TDS (46.5–78) was fairly stable while transparency reached up to 59.13 cm across dry season.

A study on the influence of man-made activities on the zooplankton structure within Aba River was conducted by Edoghotu and Nworu (2024) and revealed that water temperature varied between 26.7°C and 27.7°C, pH values from 6.7 to 6.9, salinity of 0.11–0.19 ‰, and turbidity between 0.49 and 1.35 NTU. Nutrient concentrations were relatively low, with nitrate ranging between 0.28 to 0.59 and phosphate between 0.05 - 0.09 mg/l. Dissolved oxygen values were comparatively high (10.17–15.43 mg L^{-1}), and biochemical oxygen demand fluctuated from 3.82 to 6.53 mg/l.

Ogidi *et al.* (2024) inspection of Ikarama River in Yenagoa, Bayelsa State, reported that the river exhibited consistently high water quality parameters throughout the year. surface and air temperature ranged between 28.0°C and 29.5°C, with no statistically significant spatial variation. Transparency values of 1.8–1.9 m were inversely related to total suspended solids (70.5–75.0 mg l^{-1}), while turbidity remained between 50 and 55 NTU. Depths varied from 65 to 80 cm across the four sampling stations. Conductivity was low, ranging from 9.0 to 10.7 µS cm^{-1}, and chloride concentrations were stable (60.0–60.5 mg l^{-1}). The pH levels (5.5–6.5) indicated slightly acidic conditions. Dissolved oxygen concentrations remained high (8.5–10.0 mg/l) and (BOD_5) values (2.9–4.5 mg l^{-1}) reflected an absence of organic pollution. Total solids were modest (6.1–7.0 mg/l) and TDS ranged from 65 to 72 mg l^{-1}.

Iyagbaye and Iyagbaye (2023) investigation of Owan River recorded steady temperature between 25.1°C to 33.7°C, with mean values of 28.63°C at Station 1, 27.77 °C at Station 2, and 28.85 °C at Station 3. pH levels were weakly acidic to weakly alkaline (6.10–7.90), while conductivity values were relatively low (48.3–150.0 µS cm^{-1}). Dissolved oxygen concentrations were high (4.90–6.80 mg L^{-1}) and biochemical oxygen demand (BOD_5) remained low (1.90–4.50 mg L^{-1}), indicating good oxygenation and minimal organic pollution. Concentrations of key nutrients such as nitrate (0.0–0.4), sulfate (0.1 to 1.4), and phosphate (0.1 to 1.2) were low, reflecting limited nutrient enrichment and a relatively pristine aquatic environment.

Jabbi and Isah (2022) assessment of the Yardantsi Reservoir reported variations in water quality. water temperature average (26.62 °C), depth (2.12 m), and pH (7.61 ± 0.15) was appreciably less during the low rains in comparison with seasons of heavy downpours ($p <$

0.001). In contrast, total dissolved solids (96.00 ppm), conductivity (186.32 µS/cm), transparency (48.82 ± 1.08 cm), dissolved oxygen (7.80), BOD (2.71 ± 0.09), alkalinity (40.57 ± 0.69), hardness (59.20 ± 1.01 mg/L), chloride (74.08 ± 1.67 mg/L), and sulphate (31.62 ± 1.45 mg/L) were significantly higher during low rains. Nitrate (4.44 ± 0.07 mg/L) alongside phosphate (173.48 ± 2.78) levels showed marked variation in rainy months.

Koromicha *et al.* (2022) examined the Chemususu Dam and its associated rivers and reported stations differences in the quality of water and zooplankton community structure. The study observed that most parameters, including dissolved oxygen (DO), pH, turbidity, conductivity, nitrates, and chlorides, did not differ significantly between sampling sites, total dissolved solids (TDS) and carbonates exhibited significant spatial differences. TDS values were higher in the rivers than in the dam. Examination of seasonal trends revealed substantial disparities in salinity, TDS, Temperature and TSS. with higher salinity reported in the dry season. This was due to enhanced evaporation. Despite these variations, salinity remained below 0.5 ppt, classifying the dam and rivers as freshwater systems.

Tanimu *et al.* (2022) conducted a four-month investigation, from January to April 2013, examining nine sampling stations spanning the Makera drain and its point of confluence with the River Kaduna. They reported that the Makera drain stations (1–4), directly influenced by industrial effluent discharge, displayed significantly higher pH levels (7.82–9.21) than the downstream River Kaduna stations (7.42–7.83). TDS and Electrical conductivity, followed similar gradient, maximum values at Station 1 (1410.62 µS cm^{-1} and 720.25 ppm) and minimum values at Station 6 (162.75 µS cm^{-1} and 72.63 ppm). These elevated parameters were linked to the dissociation of ions from industries and household wastes. Total DO was markedly inflated in the Makera drain (0.70–1.01 mg L^{-1}) compared to the River Kaduna stations (4.20–4.76 mg/l). Biochemical oxygen demand (BOD) demonstrated the opposite pattern, peaking at

Station 4 (4.75 mg/l) and decreasing to as little as 0.96 mg L^{-1} at Station 6. Total hardness and sulphate concentrations were also significantly higher in the drain stations, with hardness reaching 111.75 mg L^{-1} and sulphate peaking at 153.13 mg L^{-1} at Station 4. Chloride and total alkalinity displayed similar trends, with elevated concentrations at the drain sites. These results confirm that effluent input from industrial and domestic sources exerts a strong influence on water chemistry, reducing oxygen availability and elevating ionic and nutrient content.

In a study by Asibor and Adeniyi (2021) the Asejire Reservoir, the reservoir exhibited an annual mean temperature of 26.5 ± 1.45 °C and mean pH of 7.84 ± 0.23, reflecting slightly alkaline conditions. Transparency ranged from 0.73 m to 2.21 m, while dissolved oxygen (DO) averaged 4.47 ± 0.93 mg L^{-1}. Conductivity averaged 106.42 ± 7.61 µS cm^{-1} and total dissolved solids (TDS) averaged 84.34 ± 5.83 mg L^{-1}. Seasonal differences were notable, with higher values of conductivity, transparency, TDS, DO, sulphate, and chloride during dry and hot weather compared to month with characteristic rain downpour. Correlation demonstrated a positive relationship among zooplankton population density and electrical conductivity (r = 0.74), transparency (0.71), TDS (0.84), DO (0.34), and sulphate (0.30). Negative correlations were observed in pH (–0.76), temperature (r–0.54), turbidity (–0.80), biological oxygen demand (r = –0.51), phosphate (–0.12), nitrate (–0.18), and chloride (–0.21). The study’s conclusion revealed that dynamics of zooplankton in the reservoir were driven primarily by fluctuations in physicochemical characteristics such as increased amounts of dissolved oxygen and transparency.

Anyanwu *et al.* (2021) examined Eme River and reported water temperatures ranging between 22.0 and 28.5°C. The flow velocity varied from 0.21 to 0.85 m/s, with larger variations in stations 2 and 3 compared to other sites. Turbidity ranged between 0.5 and 9.4 NTU. The pH value was acidic (4.3–6.3). Electrical conductivity ranged from 45.2 to 168.4 µS cm^{-1} and was significantly higher downstream. Dissolved oxygen concentrations were generally low, between 1.6 and 6.1 mg/l. BOD was within the range of 0.8 to 4.3 mg L^{-1}. Nitrate concentrations were 1.1–5.6 mg L^{-1}, while phosphate levels varied from 0.4 to 4.6, both nutrients showed significantly higher values downstream.

2.2 Zooplankton composition and Abundance

Odigie *et al.* (2025) examined Okhuaihe River and documented six families of Cladocera comprising a total of 75 individuals. The families recorded were Daphniidae, Chydoridae, Bosminidae, Macrothricidae, Sididae, and Moinidae. Chydoridae dominated the community, contributing 33.33% of the total individuals, followed closely by Sididae (26.67%), Moinidae (16.00%), Daphniidae (14.67%). The least dominance was recorded by families Bosminidae and Macrothricidae.

Oyedapo *et al.* (2023) hydrological study on Limca Reservoir in Jos, Nigeria reported the presence of two ornamental fish species, *Hemichromis bimaculatus* (Jewelfish) and *Poecilia reticulata* (Guppy), feeding voraciously and selectively on different zooplankton. The gut content analysis revealed that *H. bimaculatus* contained fourteen zooplankton taxa, while *P. reticulata* contained eleven. Rotifers and cladocerans dominated the gut content, with preference for *Conochilus sp.*, *Brachionus angularis*, and *Anuraeopsis fissa* in the Jewelfish, and for *Conochilus sp.*, *Brachionus angularis*, *Ceriodaphnia sp.*, and *Daphnia sp.* in the Guppy. The study revealed that *Daphnia sp.* was abundant in the gut of *P. reticulata* but absent in *H. bimaculatus* despite overlapping habitats. Adult copepods were notably absent in both species, with only a few nauplii observed.

Tukur *et al.* (2025) study identified 3,634 individual zooplankton across the sampling period. Zooplankton communities were dominated by Amoebida, Cyclopoida, and Ploima, with prominent species such as *Eucyclops macrurus*, *Thermocyclops neglectus*, *Asplanchna* *brightwelli*, *Brachionus falcatus*, *Brachionus angularis*, *Keratella lenzi*, *Amoeba radiata*, *Bosmina longirostris, Alona rectangula*, *Diaphanosoma excisum*, chironomid larvae, and other Diptera larvae.

Aborigho *et al.* (2025) examination of Ozomu Lake reported stable water quality parameters across three sampling stations. Ten copepoda taxa was identified with a total of 441 individuals across three stations. Station 2 was the most abundant sampling site with 175 individual count and nine taxa, subsequent to, Station 3 (137 individual count) and nine taxa, and Station 1 with 129 individuals and eight taxa. The calanoid *Eudiaptomus gracilis* was the most prevalent species (29.5% of total individuals), preceded by *Thermodiaptomus galebi* (26.76%) and the cyclopoid *Mesocyclops bodanicola* (18.14%). Subdominant species included *Metacyclops minutus* (6.80%), *Tropodiaptomus processifer* (7.25%), and *Thermodiaptomus yabensis* (5.21%). Rare taxa—each contributing less than 5% of total abundance—included *Mesocyclops leuckarti*, *Tropocyclops prasinus*, *Ectocyclops phaleratus*, and *Tropodiaptomus incognitus*.

Igejongbo *et al.* (2024) investigation of the plankton composition of Alape River concluded that the river is eutrophic. Cladocerans showed the greatest occurrence. This dominance was attributed to selective predation by fish on small-sized zooplankton such as rotifers. In Station I, 45 species of zooplankton were recorded, including 12 cladocera, 9 rotifera, 12 copepoda, and 12 protozoa species. The highest population density (65 individuals) was observed in February and the lowest (28 individuals) in May. The annual mean percentage composition of zooplankton groups was 25.56% rotifera, 22.22% cladocera, 27.41% copepoda, and 24.81% protozoa. Station II also recorded 45 zooplankton species, comprising 10 cladocera, 12 rotifera, 12 copepoda, and 11 protozoa. Zooplankton density varied from 42 individuals in February to 48 individuals in January and March, with the same mean percentage composition as Station I.

A detailed investigation of Mbiokporo Stream reported the presence of nine zooplankton taxonomic groups comprising twelve species and a total of ninety-one individuals (Obot and Jacob, 2024). *Temora longicornis* was the frequently occurring species during this study, with 24 individuals in station 1, 19 in station 2, and 7 in station 3. The highest occurring species (4 species) and species composition (33.33%) was recorded by Branchiopoda. Hexanauplia accounted for the largest population count. (54.95%).

Uzoka and Eyo (2025) evaluation of Oguta Lake in the Imo River Basin recorded 38 zooplankton species. The dominant phylum was Arthropoda, followed by Rotifera and Protozoa. Among Arthropoda, Cladocera was the most dominant order with 11 species, while Cyclopoida was represented by five species. Rotifera were largely represented by order Ploima with 11 species, whereas Collothecacea was represented by a single species. *Difflugia sp.*, recorded the highest relative abundance (6.77%) among protozoans. The total zooplankton count was 517 individuals, with the highest relative abundance recorded in Cyclopoida (21.46%), followed by Ploima (20.69%), Cladocera (19.91%), Harpacticoida (15.08%), and Protozoa (8.51%). Zooplankton abundance varied across the four sampling stations, Osemoto, Utu, Njaba, and Orashi with relative abundances of 24.3%, 23.79%, 21.66%, and 30.17% respectively.

Mohammed *et al.* (2023) investigated Lapai-Gwari Stream in Niger State. The study recognized the presence of 902 zooplankton individuals distributed among three major groups: rotifers (51%), cladocerans (29%), and copepods (20%). The rotifers, represented by 29 species, were dominant throughout the study, peaking in May and July, while copepods, comprising 10 species, recorded their highest abundance in March and cladocerans (15 species) peaked in August. Among the rotifers, *Asplanchna sieboldi* was the most abundant species in August, followed closely by *Brachionus fulcatus*, which peaked in March. Copepod community was dominated by *Calanoida nauplis* with a maximum occurrence in May, July, and August, whereas *Eucyclops elegans* peaked in April. *Daphnia pulcaria* dominated the cladocera group with the highest abundance in August.

Eneji, *et al.* (2023) estimation of human-induced pollution effects on total count of zooplankton in the Calabar Great Kwa River, reported highest percentage abundance at Esuk Atu was highest in Cladocera (38%). The close trend followed by Ostracoda > Copepoda > Rotifera > Lepidoptera and Protozoa (3%). At Esuk Atimbo, Copepoda were most abundant (26%), followed by Cladocera and Nemata (23% each), Lepidoptera (16%), Rotifera (6%), and both Polychaeta and Paguridae (3% each). Across the four sampling periods, total zooplankton abundance was generally low: 12, 6, 3, and 11 individuals at Esuk Atu and 7, 5, 9, and 10 individuals at Esuk Atimbo. This low abundance was attributed to pollution from human activities (domestic waste, sewage effluent, industrial discharges, pesticides, sand excavation, injurious hydrocarbons and toxic related contaminants.

Ihejirika *et al.* (2023) examined the Otammiri River in Imo State reported significant spatial variation in physicochemical parameters with localized contamination and variable sediment-metal interactions. Zooplankton communities were dominated by Protozoa (47.06%), followed by Rotifera (35.29%) and Cladocera (17.65%), with *Arcella sp.* and *Peridinium umbonatum* as key taxa. Diversity indices for zooplankton showed lowest diversity at the dredging site (0.91).

Adama *et al.* (2023) investigation of the Bosso Dam and Fadipe Pool revealed tha Water temperature ranged between 26.0 - 28.5°C, and intensity of flow averaged between (0.23- 0.26 m/s). DO values ranged from 6.4 to 10.0 mg/l, while turbidity spanned 30 to 240, with Fadipe Pool showing significantly higher turbidity than Bosso Dam. The pH values were within 7.21–7.53, and total suspended solids (TSS) were low (0.04–0.40 mg/L). Electrical conductivity ranged between 69 and 228 µS/cm. TDS varied from 60 to 220 mg/L. Statistical Significance

($p < 0.05$) were recorded between both water bodies for, total alkalinity, turbidity, conductivity and TDS, with consistently higher values recorded in the Fadipe Pool. Eleven zooplankton species from three phyla were identified: Cladocera (4 species), Copepoda (2 species), and Rotifera (5 species). Cladocera recorded the most relative abundance (58.7%), Copepoda (30.0%) and Rotifera (11.3%). Among the species recorded, *Moina micrura* was the most encountered, recorded next to Cyclopoida copepod. *Brachionus caudatus* recorded the lowest occurrence.

Isukul *et al.* (2023) examination of the Santa Barbara River following a crude oil spill event reported hydrocarbon contamination as a significantly factor altering the plankton community compartmentalization. 61 plankton taxa, belonging to two classes and eight families, were identified. Of the 486 organisms recorded, 394 and 92 (18.93%) were zooplankton. Zooplankton were less abundant, with Copepoda responsible for 70 individuals (14.40%) and Cladocera 22 individuals (4.5%). Spatial analysis revealed that upstream sites directly impacted by the spill exhibited a pronounced phytoplankton bloom, particularly of Bacillariophyceae and Cyanophyceae, while downstream sites and control locations had lower phytoplankton abundance and higher zooplankton density.

Akodogbo *et al.* (2023) investigation on the animal plankton of the Cotonou Port Basin identified 35 taxa, copepod nauplii and other unidentified copepods grouped. Spatially, taxonomic richness varied from six taxa at Station 9 in April to 25 taxa at Station 7 in July. Spatially, Copepods, Molluscs, Cirripedes, Ostracods, Chaetognaths, and Rotifers occurred across nearly all stations. Only Copepods were the most distributed zooplankton, occurring in almost all the sampling stations present at all stations during all sampling periods, demonstrating their ecological dominance and resilience. Among individuals, *Oithona* . and nauplii were consistently recorded across stations and during every season. Marked spatial differences were noted within the port basin. Stations S7, S2, and S3 recorded the highest densities during July 2020, with 107,451, 76,527 and 111,259.13 ind/m³, respectively, while stations S1, S5, S4, S6, S8, and S9 had considerably lower densities. In contrast, during other seasons, stations with peak abundance shifted, reflecting dynamic hydrological and environmental conditions.

Ebesi *et al.* (2022) examined Dangana Lake in Lapai, Niger State. Ten zooplankton species was identified, comprising four species both for Rotifera and Copepoda while two species was recorded for Cladocera. Rotifera were the most abundant group (56.39%), followed by Copepoda (29.18%) and Cladocera (14.42%). The rotifer taxa included *Keratella sp.*, *Lecane sp.*, *Notholca sp.*, and *Brachionus variabalis*, while copepods were represented by *Mesocyclops sp.*, *Diaptomus gracilis*, *Cyclops sp.*, and *Microcyclops varicans*. Cladocerans comprised *Daphnia* and *Ceriodaphnia*. Zooplankton abundance was higher during the hot climate temperature in comparison with rainy season.

Omoboye *et al.* (2022) examination of Esa-Odo Reservoir recorded 53 zooplankton species. Rotifera constituted a majority of represented groups, contributing to 61.21% of the total taxa, followed by Cladocera (19.83%), Protozoa (15.08%), and Insecta (3.80%). Dominant rotifer species included *Argonotholca foliacea*, *Anuraeopsis fissa*, *Asplanchna sp.*, *Brachionus falcatus*, *Filinia pejleri*, *Lepadella ovalis*, *Polyarthra vulgaris*, and *Trichocerca tropis*. Cladocerans were primarily represented by *Simocephalus sp.*, *Alonella dentifera*, and *Daphnia sp.*, while Copepods and Insecta were least represented, with *Nauplius* larva, *Eubranchipus sp.*, *Chironomus sp.* larvae, and *Coenagrion sp.* as their dominant species. *Trichocerca tropis* and *Filinia terminalis* exhibited highly significant horizontal variations (p = .01), with mean abundance decreasing towards the riverine zone, whereas *Brachionus havanaensis* increased significantly towards the riverine zone. *Filinia terminalis* and *Lecane monostyla bulla* displayed highly significant vertical variation (p < .001), with maximum abundance at the bottom and mid-depth, respectively. Nine species were unique to the surface, two to the bottom, and one to the mid-depth, though these did not show significant vertical variance.

Nwagba *et al.* (2022) conducted a thirty-four–week survey of the Omeremaduche River in Abia State, Nigeria,) Zooplankton were represented by Cladocera (*Alona affinis*, *Bosmina longirostris*, and *Daphnia pulex*) and Rhizopoda (*Amoeba chaos*, *Amoeba clavakoidea*, and *Centropyxis aculeata*). Zooplankton groups, particularly Cladocera and Rhizopoda, also exhibited higher densities in hotter temperature seasons, a trend caused as a result of increased availability of phytoplankton food sources during this period. Station 3 consistently supported higher plankton densities, corresponding with its elevated nutrient and dissolved oxygen levels, while Station 2 showed reduced plankton occurrence, likely due to disturbances from dense anthropogenic activity. Zooplankton responded significantly to pH, DO, BOD, and nitrate in the dry season, and exhibited positive correlations with temperature in the wet season. Station 2, the site of intense human activity, consistently showed reduced plankton abundance and lower DO, while Station 3, impacted by agricultural practices, displayed higher nutrient levels and consequently greater plankton survival.

Adebayo *et al.* (2022) examined the Opa Reservoir wetlands and reported the presence of 104 plankton species, comprising 36 zooplankton species. Rotifera dominated the zooplankton assemblage. *Synedra ulna* and cyclopoid copepod nauplii emerged as the most common plant and animal plankton respectively. Among the 36 recorded zooplankton species, Rotifera dominated the species richness (19 species), followed by Arthropoda (13 species) and Protozoa (4 species). The order of dominance was Rotifera > Arthropoda > Protozoa. Copepod (cyclopoid) nauplius larvae were the most likely occuring zooplankton species, preceded by *Argonotholca foliacea* and *Keratella* species.

Ibemenuga (2020) documented twenty species of zooplankton along the Mkpume Stream. The zooplankton taxa belonged to four groups viz-a-viz Digononta, Sarcodina, Crustacea, and Ciliata. Digononta was the most dominant group, representing 50% of total species, followed by Crustacea (25%), Sarcodina (20%), and Ciliata (5%). Family Conochilidae was the most species-diverse, comprising: *Conochilus spp., Conochilus unicornis* and *Gastropus stylifer*. Other notable rotifers included *E. dilatata*. *Simantherina spp., B. patulus, Ascomorpha spp., Vorticella spp., T. stylaria and Trichocerca spp,* whereas, *A. discoides*, *A. proteus*, *D. corona*, and *Difflugia* spp all made up the Sarcodina taxa. Crustacean species included *G. testudinaria*, *A. davidi*, *B. longirostris*, *Chydorus* spp., and *Halicyclops* spp., while Ciliata was represented by a single species, *Trichodina* spp. The total zooplankton species per station was between 12 to 20, with Station 2 recording the maximum species (20) and Station 1, the least (12). Zooplankton abundance followed the order: Digononta > Sarcodina > Crustacea > Ciliata. Conversely, Station 2 recounted the maximum total abundance (100%), followed by Station 3 (75%), and Station 1 (60%).

Ekpo *et al.* (2020) investigated the Abak River in Akwa Ibom State, Nigeria, for twelve months and identified thirteen species of zooplankton belonging to five taxonomic groups: Cladocera, Rotifera, Copepoda, Polychaeta, and Nematoda. The study recorded a total abundance of 81 cells/l. Polychaete larvae were the most preponderant species, with 24 cells/l (29.63%), whereas *Temora longicornis*, *Alona rectangula* and *Alonella dadyi*, and each recorded lower abundance (1 cell/l; 1.23%). Rotifera, *Lacane* and *Philodin* each recorded 8 individuals. Within the Cladocera, *Nauplii* larvae were the most abundant (12 cells/l; 14.81%), followed by *Bosmina coregoni* and *Alona diaphnia* with 5 cells/l (6.17%) each. Copepoda was represented by *Canthocalanus sp.* and *Temora longicornis*, with abundances of 2 individuals'/litre (2.47%) and individual's/litre (1.23%), respectively. The Nematoda group consisted solely of *Angiostrongylus sp.* with 9 individuals'/litre (11.11%). In relation to species composition, Cladocera was the most species-rich group, consisting of seven species (53.86%), followed by Rotifera and Copepoda, each with two species (15.38%). Nematoda and Polychaeta were the least species-rich, each represented by a single species (7.69%). When abundance was assessed by cell counts, Cladocera contributed the highest proportion (29 cells/l; 35.81%), followed by Polychaeta (24 cells/l; 29.63%), Rotifera (16 cells/l; 19.75%), Nematoda (9 cells/l; 11.11%), and Copepoda (3 cells/l; 3.70%). Lower species composition recorded during in the study were linked with human disturbances, like riverbed dredging, agricultural runoff, and untreated effluent discharges whereas the large abundance of Polychaete larvae suggested their role in sediment bioturbation.

Jonah *et al.* (2020) examined the Ikpe Ikot Nkon River, in Nigeria, from April 2019 to March 2020 and reported that water temperature ranged between 26.3 and 26.9 °C, while dissolved oxygen (DO) differed from 2.33 at downstream stations to 5.18 mg L^{-1} at the upstream station. The pH ranged from 6.21 to 6.91, a slightly acidic to neutral conditions. TDS ranged from 12.34 upstream to 18.33 mg/l downstream. Electrical conductivity ranged from 57.03 to 62.61 µS cm^{-1}. Nutrient levels were elevated downstream, with phosphate ranging from 5.30 to 18.80 mg/l. Nitrate concentration was generally between 8.90 and 24.33. Biochemical oxygen demand (BOD) varied from 1.10 to 3.80, while TSS ranged from 46.60 to 69.34 mg L^{-1} and turbidity from 8.32 to 17.15 NTU. Elevated nutrient and turbidity levels, particularly at the lower stations, were slightly above the Federal Ministry of Environment (FMENV) limits.

Research conducted on the Egbokodo River in Delta State, Nigeria by Isibor *et al. (*2020) over a nine-month period from September 2008 to May 2009 revealed that oil spill severely altered the zooplankton community structure. The total number of individuals observed increased steadily downstream from the spill site, with 18 individuals at Station A (the point of the oil spill) compared with 100 and 155 zooplankton found in Stations B and C respectively.

Cyclopoida emerged as the most resilient taxon, representing 72.2% of the zooplankton at Station A and continuing to dominate at downstream stations, though at progressively lower percentages. Other taxa, including Calanoida, Cladocera, Amphipoda and Harpacticoida, were comparatively less abundant and displayed lower tolerance to the oil pollution.

Bonjoru *et al.* (2020) investigation of zooplankton and macrobenthos of Kashimbila River, Taraba State, Nigeria documented 21 species composed of 12 taxonomic groups. Macroinvertebrates exerted dominance across study areas constituting 38% of total number of species recorded with Ciliophora (14%) ranking next. Other groups each contributed 4.76% with one taxon recorded per group. Species occurrence varied across the three study stations: Station A (upstream, with fishing, agriculture, domestic cleaning), Station B (dam), and C (downstream, with irrigation, farming, and cattle rearing). Notably, *Vorticella* (Ciliophora), *Brachionus* (Rotifera), *Diaptomus* (Copepoda), *Polypedilum* (Diptera), *Stentor* (Heterichida), and *Daphnia* (Cladocera) were consistently present at all three stations.

2.3 Diversity Indices of freshwater body

The ecological status of two inland water bodies (Igbeba-Ago Lake and OxBow Lake) was assessed by Lelei *et al.* (2024) and the study revealed that both lakes exhibited physicochemical parameters largely within established standards. OxBow Lake consistently showed better water quality, with higher pH and dissolved oxygen (DO) levels, while Igbeba-Ago Lake had increasing temperature, salinity, TDS, and turbidity. Turbidity levels in both lakes exceeded recommended limits, likely due to suspended matter from alluvial sediments, decaying vegetation, and run-offs. On the other hand, nitrate concentrations fluctuated within 6.87 to 10.32, phosphate between 1.98 and 4.46 mg/L. Igbeba-Ago Lake had higher zooplankton abundance (214 individuals) despite having fewer species (8 taxa), while OxBow Lake had 10 taxa but 116 individuals. Odonata occurred only in Igbeba-Ago Lake. Diversity indices indicated that OxBow Lake supported a more stable zooplankton community, with higher Simpson and Shannon indices (0.84 and 1.97 respectively), while Igbeba-Ago Lake recorded lower values.

Amobi *et al.* (2023) examined Pindiga Pond in Gombe State, and reported Copepoda also exhibited the highest Simpson’s diversity value (0.099) and Margalef richness index (4.01), indicating a robust and diverse copepod community. Rotifera followed with Simpson’s indices of 0.089 and a Margalef index of 3.18, while Cladocera recorded a Simpson’s index of 0.052 and Margalef index of 1.93. Ostracoda showed the lowest diversity (Simpson’s value of 0.001 and Margalef number of 0.15). zooplankton abundance, and relationship with selected physical and chemical properties was also recorded displaying increases in dissolved oxygen and positively correlation with higher zooplankton abundance, whereas elevated temperature showed a negative relationship with overall zooplankton populations.

Anyanwu *et al.* (2023) evaluation of the Anambra River reported Shannon–Wiener diversity index values revealed that crustaceans exhibited the highest diversity (1.779) while Rotifera the least (0.6365). Species dominance was greatest for Rotifera and Insecta (0.5556 each) and marginally low for Protozoa (0.2126). Evenness values increased from 0.6865 for Insecta to 0.9868 for crustaceans, indicating an overall relatively even species distribution despite differences in abundance among groups.

Fan *et al.* (2023) investigation of the planktonic structure in a lake associated with coal mining revealed that, the Shannon–Wiener diversity indices for zooplankton was relatively low in the lake compared to natural river systems. Zooplankton diversity varied between 1.18 and 2.45 with Protozoa and Rotifera constituting the major zooplankton groups. A direct correlation (r = 0.987) was detected between phytoplankton and zooplankton densities.

Chaigneau *et al*. (2023) investigated the Physicochemical Drivers of Zooplankton Seasonal variations in West African Lagoon. Zooplankton abundance fluctuated markedly between 2 to 95 individuals. Species richness displayed a deterministic negative association with salinity (r −0.51), whereas, total zooplankton abundance was positively associated with salinity (r = 0.60, $p < 0.005$). *Synchaeta bicornis* persisted across a wide salinity ranges while Copepod nauplii were more abundant at lower salinities.

Adewumi *et al.* (2023) examination of six tributaries of the Opa Reservoir catchment area reported station specific variations in water quality parameters. Spatial analysis of diversity indices revealed that the Parakin River had the highest taxa index (47) and Margalef index (4.677), while the Postgraduate College (PG) River recorded the highest Shannon index (2.851) and high evenness (0.665). The Opa River exhibited the highest evenness (0.697), while the Obudu River recorded the lowest evenness (0.220). Simpson index values were highest in the PG River (0.896) and Esinmirin River (0.895), indicating a community structure dominated by a few species. Seasonal patterns revealed higher Shannon (3.900) and Margalef (7.131) indices during the wet season, whereas Simpson (0.972) and Berger-Parker (0.586) indices were higher during in the months with increased hotness.

Karmakar *et al.* (2022) studied ten homestead ponds and identified 16 zooplankton species. Shannon–Wiener (H′) values varied 2.12–2.49; evenness (e) 0.84–0.93; Margalef (J) 1.56–2.05; dominance (D) 0.09–0.13. Significant spatial differences occurred in diversity and richness across stations, but no temporal change was found between December and February. SIMPER analysis showed *Diaptomus gracilis* and *Brachionus calyciflorus* as major determinants (>10 %) of community structure through time, while *Cyclops nanus*, *Keratella cochlearis*, *M. leuckarti*, nauplii, *B. quadridentatus*, and *B. rubens* explained spatial dissimilarity among stations. Cluster analysis separated stations into distinct groups at an 88 % similarity level.

Anyanwu and Mbekee (2020) investigated the plankton community structure of the Ossah River in Umuahia, Southeast Nigeria the Shannon-Weiner diversity indices zooplankton (2.140–2.189) indicated moderately polluted conditions, while low Margalef indices suggested some level of community instability. Evenness indices were high and close to 1, suggesting a relatively even distribution of species. Physicochemical analyses revealed acidic pH values (4.6–6.3), dissolved oxygen concentrations mostly below the acceptable limit (>6 mg/l), and elevated BOD at Station 1, indicating organic pollution. Higher total dissolved solids and electrical conductivity were also recorded at Stations 1 and 2.

2.4 Seasonal Variation of Freshwater Body

Bekederemo *et al.* (2025) investigation of river-fed earthen fish ponds in Ekpan Fishing Community, Niger Delta, recorded high zooplankton diversity dominated by Rotifera and Copepoda. *Keratella* and *Synchaeta* were particularly abundant, with high abundance of 244 individuals in October and 214 individuals in November, respectively. *Cyclops*, *Eucyclops*, and *Mesocyclops* were the most abundant Cyclopoida alongside *Cyclops* with 208 individuals in September, *Eucyclops* 230 in October, and *Mesocyclops* 187 in November.

Fabian *et al.* (2025) examined Lake Alau, Borno State, Nigeria, over an 18-month sampling period and reported Monthly and seasonal variations. The highest monthly abundance was identified in October and December 2019, with 23 organisms (7.54%) each month, while the lowest was in April 2019 with 10 organisms (3.28%). Rotifers consistently dominated most months, peaking in August 2019 (84.62%). Seasonal analysis revealed that the dry season (October to May) contributed 223 organisms (73.10%), whereas the wet season (June to September) contributed 82 organisms (26.89%). Rotifers remained the dominant group in both seasons, accounting for 54.71% of the dry-season total and 72.50% of rainy season total. Cladocerans reached their highest seasonal proportion in May 2020 (44.44%), while copepods peaked in December 2019 (26.09%).

Imoobe *et al.* (2025) examined Eruvbi Stream and reported that physicochemical parameters significantly influenced copepod species. The study recorded a total of 61 copepod individuals across two orders, Cyclopoidae and Calanoidae, comprising seven species. *Thermocyclops crassus* (26.23%) and *Mesocyclops salinus* (22.95%) were the most abundant species, while *Eurytemora affinis* (1.64%) showed the lowest occurrence. Station 2, exhibited the highest turbidity (67 ± 10.7 NTU) and total suspended solids (38.33 ± 5.36 mg/L), along with high electrical conductivity (190 ± 71.35 µS/cm), alkalinity (96 ± 73.11 mg/L), hardness (18 ± 7.20 mg/L), and chemical oxygen demand (29.67 ± 11.83 mg/L) due to influx of soft drink effluent at the discharge point.

Opeh *et al.* (2025) examined the Great Kwa River in southeastern Nigeria. Zooplankton abundance also increased in the wet season (5,863.5 organisms/L) compared to the dry season (5,270.67 organisms/L), though this difference estimated absence of statistical significance. Zooplankton diversity was substantially higher in the wet period (2.11) compared to dry period (1.99, $p < 0.05$).

Seasonal variations in zooplankton abundance the Niger River was evaluated by Hassane *et al.* (2024). 48 zooplankton groups were recorded across the study periods, belonging to Rotifera, Copepoda, and Cladocera. During reduced depth, rotifers were the dominant group, making up 74.89% of the community, succeeded by copepods and copepodites (20.17%) and cladocerans (4.93%). Contrary, during the high-water period, copepods and copepodites were the abundant (53.2%), subsequent to rotifers (32.63%) and cladocerans (14.09%). Overall zooplankton abundance was markedly higher during low water (327,070 ind/m^3) than during high water

(43,344 ind/m³), with rotifers contributing 244,949 ind/m³ in low water compared to 14,144 ind/m³ in high water. Cladocerans, while consistently less abundant than the other groups, increased in relative proportion from 4.93% in low water to 14.09% in high water. The number of taxa varied from 14 to 20 per station during low water and from 8 to 21 during high water.

Seasonal fluctuations were evident, with some physicochemical attributes influenced by rainfall and Harmattan-driven temperature changes. Variations in air and water temperature was linked to seasonal climatic patterns, while conductivity values decreased during the rainy season due to dilution (Ogidi *et al.* 2024)

Dauda *et al.* (2021) investigation of River Rido, reported Positive correlations were observed between Protozoa and temperature at Station A, while pH and nitrite levels were positively associated with Protozoa abundance at Station B. Magnesium and chloride demonstrated an inverse relationship. The high temperature, TDS, conductivity, chloride sulphate, and oil and grease levels at Station B, combined with low dissolved oxygen and transparency, were identified as critical factors contributing to the observed decline in zooplankton density at the effluent discharge point.

Neelgund and Kadadevaru (2022) examined the Bidi Minor Irrigation Tank in Khanapur Taluk India over an 18-month sampling period The study also revealed distinct seasonal fluctuations in zooplankton populations across the 18-month observation period. Rotifer richness was highest in February 2017 with 25 species and lowest in May 2018 with seven species. Among cladocerans, the greatest number of species (16) was reported between March and June 2017, while the lowest (six species) occurred in January 2017. Copepoda exhibited maximum species richness (seven species) during February, April, May, November, and December 2017 and January 2018. The least (three species) was observed in January. Protozoan diversity peaked at four species in June and July 2017 and was lowest (one species) in February and March 2017 and April 2018. Ostracods were consistently sparse, with *H. fossulata* present for 12 months and *Ilyocypris sp.* for four months only.

James and Ajah (2021) assessed the effects of tidal fluctuations on numerical abundance of zooplankton during their examination of the Great Kwa River, Calabar, Nigeria. Copepods, primarily represented by *Microcyclops varicans*, were dominant at low tide, whereas Rhizopoda, notably *Paraquadrula irregularis*, were most abundant at mid and high tides. Low tide recorded the highest species richness (33 species), followed by high tide (26 species) and mid tide (22 species).

Suleiman *et al.* (2021) examined Ajiwa Reservoir, Katsina State, Nigeria, Seasonal comparisons revealed that dry-season values were generally higher for temperature, EC, TDS, and transparency, whereas rainy-season values were higher for nitrate, phosphate, DO, and BOD. Rotifers and Cladocerans displayed highest mean monthly abundance in April, whereas the lowest densities for these groups were recorded in August. Seasonal analysis revealed that zooplankton numbers rose with the onset of the rainy season and declined as it progressed

Krishnamoorthi and Moorthikumar (2020) examined Amaravathi Dam in Tirupur District, Tamil Nadu, India, through monthly sampling across five sites and identified 25 zooplankton species comprising 10 species of Rotifers, 5 species of protozoa, 6 species of Cladocerans, 4 species of Copepods, and additional larval forms. Rotifer abundance peaked during the post-monsoon season with 56 individuals per litre and was lowest during the pre-monsoon season with 31 individuals per litre. Copepods showed maximum abundance in summer (24 individuals per litre) and minimum during pre-monsoon (14 individuals per litre). Cladocerans followed a similar pattern with maximum abundance in summer (24 individuals per litre) and minimum in pre-monsoon (16 individuals per litre). Protozoa were most abundant during the monsoon season (19 individuals per litre) and least during summer (5 individuals per litre).

Larval forms were recorded only during post-monsoon and rainy seasons, contributing 2% of total zooplankton. The observed seasonal patterns were attributed to factors such as feeding ecology, predation pressure, water level fluctuations, and water quality. The high abundance of zooplankton during the post-monsoon period was linked to optimal temperature, higher oxygen concentrations, rich nutrient availability, greater light penetration, and reduced predation.

Tusayi *et al.* (2020) examined Dadin Kowa Dam in Gombe State, Nigeria, over a six-month period from May to October and reported zooplankton community comprising of 10 species. *Brightwellii* recorded the highest abundance (428 individuals) in June and the lowest (121 individuals) in October. *Philodina* peaked at 550 individuals in June and dropped to 195 in September, while *Bdelloid* attained a maximumof 402 in May and a minimum of 116 in October. Moina *attained* 97 individuals in June and 30 in September, and Diaptomus reached 112 in May but fell to 30 in September. Daphnia showed relatively lower abundance, peaking at 43 individuals in May and decreasing to 26 in September. Cyclops and *Camtocerus* recorded a maximum of 70 and 76 individuals respectively in July, lowest of 35 in September and October. *Camtocerus* reached 76 individuals in May and a low of 35 in September and October. *Bidentata* attained maximum abundance of 331 individuals in May and the lowest of 49 in October.

Omoboye *et al.* (2022) examination of Esa-Odo Reservoir revealed that 25 species recorded higher mean abundance during the harmattan, while 19 species peaked in the wet season months. Among these, *Lepadella ovalis* exhibited greater prevalence during the rainy season, whereas *Filinia pejleri* and *Brachionus angularis* had considerably higher abundances in the dry months. ($p \leq .01$). In addition, *Polyarthra sp.* and *Argonotholca foliacea* displayed very highly significant seasonal variation ($p \leq .001$), with *Polyarthra sp.* more during the harmattan, and *Argonotholca foliacea* during heavy rains. Five species occurred exclusively in the humid period and four species only in the rainy season. Analysis of diversity indices revealed that riverine surface water station was the most diverse in species richness, while the transition littoral zone was the least diverse.

2.5 Correlation and Multivariate Relationships

Akinsorotan *et al.* (2024) investigated the effects of fish cage culture on zooplankton abundance in Itapaji Reservoir, southwest Nigeria. According to the study, Principal Component Analysis (PCA) revealed that zooplankton community structure varied significantly across the phases, with the first principal component explaining 76.4% of variation before stocking, 70.4% during culture, and 67.3% before harvesting. Positive correlations were observed between *Frontonia*, *Coleps*, and *Cypridopsis* and the first principal component before harvesting, while *Euglena* and *Rotaria* showed negative correlations.

Statistical analyses distinct direct correlations between copepods and rotifers (r = 0.87) and between copepods and key water parameters including BOD, conductivity, TDS, pH, and transparency whereas Rotifera correlated positively with dissolved oxygen, while cladocerans showed a negative relationship with water and air temperature (Jokthan *et al.* 2023).

Umi *et al.* (2024) examination of freshwater lentic ecosystems in Malaysia reported that zooplankton community were strongly influenced by environmental conditions linked with trophic monitoring. Canonical correspondence analysis revealed that environmental parameters determined 60.59% of the variation in zooplankton distribution. Axis 1, representing 34.66% of the variance, showed positive correlations with total nitrogen, turbidity, pH and chlorophyll a, but negative association with water transparency. Species including *B. falcatus*, *T. similis*, *C. cornuta*, *K. cochlearis* and *B. calyciflorus* were positively associated with these nutrient-rich, turbid conditions. In contrast, *P. vulgaris* showed inverse correlations with total nitrogen (-0.669), chlorophyll a (–0.666), and total phosphorus (–0.522), highlighting its preference for clearer, less nutrient-enriched waters. Further analysis demonstrated that total zooplankton density was directly associated with chlorophyll a (0.571), turbidity (0.496), and total nitrogen (0.457), but inversely associated with water transparency (–0.487).

Opeh *et al.* (2025) Pearson correlation analysis revealed negative correlations between pH and plankton indices, including phytoplankton abundance (r = –0.76) and zooplankton diversity (r = –0.80), suggesting that higher pH levels may suppress plankton productivity. Temperature also exhibited negative correlations with plankton indices, though less strongly than pH. In contrast, DO showed strong positive correlations with all plankton indices, including zooplankton diversity (r = 0.76). BOD was strongly and negatively correlated with plankton abundance and diversity, particularly with zooplankton diversity (r = –0.87). Nutrients such as nitrate and phosphate exhibited significant positive correlations with plankton abundance and diversity, with nitrate showing particularly high correlation with zooplankton diversity (r = 0.87).

According to Mohammed *et al.* (2023), Canonical Correspondence Analysis (CCA) indicated that environmental characteristics of water determined over 29.37% of the observed variation in zooplankton distribution. *B. palas*, *A. multiceps*, *B. sessilis*, *E. mentameyers*, and *A. intermedia* exhibited positive relationship with alkalinity in the rainy months of June and July, whereas *C. tatic*, *P. brachiate*, *L. macrurus*, and *T. parva* were positively in relationship with DO and were more abundant in May and August.

Auta *et al.* (2023) examined Jibia Lake in Katsina State, Nigeria. *Eucyclops macrurus*, whose abundance varied significantly across months (p = 0.011). Pearson correlation analysis revealed complex interactions between water quality parameters and zooplankton species. For instance, DO showed negative correlations with *Canthocamptus staphylinus*, *Platypus* *quadricornis*, *Eucyclops macrurus*, and *T. oithnoides*. BOD negatively correlated with *D. longispina*, *R. rotatoria*, *Canthocamptus staphylinus*, and *Thermocyclops oithnoides*. TSS exhibited a strong negative relationship with *Eucyclops macrurus*. pH negatively correlated with most species, including *Daphnia longispina*, *Rotaria rotatoria*, and *Platypus quadricornis*

Edoreh *et al.* (2021) reported zooplankton groups correlated positively with depth, lead (Pb), and total hydrocarbons (THC), and negatively with colour and metals (Na, Ca, Fe and zinc). Specifically, members of the family Chydoridae were positively associated with THC, chromium (Cr), and lead, while showing negative correlations with Fe, Zn, and Ca. Cyclopidae exhibited positive correlation with depth and negative correlation with colour, turbidity, Na, Ca, Fe, and Zn. Macrothricidae correlated positively with lead alone, whereas Sididae correlated negatively with phosphorus.

Ojelade *et al.* (2021) examination of the coastal waters of Ogun State reported mean values of water quality parameters: temperature (28.60 ± 0.27 °C), salinity (29.25 ± 0.45 ‰), pH (7.38 ± 0.07), EC (42.13 ± 0.33 µS/l), TSS (29.59 ± 0.30 mg/l), DO (6.48 ± 0.07 mg/l) and nutrients. No significant differences for most parameters was recorded. with the exception of dissolved oxygen and nutrients, which were significantly higher during the wet season. Significant positive correlations were observed between temperature and salinity (0.67), and between phosphate and nitrate (0.83), while phosphate correlated negatively with temperature (r = −0.70) and salinity (−0.69).).

Wokoma (2021) investigation across ten sampling stations in the Sombreiro River, recorded zooplankton richness varying from 1.852 in Station 6 to 4.297 in Station 2, with evenness values between 0.748 and 0.921 and Shannon–Wiener diversity indices ranging from 0.920 to

1.399. The community structure was dominated by Protozoa and Rotifera. Species richness and diversity for all biotic groups followed a spatial gradient.

Ajagbe *et al*. (2020) evaluated the physicochemical features of Ikere-Gorge in Oyo State and detected a significant inverse correlation between surface temperature and dissolved oxygen. Transparency showed negative relationships with both phytoplankton abundance and nutrients. Dissolved oxygen correlated positively with phosphate. Electrical conductivity demonstrated strong positive ties with total dissolved solids, total hardness, and zooplankton abundance and moderate ones with total alkalinity and phytoplankton. Similarly, total dissolved solids correlated positively with total hardness, alkalinity, and zooplankton, total hardness was positively linked to alkalinity and nitrate, total alkalinity correlated positively with nitrate and zooplankton. Phosphate and nitrate were also positively related, and nitrate exhibited positive relationships with both phytoplankton and zooplankton. Phytoplankton and zooplankton abundances themselves were positively associated. The annual mean Trophic State Index (TSI) based on total phosphate was 15.04 ± 1.63, classifying Ikere-Gorge as mesotrophic indicating moderate productivity and possible oxygen depletion in deeper layers.

2.6 Water Quality Index

Alprol *et al.* (2021) investigated the ecological status of Lake Burullus, in Egypt. This Ramsar-protected critical for fisheries and bird habitats faced escalating anthropogenic pressures. Anthroropegnic pressures recorded during this study included, agricultural drainage, municipal discharges, and industrial effluents. Carlson’s Trophic State Index (TSI) and Water Quality Index (WQI) was used to classify the trophic status and overall water quality. WQI values indicated generally *good* water quality but the trophic state was considered as hypereutrophic. High nutrient inputs, particularly nitrogen and phosphorus from agricultural runoff and drainage systems, were the major factors behind this hyper eutrophication. These nutrient loadings resulted in gradual but eventual algal blooms and organic matter accumulation. Heavy metals concentrations monitored during this study generally remained within international permissible limits, although localized elevations were linked to industrial and agricultural discharges.

CHAPTER THREE

MATERIALS AND METHODS

3.1. DESCRIPTION OF THE STUDY AREA

3.1.1 GEOGRAPHIC LOCATION

Obazuwa Lake is a rural freshwater body located within the Obazuwa community, Ovia North-East Local Government of Edo State, Nigeria. The lake lies between Longitude (5°28′47″E - 5°30′18″E) and (6°16′10″N - 6°16′56″N). It is primarily fed year-round by groundwater inflows and surface runoffs from rainfall and retains water throughout the year.

3.1.2 CLIMATE

Benin City is located within the tropical rainforest zone of south-south Nigeria. The climate is influenced by south-westerly winds from the Atlantic Ocean and exhibits an annual pattern with minimal demarcation between seasons. The area experiences two distinct seasons, wet and dry season, regulated by the intensity of rainfall and temperature. Wet season begins in April and lasts till October, covering about seven months and is characterized by high humidity and warm air temperature. Dry season extends from November to March, lasting only five months and is marked by low humidity and higher atmospheric temperature. The peak of rainfalls typically occurs in June, July and September, with a brief dry spell in August. This dry spell is transitional in and is not prolonged. The driest months occur between November to mid-January and is characterized by elevated intensity of temperature. The mean annual temperature ranges from 22 ℃ - 31 ℃ (Amaechi, 2024)

3.1.3 VEGETATION

The vegetation surrounding Obazuwa lake is characteristic of tropical rainforest with tall and dense canopy of trees that occasionally reduce precipitation and evaporation at lower depth. The dominant vegetation comprises of bamboo, palm trees along with submerged and epiphytic aquatic plants and scrubs around the lake margins.

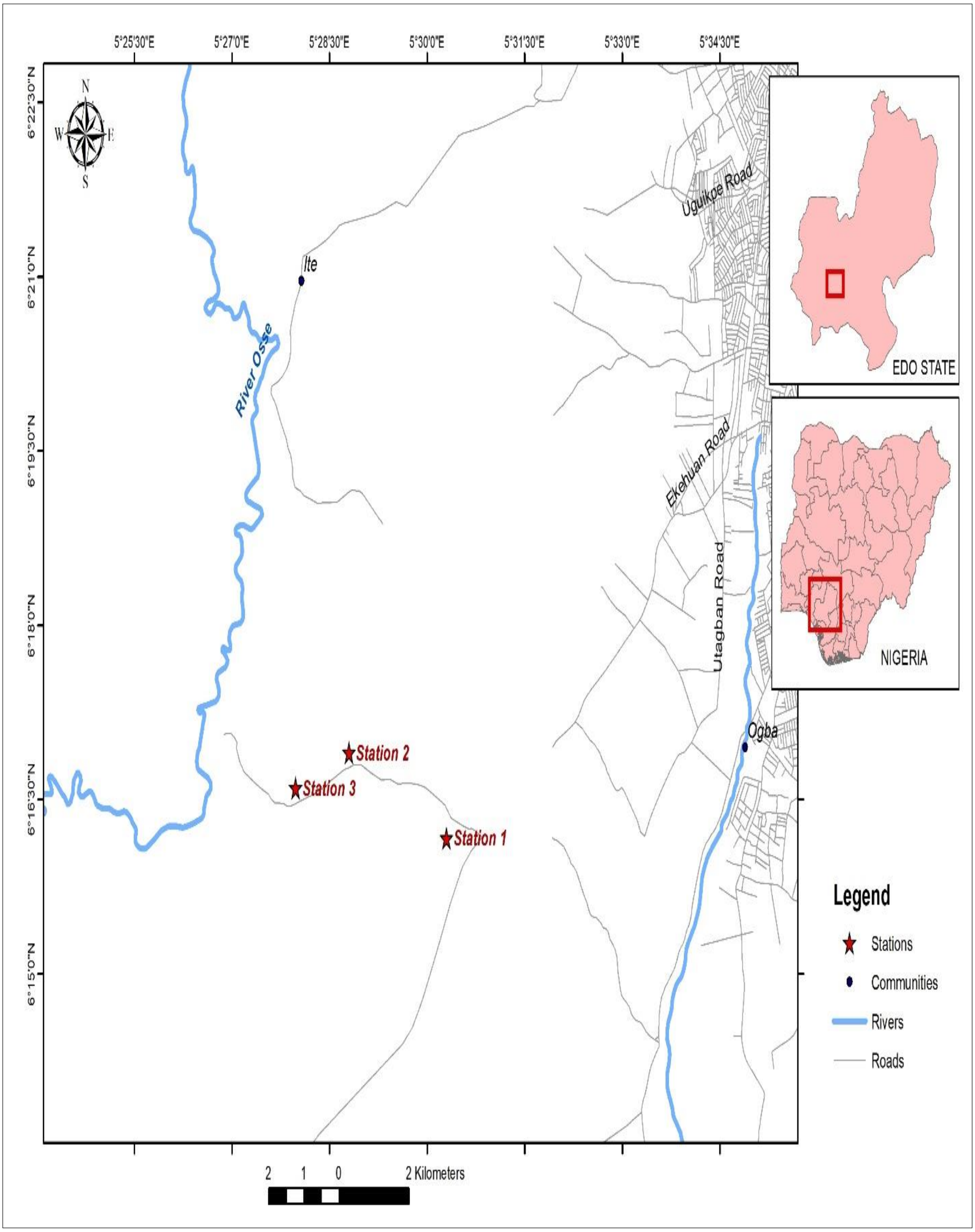

Figure 3.1: Sampling stations of Obazuwa Lake, Edo State, Nigeria

3.1.4 HUMAN ACTIVITIES

The rural settlers of Obazuwa community are primarily farmers, traders, fishermen and wood fellers. Most farmers cultivate staple crops like Cassava, yam, Maize and oil palm while women are mainly involved in garri production from cassava. The trading of palm wine and local gin (known as *ogogoro*) is also a common economic activity. Obazuwa lake serves as a major source of domestic water supply and a cultural heritage site for the community, Occasionally, it is used for religious and ceremonial purposes.

3.2 DESCRIPTION OF SAMPLING SITES

Three sampling sites were investigated during the period of the study.

Station 1

Station 1 with average depth of 0.96 meters, is located upstream, slightly away from the village settlement and domestic homes. It lies between longitude 5°30′18″E and Latitude 6°16′10″N. The area is surrounded by, dense vegetation composed mainly of large trees, shrubs and decaying organic leaves across the stations (Plate 3.1)

Station 2

Station 2 is found downstream, about 1,000m from station 1, with mean depth of 1.09 metres, is located close to human settlements. It lies between longitude 5°28′48″E and latitude 6°16′54″N. The area contains an abundance of dead and decaying leaves on the water surface indicating significant organic input from surrounding vegetation (Plate 3.2)

Station 3

Station 3 is positioned further downstream, approximately 400m from station 2, mean depth of 1.14 meters and slightly away from residential houses. It lies between longitude 5°28′47″E and Latitude 6°16′56″N. This station exhibits a large accumulation of decaying leaves and organic debris.

Plate 3.1: Overview of Station 1 of Obazuwa Lake

Plate 3.2: Overview of Station 2 of Obazuwa Lake

Plate 3.3: Overview of Station 3 of Obazuwa Lake

3.3 Sampling Technique

Sampling was conducted at three established sites on a monthly basis for seven (7) months, spanning from May 2024 – November 2024 between 8.00 am and 9.00 am. A total of 3 composite water and zooplankton samples were collected monthly totally 21 water samples and 21 zooplankton samples over the seven (7) months duration.

3.3.1 Collection of Water Samples

Water for physicochemical assessment was collected in properly washed and rinsed 50cl polyethylene bottles. At the start of each sampling, the bottles were rinsed with water from their respective sampling sites to ensure consistency. Samples were collected by immersing the bottles 5-8cm below the water surface to avoid contamination from surface debris and the bottles were immediately sealed. Samples for dissolved oxygen (DO) estimation were taken using 250ml glass-stopper bottles. Each bottle was carefully submerged, filled to the brim to eliminate air bubbles and tightly stoppered underwater to prevent oxygen trapping. The dissolved oxygen was then fixed *in situ* using 1ml each of Winkler’s Solution A (Manganese Sulphate and potassium hydroxide) and Winkler’s solution B (Azide iodine) respectively. A visible precipitate of manganese hydroxide confirmed successful fixation. Samples for BOD determination were also collected in 250ml glass stopper bottles, sealed under water and stored in dark containers to prevent light penetration.

3.4 Determination of Physical and Chemical Parameters

3.4.1 Air Temperature

In-situ Air temperature at each station was collected with a mercury in glass thermometer. The thermometer was held slightly above the water surface for about five minutes before readings were taken to ensure accuracy (APHA 2023).

3.4.2 Water temperature

A similar procedure to Air temperature measurement was adopted. The mercury in glass thermometer was immersed in the water, at a depth of 10-15 cm for five to seven minutes after which the readings were collected and written in a sampling notebook (APHA 2023).

3.4.3 Hydrogen Ion Concentration (Ph)

The pH of the water sample was measured with a digital Ph meter (Hanna-H1 96107). The instrument was standardized with appropriate buffer solution before readings were taken. The probe was then rinsed with distilled water, and dropped in the samples until the display readings stabilized. The ph was taken after (APHA 2023).

3.4.4 Turbidity

Turbidity was determined with a homogenized Hanna-H1 93703 Turbidimeter. Water Samples collected *in-situ* was poured into a clean, dry cuvette, which was wiped with silicon oil to remove impurities or water droplets. The cuvette was then inserted into the turbidimeter and readings were recorded in Nephelometric turbidity units (NTU) (APHA 2023).

3.4.5 Electrical Conductivity

Conductivity was measured with a Hanna H1 96107 conductivity meter. The apparatus was first calibrated with 0.01 M KCL solution. A 100ml solution added to a clean beaker and the probe was immersed until the display stabilized. The conductivity readings were then recorded in microsiemens per centimeter (APHA 2023).

3.4.6 Total Dissolved Solid (TDS)

Total Dissolved solid represents the total concentration inorganic salts with a number of substances dissolved in water. TDS was determined using gravimetric method according to APHA (2023). Whatman filter paper was used to filter the water sample collected and the filtrate was evaporated in a pre-weighed 250ml flask at 105°Cfor 3 hours. The increase in flask weight after drying represented TDS in milligram per litre (mg/l)

Then TDS was calculated thus:

Weight of empty conical flask = Xg

Weight of flask residue Yg

Weight of residue (TDS) = (Y-X)g

Then TDS (mg/l) = (Y-X) x 1000 x 10

3.4.7 Total Solid (TS)

100ml of well-mixed solution of water collected from the field was measured using a pre-rinsed beaker. The samples were evaporated to dryness using a hot plate. The oven was thereafter dried at 180°C until a stable weight was attained. The final weight represented the total solids and was expressed in mg/L (APHA 2023).

3.4.8 Total Suspended Solids (TSS)

Total suspended solids were demonstrated as the arithmetic difference between total solids and total dissolved solids, both expressed in mg/L (APHA 2023).

Total Suspended Solids = Total Solids – Total Dissolved Solids

3.4.9 Dissolved Oxygen (DO)

Dissolved oxygen was fixed *in-situ* at the point of collection using 1ml each of Winkler's solution -A (manganese sulphate and potassium hydroxide) and B (Azide iodide). The bottles were shaken thoroughly to ensure proper mixing and a thick precipitate manganese hydroxide confirmed successful oxygen fixation.

The fixed samples were analyzed using titrimetric method. 2.0ml of concentrated tetraoxosulphate (VI) acid was added to dissolve the precipitate, forming a clear yellowish solution. The iodine liberated corresponding to the amount of dissolved oxygen present in the sample was titrated against sodium thiosulphate ($Na_2S_2O_3$) using 2 drops of starch solution as indicator. The end point was indicated by a color change from yellow to colourless. (Schwoerbel, 1979).

The amount of dissolved oxygen was then calculated in mg/l using the formula

$$\text{Mg /L (DO)} = \frac{1600 \times M \times V}{V_2 (V_1 - 2)/V_1}$$

Where M = molarity of $Na_2S_2O_3$

V = Volume of $Na_2S_2O_3$ used

V_1 = Volume stoppered bottle

V_2 = Volume of titration aliquot

Manganese (II) sulphate anhydrous reacts with KI to give a white precipitate of manganese (II) hydroxide ($Mn(OH)_2$) DO in water combines with the manganese (II) hydroxide and oxidizes the Mn^{2+} to higher valence state Mn^{4+} which is precipitated as brown hydrated oxide

$Mn^{2+} + 2OH$ .... $Mn(OH)_2$ i.e

$Mn^2 + SO4 + 2KOH$ .... $Mn2 + (OH) + K_2SO_4^{2-}$

$2Mn(OH)_2 + O_2$ .... $2MnO_2 + 2H_2O$. The MnO_2 is the fixation of the oxygen (APHA 2023)

3.4.10 Biochemical Oxygen Demand (BOD)

The BOD was determined by measuring the amount of DO ingested by microorganisms during the biochemical degradation of organic matter in water samples. The procedures followed was similar to DO determination, except that water samples were not fixed immediately with Winkler's reagent.

Water samples were added to a darkly lit incubator in a temperature of 20 °C for five days. After incubation, DO was fixed and measured as previously described for DO determination. The BOD values were calculated as the difference between the initial and final DO readings.

Thus BOD_5 (mg /L) = $DO_0 - DO_5$

Where DO_0 = initial day dissolved oxygen

DO_5 = Final day dissolved oxygen (APHA 2023).

3.4.11 Alkalinity

Total alkalinity of the water samples was determined using the titrimetric method as described by (APHA, 2023). 100ml of each water sample was added to a 250ml Erlenmeyer flask and three drops of phenolphthalein indicator ware added to test for alkalinity. Carbonate alkalinity was absent (no color change was observed) and three drops of mixed indicator (methyl orange and bromocresol red) were then added. The solution was then titrated against 0.1M HCL (Hydrochloric acid) until the color changed from blue to light pink indicating the end point. The titrated value was noted, and total alkalinity as $MgCaCo_3\ L^{-1}$ was determined using the formula

$$\text{Total alkalinity } (MgCaCo_3\ L^{-1}) = \frac{V \times N \times 1000}{V_I}$$

Where V = ml of titre used

N = acid normality

Vi = volume of sample used

3.4.12 Chloride

Chloride was calculated using MOHR's procedure as outlined in APHA (2023). This method involves titration of the sample with silver nitrate and potassium chromate as the end point indicator. Chloride ions in the sample reacts with silver nitrate to form a white precipitate of silver chloride. A control blank was prepared by adding 1ml potassium chromate indicator and 0.02M silver nitrate solution to 100ml distilled water in a clean conical flask. For the actual determination, 100ml of the water sample was measured in to a conical flask, followed by the addition of 1ml potassium chromate indicator. The solution was then titrated against 0.02M silver nitrate with constant stirring, until a reddish brown endpoint appeared indicating the completion of the reaction. The chloride ion concentration was estimated with the equation

$$\text{Cl (mg/L}^{-1}) = \frac{(A - B) \times M \times 70900}{\text{ml of sample}}$$

Where: A = ml silver nitrate used

B = 0.2ml silver nitrate used

M = of silver nitrate

3.4.13 Total Hardness

2ml of hydroxide buffer solution was measured alongside 100ml of the water sample while mixing to prevent excess of CO_2 absorption. Then, 0.4g of mureoxide indicator was added and the solution was titrated against sequestric acid until the colour transformed from pink to purple. The burette reading was recorded (APHA 2023).

3.4.14 Calcium

Calcium content was estimated by titrating ethylene diamine tetra acetic acid (EDTA) and mureoxide as indicator. The indicator forms an unstable complex with calcium ions, producing a pink coloration. Upon titration, EDTA reacts with uncomplexed Ca^{2+}ions, forming a stable calcium – EDTA complex. The disappearance of the pink color and appearance of a purple endpoint indicated completion of titration. Ionic Calcium concentration was calculated using the equation:

$$Ca^2 = \frac{A \times B \times 400.8 \text{ mg}}{\text{Vol of Sample}}$$

Where:

A = ml of titration of sample

B = mg of $CaCo_3$ equivalent to 1.0ml EDTA (APHA 2023).

3.4.15 Magnesium

After determining calcium, magnesium concentration was estimated from the same sample. During the end of calcium titration, 3ml of 5M HCL and 1.5 ml of concentrated HCL were added and made up to 1L with distilled water. Then, 6 ml of concentrated ammonia solution was added, followed by a few drops of Erichrome Black T indicator. The solution was titrated against EDTA (1.0ml EDTA = 2.432ug) until the color changed from wine red to blue, marking the endpoint. The magnesium concentration was calculated as follows:

$$\text{Magnesium} = \frac{A \times B \times 2432}{\text{Vol of Sample}}$$

A = ml titre for sample

B = mg of $CaCo_3$ equivalent to 1.0ml EDTA titrant at magnesium end point (APHA 2023).

3.4.16 Nitrate

Nitrate concentration was determined by the colorimetric methods using phenoldisulphonic acid as described in APHA (2023). A 50ml water sample was evaporated to dryness in a porcelain dish at 108℃ using a Gallenkamp water bath. The dry residue was dissolved by adding 2ml of phenoldisulphonic acid, followed by 20ml of distilled water and 7ml of concentrated ammonia to neutralize the acid. The resulting yellow coloration was measured spectrophotometrically to determine nitrate concentration.

3.4.17 Phosphate

Phosphate concentration was determined using the ascorbic acid method as described in APHA (2023). The method used a reagent mixture consisting of ascorbic acid, antimony potassium tartrate, sulphuric acid and ammonium molybdate. 50ml portion of water sample was added to a conical flask followed by the addition of 2.5ml of the combined reagent. The solution was thoroughly mixed and allowed to remain still for 30 minutes to permit full color changes. The resulting blue coloration was measured at a wavelength of 880nm using a Milton Roy Spectronic 21D spectrophotometer.

3.4.18 Sulphate

Sulphate concentration was estimated using the turbidimetric method outlined in APHA (2023). This method involves a mixture of sodium chloride - hydrochloric acid, barium chloride and glycerol-ethanol solutions. Precipitation of barium chloride under controlled acidic conditions is measured. A 10ml of the water sample was measured into a 25 ml conical flask and 1 ml concentrated HCL and 2 ml of glycerol ethanol solution were added subsequently to. 0.3 g of barium chloride crystals. The solution was added quickly into the absorption cell and measure using the absorbance at 420nm after 3 minutes. Spectrophotometric readings were then taken and comparison made with the control blank (APHA 2023).

3.4.19 Sodium

Sodium concentration was estimated using the Technicon Autoanalyzer flame photometer (IV model), pre-calibrated with standard sodium solutions. Known concentrations of sodium standards were prepared using lithium as an internal standard. Samples and standards were aspirated automatically through the sample tray module into the mixing chamber. Proper mixing of the lithium and sodium sample were ensured and the solution was atomized into the flame chamber fuelled by propane gas. The sodium concentration was determined based on the intensity of the emitted flame color with results recorded from an attached chart recorder (APHA 2023).

3.4.20 Potassium

Potassium concentration was determined using the same flame photometric method as described for sodium. The flame photometer was adjusted for potassium detection at 766.5nm. Calibration was performed using known potassium standards and the instrument was set to zero and maximum scales using distilled water and the highest standard respectively. A standard curve for potassium concentration was established by feeding the standard solutions through the flame photometer. The water sample was filtered, aspirated into the instrument and its potassium concentration determined directly from the recorded readings (APHA 2023).

3.4.21. Iron

Iron concentration was determined using the colorimetric method as described by APHA (2023). This method is based on the change in color intensity of the solution as a function of iron concentration. A standard iron solution was prepared by dissolving 0.2500 g of pure iron wire in 25 ml of 1:1 HCL and diluting to 500 ml with distilled water in a volumetric flask.

Aliquots of this solution were further diluted to obtained working standards. The color intensity of the sample was measured spectrophotometrically, and iron concentration was gotten from the calibration curve plotted for the standard iron solutions.

3.4.22 Chemical Oxygen Demand

The COD of the water samples was determined using the closed reflux dichromate method (APHA 5220B, 2023). The method conforms to the base knowledge on the oxidation of organic matter in the water sample by potassium dichromate ($K_2Cr_2O_7$) in a strongly acidic medium.

Ten millilitres of sample were pipetted into a reflux flask. To this, 1 g of Mercury sulfate ($HgSO_4$) and 5 mL of 0.25 N Standard $K_2Cr_2O_7$ solution were added, followed by 15 mL of the H_2SO_4–Ag_2SO_4 reagent. The mixture was gently mixed and refluxed for two (2) hours at 150 °C. After cooling, the digested mixture was diluted to 150 mL with deionized water and titrated with 0.1 N Ferrous ammonium sulfate (FAS) using ferroin as indicator until a distinct color change from blue-green to reddish brown was observed. A reagent blank was processed concurrently using distilled water.

Calculation:

$$\text{COD} = \frac{(A - B) \times N \times 8000}{\text{Volume of sample (mL)}}$$

A = mL of Ferrous ammonium sulfate (FAS) used for blank;

B = mL of FAS used for sample;

N = Normality of FAS

3.4.23 Copper

Copper was determined using the flame AAS technique at a wavelength of 324.8 nm following APHA 3111B. Calibration standards were prepared within the range of 0.1–1.0 mg/L. The concentration of copper was read directly from the instrument after blank correction.

3.4.24 Lead

Lead determination was performed using graphite furnace AAS at 283.3 nm (APHA 3111B). Lanthanum chloride ($LaCl_3$) was added to suppress interference. Calibration standards ranged from 0.05 to 1.0 mg/L.

3.4.25 Chromium

Total chromium (Cr) was analyzed using flame AAS at 357.9 nm in accordance with APHA 3111B. Potassium dichromate standards (0.1–1.0 mg/L) were used for calibration. This method detected both trivalent and hexavalent forms of chromium.

3.4.26 Cadmium

Cadmium concentration was measured using flame AAS at 228.8 nm (APHA 3111B). All reagents were of analytical grade, and samples were handled to avoid contamination. The detection limit was 0.001 mg/L.

3.4.27 Manganese (Mn)

Manganese was quantified by flame AAS at 279.5 nm following APHA 3111B. Lanthanum was added as a chemical suppressor to minimize interference from iron and calcium.

3.4.28 Zinc

Zinc was determined using flame AAS at 213.9 nm as per APHA 3111B. Standard calibration solutions were prepared within 0.1–2.0 mg/L.

3.5 Zooplankton Collection

Qualitative plankton estimation was determined by towing a plankton net of (mesh size 0.25mm) made of fine monofilament nylon along surface water. The net was hauled both vertically and horizontally during each sampling period. The collected samples were concentrated at the 50ml mark of a plankton cylinder attached to the end of the plankton net. The concentrated zooplankton samples were then transferred into a 75ml well labelled and pre-washed plastic bottle and preserved with 4% formalin immediately after collection (APHA 2023).

3.5.1 Zooplankton Analysis

Zooplankton analysis was conducted at the National Centre for Energy and Environment (NCEE) laboratory, University of Benin. Each concentrated zooplankton sample was reduced to 25 ml by decantation. Subsamples were taken in succession using a well-cleaned pipette, placed on a glass slide and viewed under a binocular microscope (Amscope T690C-PL model) at 10x, 25x and 40x magnifications.

3.5.2 Sorting and Counting of Plankton

Zooplankton was carefully picked out with the aid of a sorting pin and a micro-pipette, Accurate count of each taxon was taken and thereafter stored in a well labeled transparent vial bottle and preserved in 4% formalin. In the laboratory, a 3ml aliquot of each concentrated samples was mounted on a glass slide and examined under the binocular microscope at various magnifications. Each plankton sample was sorted and counted and results were expressed as the number of species per millilitre of a sample.

3.5.3 Identification of Species

Identification of zooplankton species was carried out also at the National Centre for Energy and Environment (NCEE), University of Benin. Identification followed standard checklist by Jeje and Fernando (1988, 2002).

3.5.4 Data Analysis

All raw data were processed and converted to meet the requirements of parametric analysis (Omoigberale and Ogbeibu, 2005). Data were analyzed using the Statistical package for Social Science (SPSS version 22) to determine the measures of central tendency and dispersion. The parametric one-way analysis of variance ANOVA (Zar, 1974) was performed to test for significant differences among sampling stations and physicochemical conditions. Graphical representations (charts) were prepared using Microsoft Excel 2016. Correlation and Multivariate analyses (PCA, CCA and RDA) were conducted using the Palaeontological statistical software PAST (version 4.03) to examine the relationships between the physicochemical parameters and zooplankton taxa observed in the water samples.

3.5.5 Community Structure Analysis

Major diversity indices were calculated using paleontological statistics (PAST, version 4.03) to evaluate the community structure of zooplankton species. These were used to compare the diversity, evenness and overall taxonomic richness of the three stations investigated.

3.5.5.1 Species Richness Index (d)

The species richness index (d) according to Margalef (1968) is used to assess the community structure based on the number of species present. The equation below was used to estimate the richness of species and results were recorded to four decimal places.

$$D = \frac{S-1}{\mathrm{Log}_e N}$$

Where

D = species richness index

S = Number of Species

N = Total number of individual

3.5.5.2 Shannon-Weiner diversity Index (H)

Shannon-Wiener Diversity index (H) according to Shannon and Wiener (1949) was used to determine species diversity and evenness.

$$H = \sum Pi \ \mathrm{In} \ Pi$$

H = Diversity Index

T = count denoting the ith species ranging from 1 - n

Pi = proportion of individuals belonging to the ith species, calculated as the number of individuals of that species divided by the total number of individuals in the sample.

3.5.5.3 Species Evenness (i)

Species equitability or evenness (Pielou, 1966) measures the distribution uniformity of species within the community.

$$E = \frac{H}{\mathrm{Log}_2 S}$$

H = Shannon Weaver's Index

S = overall number of Species

3.5.6 Water Quality Index (WQI)

The Water Quality Index (WQI) estimates a single numerical value that reflects the overall quality of surface water. It serves as a criterion for water classification, integrating multiple physico-chemical parameters into one comprehensive indicator of water condition (Hanh *et al.*, 2011; Cude, 2001). The WQI value ranges from 0 to 100, with higher values indicating better water quality (Pham, 2016).

3.5.6.1 Weighted Arithmetic water quality index

The WQI was calculated using the Weighted Arithmetic water quality index method originally proposed by Horton (1965) and later modified by Brown *et al.* (1972). The formula is expressed as follows.

Formula of weighted arithmetic index is as follows

$$WQI_A = \frac{\sum^n{}_i = 1\ Wiqi}{\sum^n{}_i = 1\ wi}$$

Where n = number of parameter

Wi = relative weight of the ith parameter

Qi = the water quality rating of the ith parameter

According to brown *et al*. (1972), the quality rating scale (Qi) is calculated using the equation

$$Qi = 100 \frac{x\ (Vi - Vid)}{(Si - Vid)}$$

Where

Vi = Observed value of the i^{th} parameter

Si = standard permissible value of the ith parameter

Vid = ideal value of the ith parameter

The Computed WQI values were then categorized into qualitative grades as shown in Table 3.1

3.5.6.2 Canadian Council of Ministers of the Environment (CCME) WQI

The CCME WQI is an index developed to simplify and summarize complex water quality data so that it can be more easily communicated to non-specialists (e.g. the public, decision-makers). It was adopted by the Canadian Council of Ministers of the Environment (CCME) and is applied to assess ambient (e.g. stream, river, lake) water quality relative to guideline (objective) values (Canadian Council of Ministers of the Environment, 2001).

The CCME WQI is based on three factors (sometimes called "vectors"):

1. Scope (F_1) — the number of variables (parameters) whose observed values fail to meet the guideline (at least once)
2. Frequency (F_2) — the percentage (or fraction) of individual tests or observations that fail to meet the guidelines
3. Amplitude (F_3) — the extent (magnitude) by which the failing observations deviate from the guideline values

After computing these three factors (each normalized to a scale of 0 to 100 in their formulation), they are combined into a single index value (also 0 to 100), where higher values indicate better water quality (i.e. closer to guideline compliance). Due to the flexibility of the CCME WQI, 10 parameters were choses and used to determine this assessment. The index was then interpreted with qualitative classes ("Excellent", "Good", "Fair", "Marginal", "Poor") based on where the computed index value falls. (Table 3.2) (CCME, 2001)

Table: 3.1: Classification of Water Quality Based on Arithmetic Mean WQI

(Brown *et al.* 1972)

Water Quality Index	Water Quality Status	Grading
0 - 25	Excellent	Grade A
26 - 50	Good	Grade B
51 - 75	Poor	Grade C
76 - 100	Very Poor	Grade D
> 100	Unfit for consumption	Grade E

Table 3.2: Classification of Water Quality Based on CCME WQI (CCME, 2001)

CCME WQI	Ranking	Water Quality Characteristics
95 - 100	Excellent	The water is virtually free from any threats or pollution, maintaining conditions that are almost identical to natural and unaltered sites.
80 - 94	Good	Water remains well protected, though there may be slight level of threat or minor disturbance. Overall condition seldom deviate from what is considered desirable.
65 - 79	Fair	Water quality is generally maintained but it can occasionally face threats or mild degradation. Environmental conditions may sometimes differ from the ideal.
45- 64	Marginal	Water is often at risk or show signs of degradation. The quality frequently falls below natural or preferred standards.
0 - 44	Poor	Water is heavily threatened or consistently degraded with conditions that commonly stray far from natural or acceptable quality levels

Source: Canadian Council of Ministers of the Environment (2001)

The CCME WQI was computed using the following equations

$$F_1 = \frac{n_f \times 100}{n}$$ ………………………………………………………… equation 1

F_1 = scope

n = total number of variables (parameters) being considered,

n_f = number of variables for which at least one observed value fails to meet the guideline.

$$F_2 = \frac{N_f \times 100}{N}$$ ………………………………………………………… equation 2

F_2 = frequency

N = total number of individual tests (observations across all variables),

N_f = total number of tests that fail to meet the guideline.

$$F_3 = \frac{100}{0.01(nse) + 0.01}$$ ………………………………………………………… equation 3

F_3 = Amplitude

But, nse = normalized sum of excursions = $\frac{1}{N} \sum \text{excursions}$

$$\text{excursion}_{ij} = \frac{\text{Failedvalue}_{ij}}{\text{Objective}_j} - 1$$ ……………………………………………………….equation 4

$$\text{excursion}_{ij} = \frac{\text{Objective}_j}{\text{FailedValue}_{ij}} - 1$$ … ……………………………………………………. equation 5

$$\text{CCME WQI} = 100 - \frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}$$ ……………………………….……….equation 6

(CCME, 2001)

CHAPTER FOUR

RESULTS

4.1 Physical and Chemical Characteristics of Obazuwa Lake

Mean concentration for physical and chemical characteristics of water samples, Test of Significance (ANOVA), and recommended limits for surface water obtained for Obazuwa are presented in Table 4.1, while Figure 4.1 – 4.27 shows the spatial and temporal variations across stations from May to November, 2024.

4.1.1 Air Temperature

Mean air temperature of 26.10 ^{o}C, 26.40 ^{o}C and 26.40 ^{o}C were observed in Stations 1, 2 and 3 respectively. Station 1 exhibited the lowest air temperature, while stations 2 and 3 showed the highest concurrent readings. Tests of significance for the air temperature of the three stations revealed an absence of significance difference between the means of air temperature across the three stations (Table 4.1).

The temperature range was steady in all the months of sampling, varying between 24.8 ^{o}C - 28.2 ^{o}C at station 1 and 2, respectively whereas station 3 ranged from 25.2 - 29.1 ^{o}C. The highest air temperature was measured in May (station 2), followed in magnitude by station 3 and 1 respectively. Increased air temperature was noticed in May and dry season months of October and November, typical of tropical regions. Generally, the stations had an almost similar air temperature across the duration of study (Figure 4.1)

4.1.2 Water Temperature

Water temperature between the stations ranges from 26.90 ^{o}C, 27.30 ^{o}C and 27.27 ^{o}C in stations 1, 2, 3 respectively. The maximum water temperature was recorded at Station 2 and 3 respectively, while the minimum was recorded in station 1. .

Table 4.1: Summary of Physicochemical Characteristics of Obazuwa Lake between May and November, 2024

Parameters	**Station 1**	**Station 2**	**Station 3**	**F-value**	**P-value**	**Sig.**	**WHO Limits**	**FMEnV Limits**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**					
	(Min – Max)	**(Min – Max)**	**(Min – Max)**					
Air Temperature (^{o}C)	26.10 ±.26	26.40 ± 1.40	26.40 ± 1.37	0.116	0.891	P > 0.05		
	24.8 – 28.2	24.8 – 28.2	25.2 – 29.1					
Water Temperature (^{o}C)	26.90 ± 2.22	27.30 ± 2.18	27.27 ± 2.22	0.071	0.931	P > 0.05		< 40
	23.5 - 30.2	24.0 - 30.8	23.8 – 30.8					
pH	6.64 ± 0.65	6.68 ± 0.67	6.53 ± 0.65	0.09	0.915	P > 0.05	6.5 – 9.2	6 - 9
	6.00 – 7.73	6.00 -7.63	5.80 – 7.44					
Electrical Conductivity (µS/cm)	70.43 ± 12.14	66.86 ± 13.69	63.14 ± 8.275	0.691	0.514	P > 0.05		≤ 1000
	48.00 – 86.00	52.00 – 85.00	50.00 – 77.00					
Total Dissolved Solids (TDS) mg/l	35.00 ± 6.00	33.29 ± 6.94	31.29 ± 3.99	0.725	0.498	P > 0.05	500	1000
	24.00 – 43.00	26.00 – 42.00	25.00 – 38.00					
Total Suspended Solids (TSS) mg/l	7.98 ± 12.93	11.27 ± 17.81	8.43 ± 13.11	0.102	0.904	P > 0.05		≤ 5
	0.564 – 34.00	0.860 – 42.00	0.546 – 30.00					
Total Solids (TS) mg/l	42.98 ± 10.58	44.56 ± 14.78	39.72 ± 10.69	0.288	0.753	P > 0.05	30	30
	34.98 – 66.00	26.89 ± 70.00	30.70 – 59.00					
Turbidity (NTU)	18.01 ± 14.36	21.94 ± 13.27	20.29 ± 12.51	0.152	0.860	P > 0.05		

	9.67 – 49.00	9.3 – 47.00	9.48 – 44.00					
Alkalinity (mg/l)	21.69 ± 7.28	19.16 ± 6.80	21.80 ± 14.67	0.153	0.859	P > 0.05		
	15.00 – 32.00	6.00 – 28.00	1.75 – 50.00					
Dissolved Oxygen(mg/l)	2.76 ± 1.77	2.57 ± 1.49	3.00 ± 1.74	0.116	0.891	P > 0.05	4 - 6	≥ 5
	0.30 – 5.20	0.60 – 4.40	0.20 – 5.00					
Biological Oxygen Demand (BOD) (mg/l)	6.67 ± 3.38	6.7 ± 4.24	5.59 ± 4.56	0.169	0.846	P > 0.05	6	≤ 5
	3.20 – 10.40	2.60 -12.60	2.80 – 14.20					
Chemical Oxygen Demand (COD) (mg/l)	106.34 ±20.25	117.29 ±39.13	106.00 ± 32.52	0.289	0.735	P > 0.05		40
	86.00 - 136	64 - 174	74 - 162					
Salinity as Chloride (mg/l)	17.43 ± 9.87	16.41 ± 7.04	13.58 – 5.45	0.472	0.859	P > 0.05	75	20
	10.64 – 38.29	7.09 ± 25.54	10.64 – 25.54					
Total Hardness (mg/l)	34.30 ± 5.46	32.36 ± 9.19	31.56 ± 4.77	0.305	0.741	P > 0.05		
	30.42 – 44.00	17.61 – 48.00	25.62 – 40.00					
Nitrate (mg/l)	3.53 ± 3.74	4.24 ± 5.17	2.38 ± 2.34	0.401	0.675	P > 0.05	50	20
	0.040 – 8.120	0.040 – 14.080	0.050 – 5.690					
Phosphate (mg/l)	0.080 ± 0.29	0.83 ± 0.32	0.79 ± 0.46	0.013	0.987	P > 0.05	0.1	3.5
	0.419 – 1.210	0.360 – 1.230	0.160 – 1.560					
Sulphate (mg/l)	42.34 ± 19.38	43.67 ± 15.13	38.58 ± 14.82	0.178	0.838	P > 0.05		500
	7.11 – 67.31	11.81 – 59.54	12.98 – 56.61					
Chromium (mg/l)	0.089 ± 1.37	0.087 ± 1.29	0.087 ± 1.51	0	1.00	P > 0.05		
	0.026 – 0.40	0.026 – 0.30	0.016 – 2.412					

Cadmium (mg/l)	< 0.50 ± 0.00	< 0.50 ± 0.00	< 0.50 ± 0.00	0	1.00	$P > 0.05$
	< 0.50	< 0.50	< 0.50			
Copper (mg/l)	0.055 ± 0.024	0.053 ± 0.025	0.046 ± 0.023	0.262	0.772	$P > 0.05$
	0.017 – 0.099	0.014 – 0.094	0.008 – 0.080			
Lead (mg/l)	0.021 ± 0.0099	0.017 ± 0.0076	0.017 ± 0.0058	0.535	0.594	$P > 0.05$
	0.008 – 0.036	0.005 – 0.028	0.008 – 0.025			
Iron (mg/l)	1.33 ± 0.90	1.51 ± 1.14	1.11 ± 0.89	0.297	0.746	$P > 0.05$
	0.043 – 2.254	0.056 – 2.859	0.060 – 2.412			
Zinc (mg/l)	0.083 ± 0.028	0.078 ± 0.025	0.071 ± 0.016	0.404	0.674	$P > 0.05$
	0.038 - 0.129	0.036 – 0.110	0.055 – 0.105			
Magnesium (mg/l)	3.74 ± 1.53	3.38 ± 1.11	3.36 ± 1.37	0.173	0.842	$P > 0.05$
	0.97 – 5.35	1.56 – 4.67	1.46 – 4.67			
Manganese (mg/l)	0.090 ± 0.043	0.061 ± 0.028	0.072 ± 0.039	0.356	0.356	$P > 0.05$
	0.027 – 1.174	0.021 – 0.090	0.018 – 0.147			
Calcium (mg/l)	7.47 ± 4.05	7.40 ± 3.23	7.05 ± 3.21	0.028	0.972	$P > 0.05$
	4.49 – 16.03	4.49 – 14.43	3.50 – 12.02			
Sodium (mg/l)	5.92 ± 2.99	5.77 ± 2.88	5.28 ± 2.59	0.098	0.907	$P > 0.05$
	1.05 – 7.96	1.67 - 8.57	0.91 – 7.85			
Potassium (mg/l)	3.27 ± 1.63	3.31 ± 1.55	2.93 ± 1.40	0.127	1.0.881	$P > 0.05$
	0.865 – 4.721	1.06 – 4.592	0.714 – 4.004			

$P > 0.05$ Indicates no significant difference.

Tests of significance for water temperature elucidated no relevant statistical difference between the mean values of the three stations (Table 4.1). Water temperature across sampling stations varied throughout the duration of study. In May, station 2 and 3 recorded the highest water temperature and reduced slightly between April and September but gradually increased between the last two months of October to November due to increased solar radiation and reduced cooling effect of the lake.

Station 3 recorded the highest water temperature throughout the study in May and thereafter declined slowly between June and September only to spike in October and November. On the other hand, Station two showed similarity to station 3, possibly due to their close proximity and similar environmental conditions. The water temperature of station 2, was also highest in May, reduced between June and September and then increased in October and November.
Water Temperature in Station 1, was also highest in May at the beginning of the study, decreased in June and remained steady till September, and increased from October to November. There was no irregular pattern observed in the water temperature of all the stations during the study (Figure 4.2).

4.1.3. Hydrogen Ion Concentration (pH)

Hydrogen ion concentration ranged across the three stations with mean pH of 6.64 in station 1, 6.68 in station 2 and 6.53 in station 3. The highest mean highest mean pH (7.73) was recorded in station 1, while station 3 recorded the lowest mean pH (5.80). No significant difference was observed between the mean Ph of the studied sites (Table 4.1).

pH concentration was high in May in all stations and then decreased across all the stations in June, July and August. pH also shifted positively, increasing from a mean average of 6.05 in August to elevated levels in September, October and November.

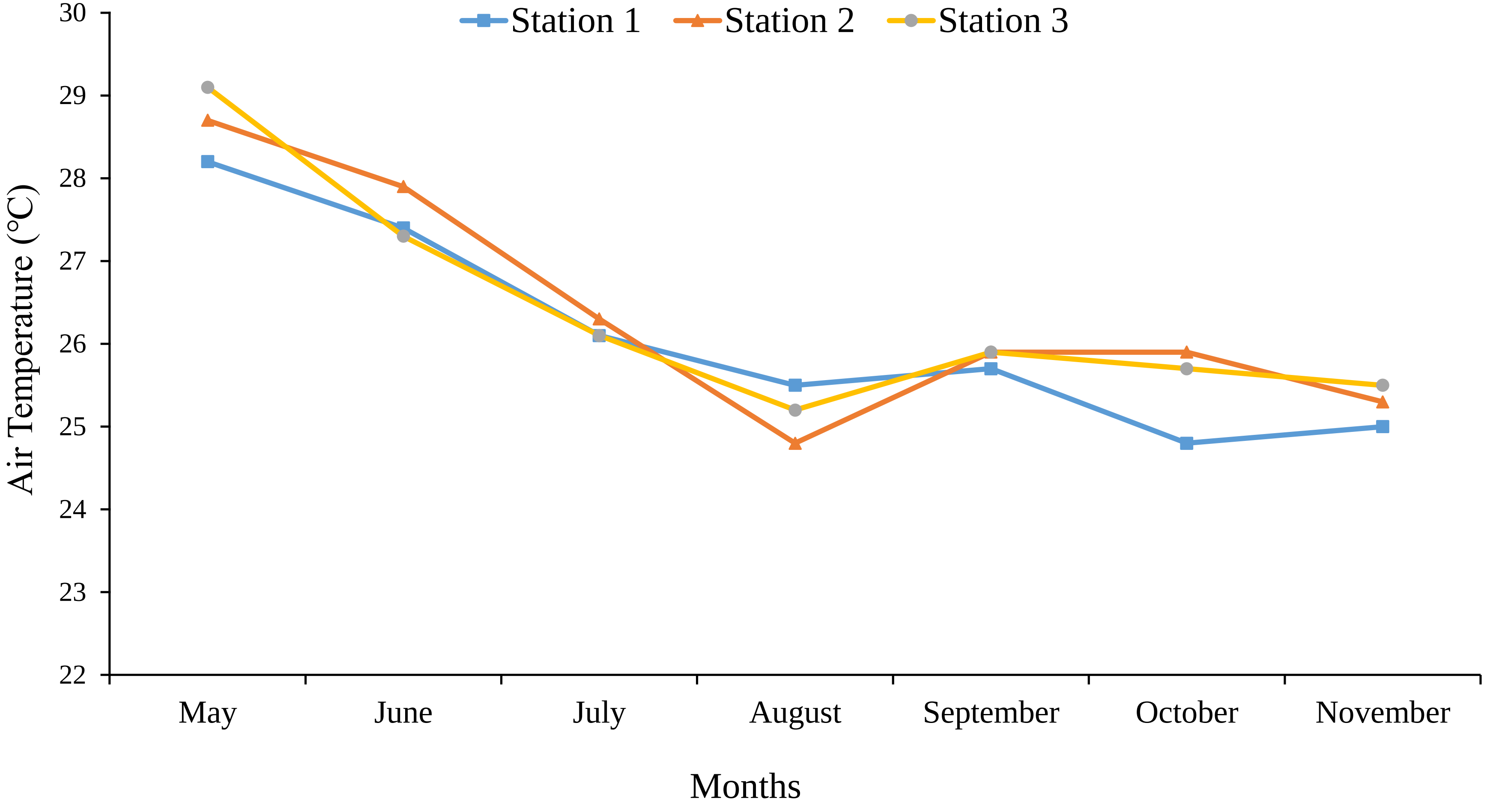

Figure 4.1: Spatial and temporal variation in Air Temperature of Obazuwa Lake from May to November 2024

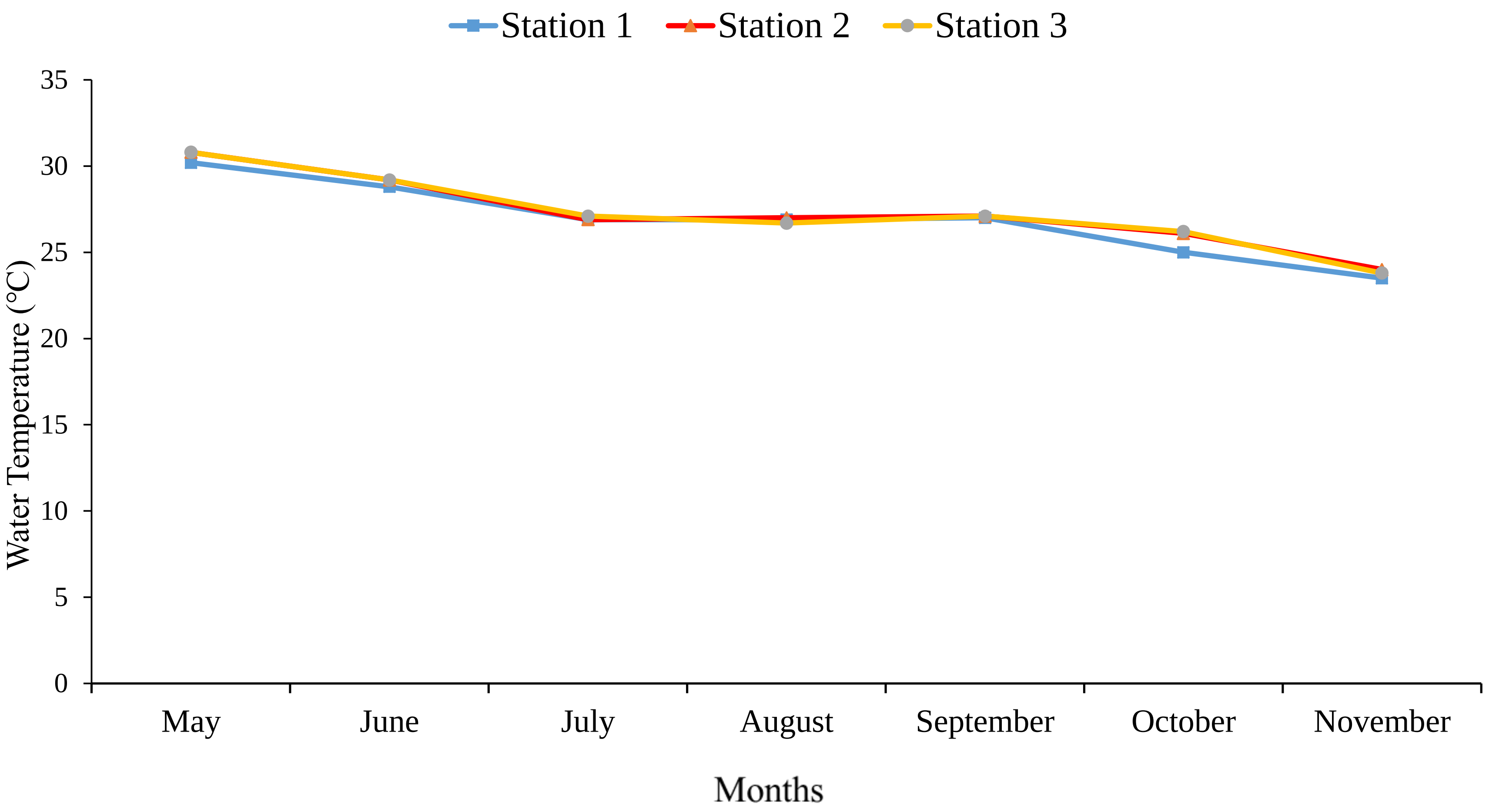

Figure 4.2: Spatial and temporal variation in Water Temperature of Obazuwa Lake from May to November 2024

November recorded the highest pH range in all stations, followed by March (Figure 4.3). Station 2 and Station 3 recorded the lowest pH in July and June respectively and increased from August to November (Figure 4.3).

4.1.4 Electrical Conductivity

Electrical conductivity ranged from 70.43 uS/cm in station 1, 66.86 in station 2 and 63.14 in station 3. Station 1 had the highest mean conductivity while station 3 accounted for the lowest mean conductivity. Statistical analysis revealed that there was no significance difference ($p > 0.05$) in mean conductivity of the three stations (Table 4.1).

EC showed both spatial and temporal variation within and between stations. Station 1 had the highest conductivity in September whereas Station 2 and 3 recorded their highest conductivity in May. In station 1, Conductivity was high during the early months of the study and declined between June and July. Conductivity increased between August and September reaching its peak in September for Station 1. Electrical conductivity fell rapidly in October and increased slowly in November. Similar trend was recorded in station 2 and 3 (conductivity increase at the start of study, decline midway, increase in August and September and then another wave of decline towards the end of the study (Figure 4.4).

4.1.5 Total Dissolved Solids

Total dissolved solids (TDS) ranged between the stations, with mean total dissolved solid concentration of 35.00, 33.29 and 31.29 in station 1, 2 and 3 respectively. Maximum TDS concentration were seen in station 1 while the lowest mean concentration was recorded in station 3. Test of significance difference revealed that there was no significant difference ($p > 0.05$) in the mean TDS (Table 4.1).

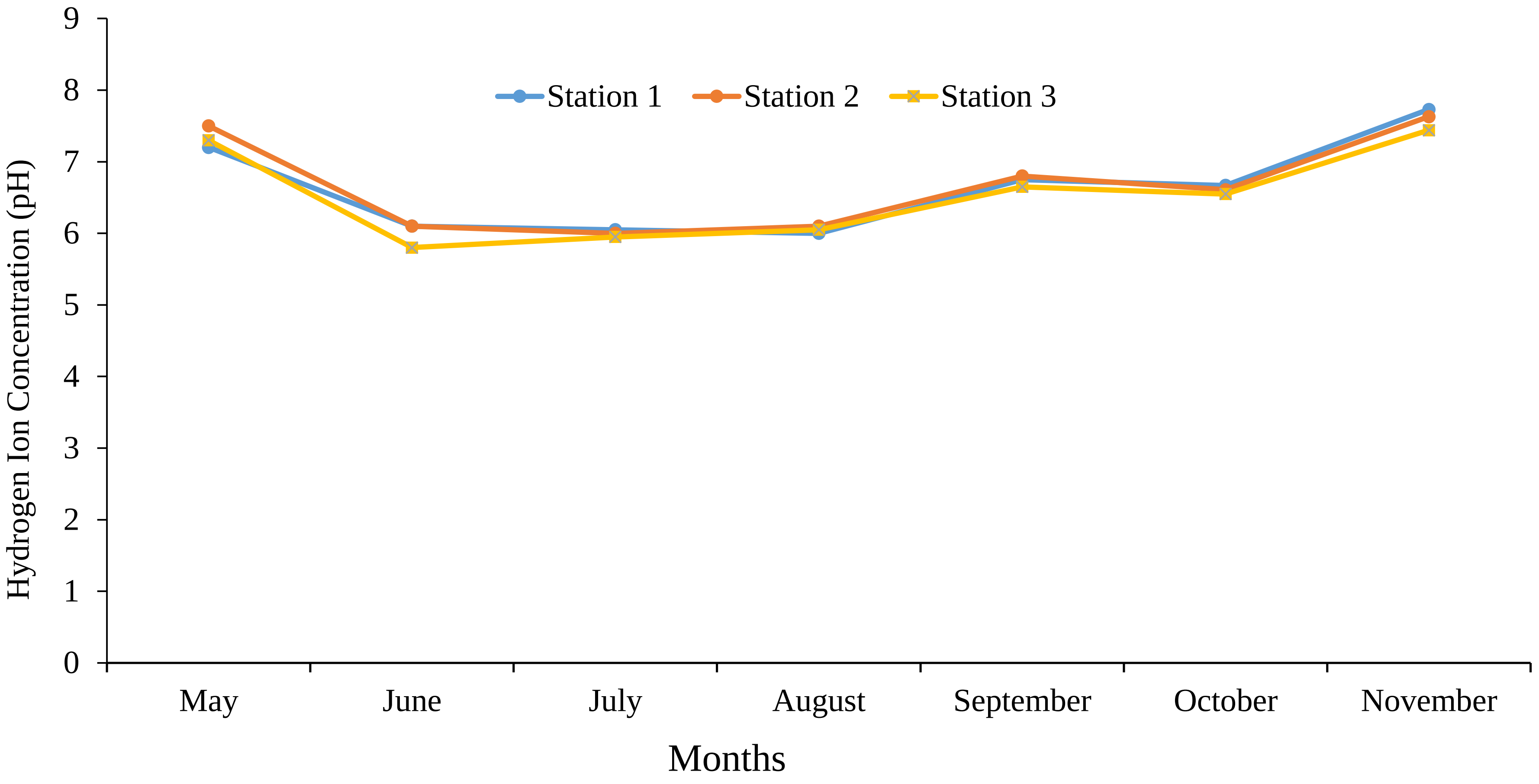

Figure 4.3: Spatial and temporal variation in Hydrogen Ion Concentration of Obazuwa Lake from May to November 2024

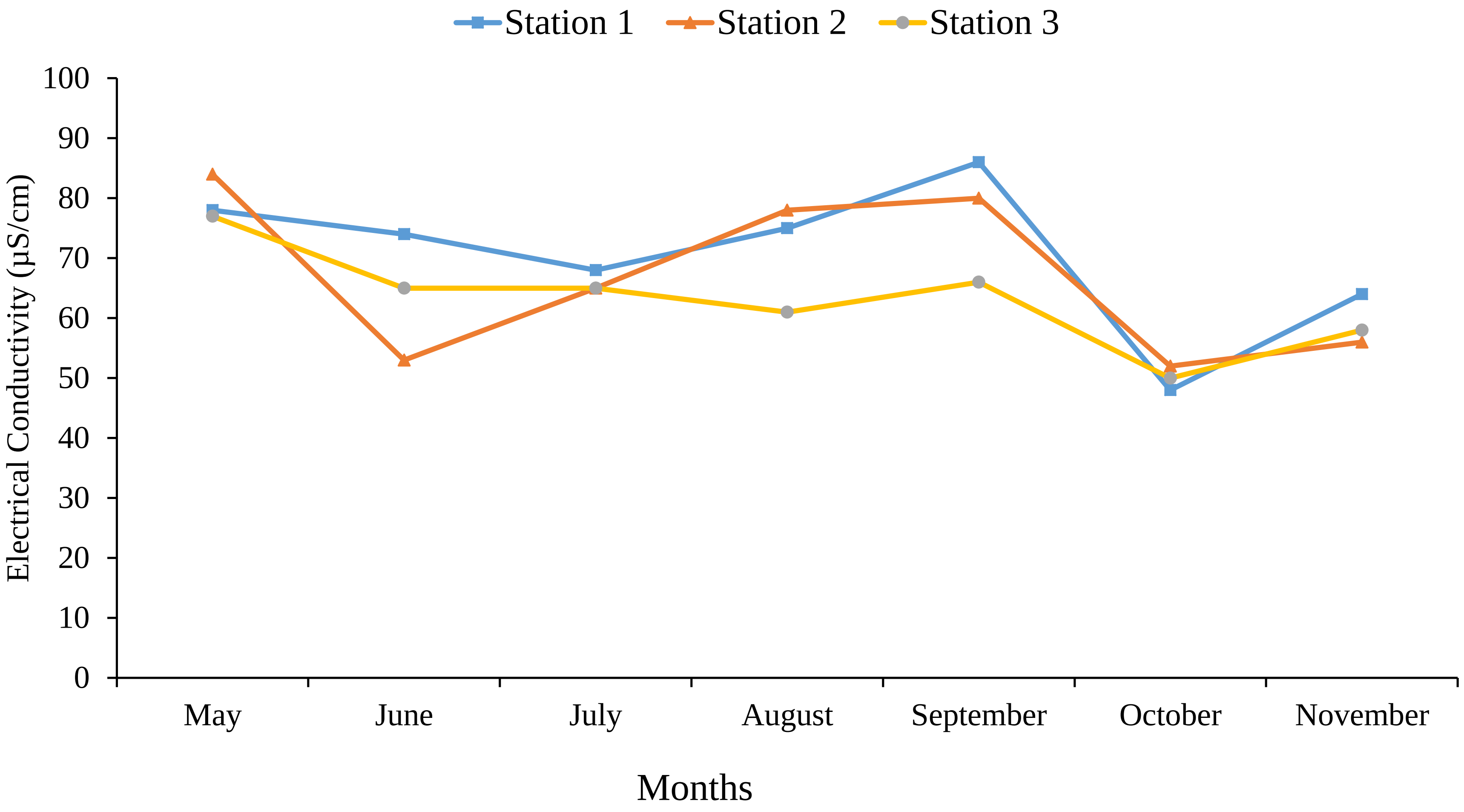

Figure 4.4: Spatial and Temporal variation in Electrical Conductivity of Obazuwa Lake from May to November 2024

The concentration was almost the same in May across stations. Peak TDS of station 2 (42 mg/l) was recorded also in May. Thereafter, results of subsequent months (June and July) showed decline with increasing concentration in dissolved solids resuming in July and reaching a second maximum in September before falling from October to November. In Station 1, Total dissolved solids were fairly the same May recorded a high value of 39 mg/l, declined until September and reached it maximum concentration. Station 1 recorded the lowest TDS in October, before increasing in November. In Station 3, TDS were fairly constant from June to September. Sharp decline was recorded in October, and increased in November. Peak total dissolved solids in station 3 was recorded in May while the minimum concentration was recorded in October (Figure 4.5).

4.1.6 Total Suspended Solids

Total Suspended solid concentration (TSS) ranged among stations with mean TSS of 7.98 mg/l in station 1,11.27 in station 2 and 8.43 in station 3. Overall peak mean TSS was recorded in station 2 while the lowest occurred in station 1. One-way ANOVA revealed no distinct difference ($p > 0.05$) in mean total Suspended solid (Table 4.1). Spatial and temporal variations in TSS were observed throughout the sampling period (Figure 7).

In June, Station 1 recorded higher levels of suspended solids whereas Station 2 and 3 remained relatively stable. Similar patterns were observed in July with Station 1 showing elevated suspended solids concentration. August and September exhibited increases in all stations, with station 1 and station 2 recording the highest peaks, while station 3 consistently showed lower levels of suspended solids. Elevated levels of suspended solids were recorded in October and November (Figure 4.6).

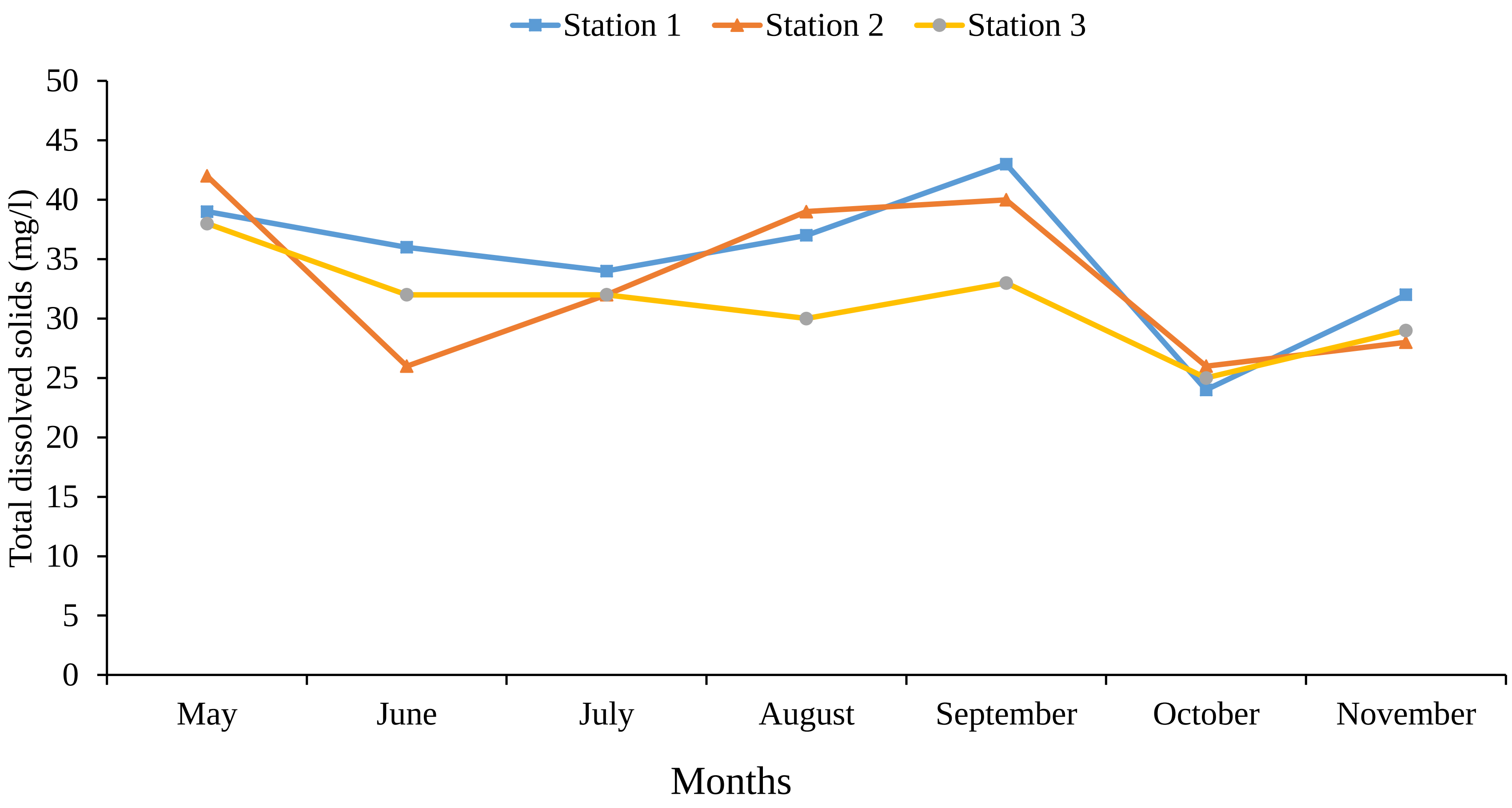

Figure 4.5: Spatial and Temporal variation in Total dissolved solids of Obazuwa Lake from May to November 2024

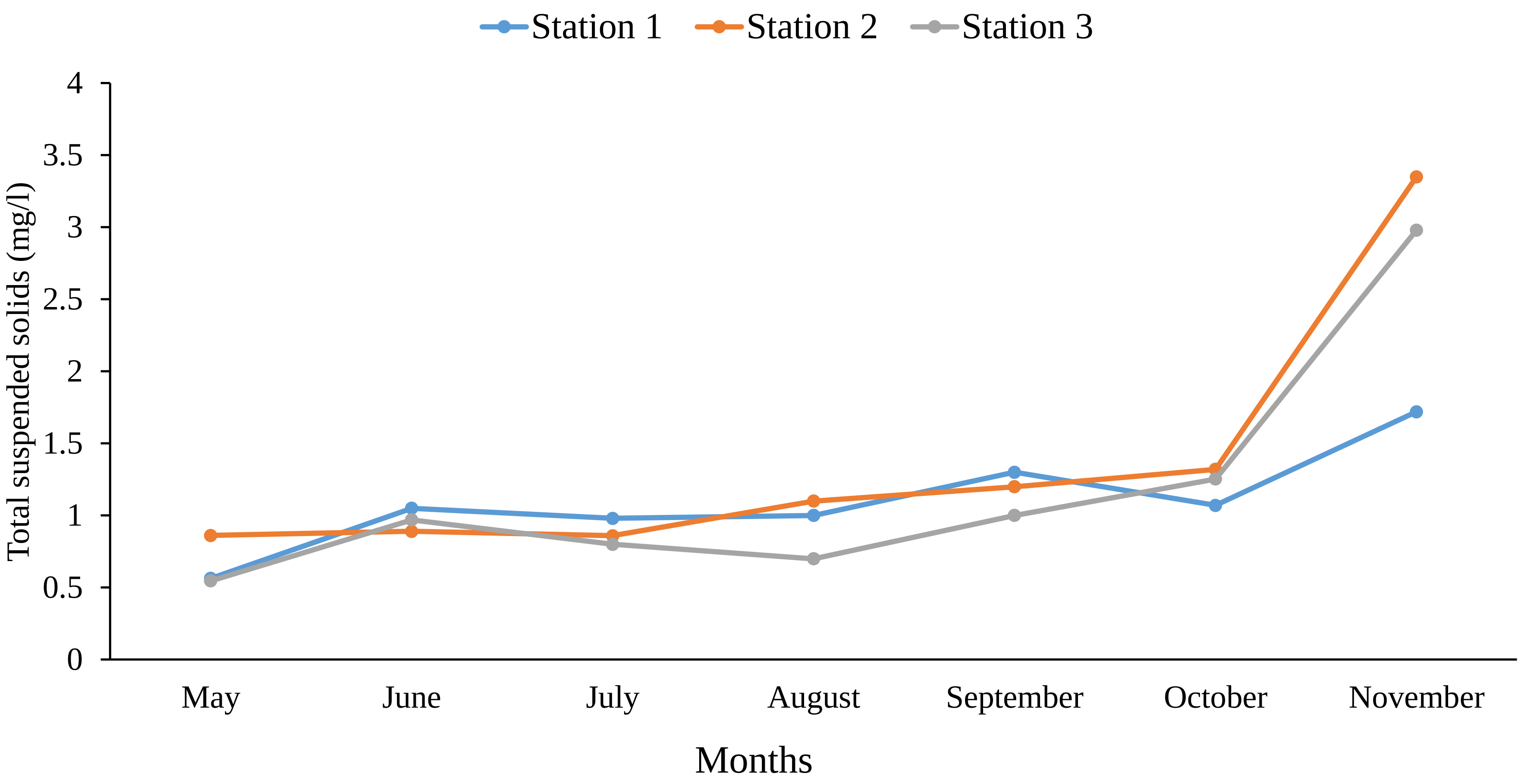

Figure 4.6: Spatial and Temporal variation in Total suspended solids of Obazuwa Lake from May to November 2024

Total suspended solids ranged as high as 32 mg/l in October in station 2 followed by station 3 and Station 1 (25 mg/l and 17 mg/l of suspended solids respectively). November also recorded higher concentration in station 2, while station 1 and station 3 followed closely. increasing in august and September. Peak concentration was encountered in October and November across all stations.

4.1.7 Total Solids

Mean total solids concentration of 42.98 mg/l, 44.56 and 39.72 mg/l were recorded in station 1,2 and 3 respectively with the highest and lowest concentration observed in stations 2. One-way ANOVA identified no relatable difference ($p > 0.05$) in the mean total solids among the three stations (Table 4.1). Station 3 recorded the highest solids concentration in November. Total solids were fairly constant but slight variation were noticeable across months. In May, the concentration was similar in station 1 and 3 while station 2 had a slight increased concentration level (Figure 4.7).

By June, stations 1 and 3 exhibited similar concentration, with station 2 recoding a marginal decline in total solids. Total solids were constant in July but slight differences were observed in August and September respectively. In August, station 1 and 2 exhibited higher levels of total solids compared to station 3 whereas similar occurrence was identified in September with station 1 and 2 also recording higher levels of total solids than station 3. October recorded higher levels of total solids in station 2 and 3 when compared to station 1 which recorded a rather lesser total solid. At the end of the study, all stations recorded peak total solids in November, with station 2 reporting peak limits followed by station 1 (Figure 4.7).

4.1.8 Turbidity

Turbidity concentration varied among stations with mean turbidity of 18.01 NTU in station 1, 21.94 NTU in station 2 and 20.29 NTU in station 3.

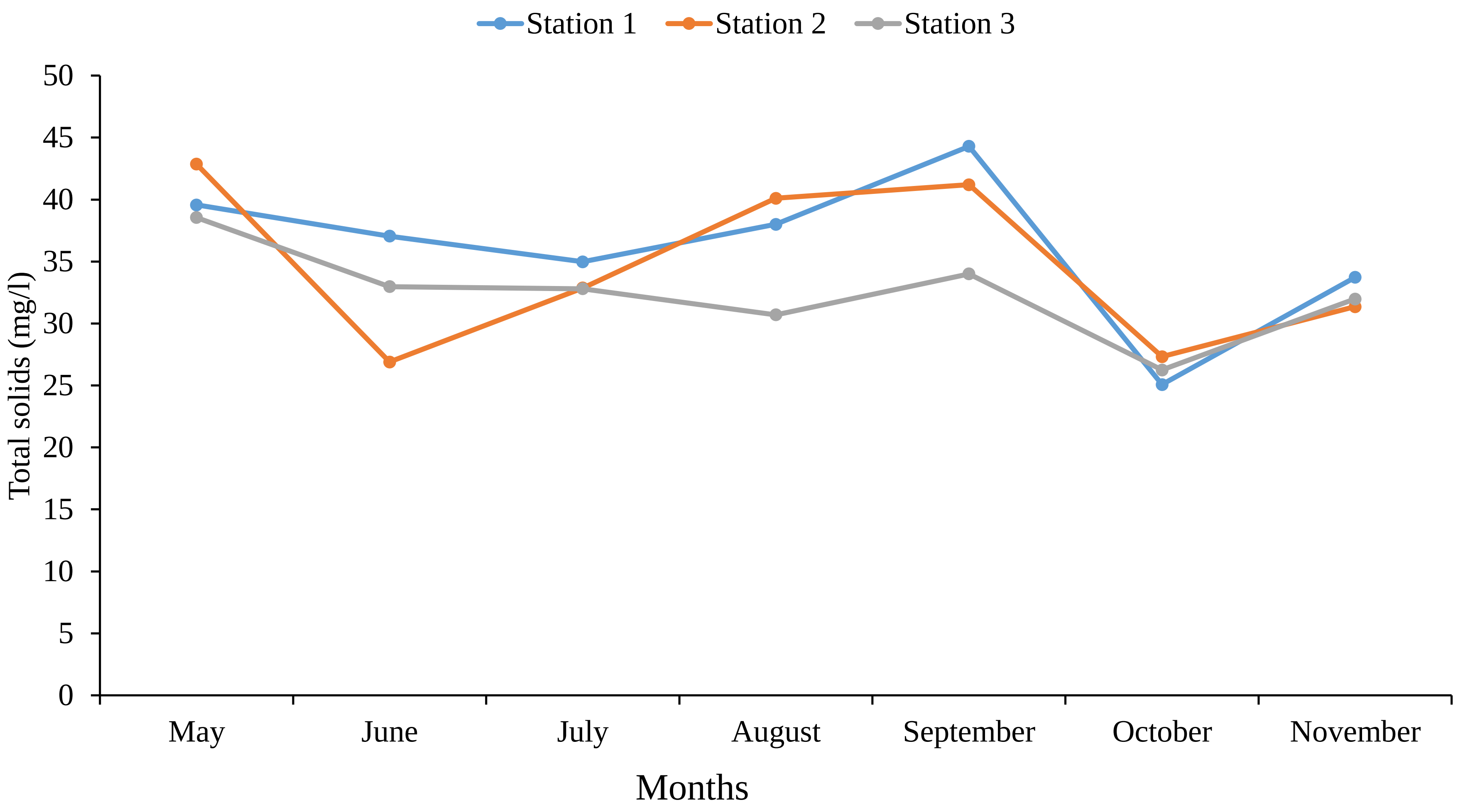

Figure 4.7: Spatial and Temporal variation in Total solids of Obazuwa Lake from May to November 2024

Peak turbidity was observed in station 2 whereas least concentration was recorded in station 1. Test of Significance difference showed no significant difference ($p > 0.05$) in the mean turbidity of the three stations (Table 4.1).

At the start of the study, turbidity values were consistent in station 2 and 3 while station 1 had a low turbidity concentration. In June and July, station 1 recorded the highest turbidity values followed by station 2 and 3 respectively. In August, station 2 recorded the highest turbidity concentrating followed by station 1 and 3 respectively. From May till August, turbidity units increased slowly with slight differences in concentration. All stations witnessed a decline in turbidity from June till August before increasing in September (Figure 4.8).

In September, a sharp increase in turbidity concentration was observed, with turbidity increasing as high as 26.88 NTU while in October, Turbidity maintained a steady increase in station 2 and 3 but dropped drastically from 22.36 NTU in September to 12.43 NTU. In November, turbidity showed maximum concentration rising up to 49.00 in station 1. Station 2 and 3 also showcased similar heightened levels in turbidity. Spatially, Station 1 recorded the peak levels of turbidity whereas Station 3 recorded the lowest turbidity in November and August respectively (Figure 4.8).

4.1.9 Dissolved Oxygen

Dissolve Oxygen ranged between stations with mean concentration of 2.76 in station 1, 2.57 in station 2 and 3.00 mg/l in station 3. Peak dissolved oxygen concentration was in station 1 whereas the lowest concentration was recorded in station 3. one-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean dissolved oxygen concentration of the three stations (Table 4.1). Dissolved oxygen concentration exhibited both spatial and temporal variation (Figure 4.9).

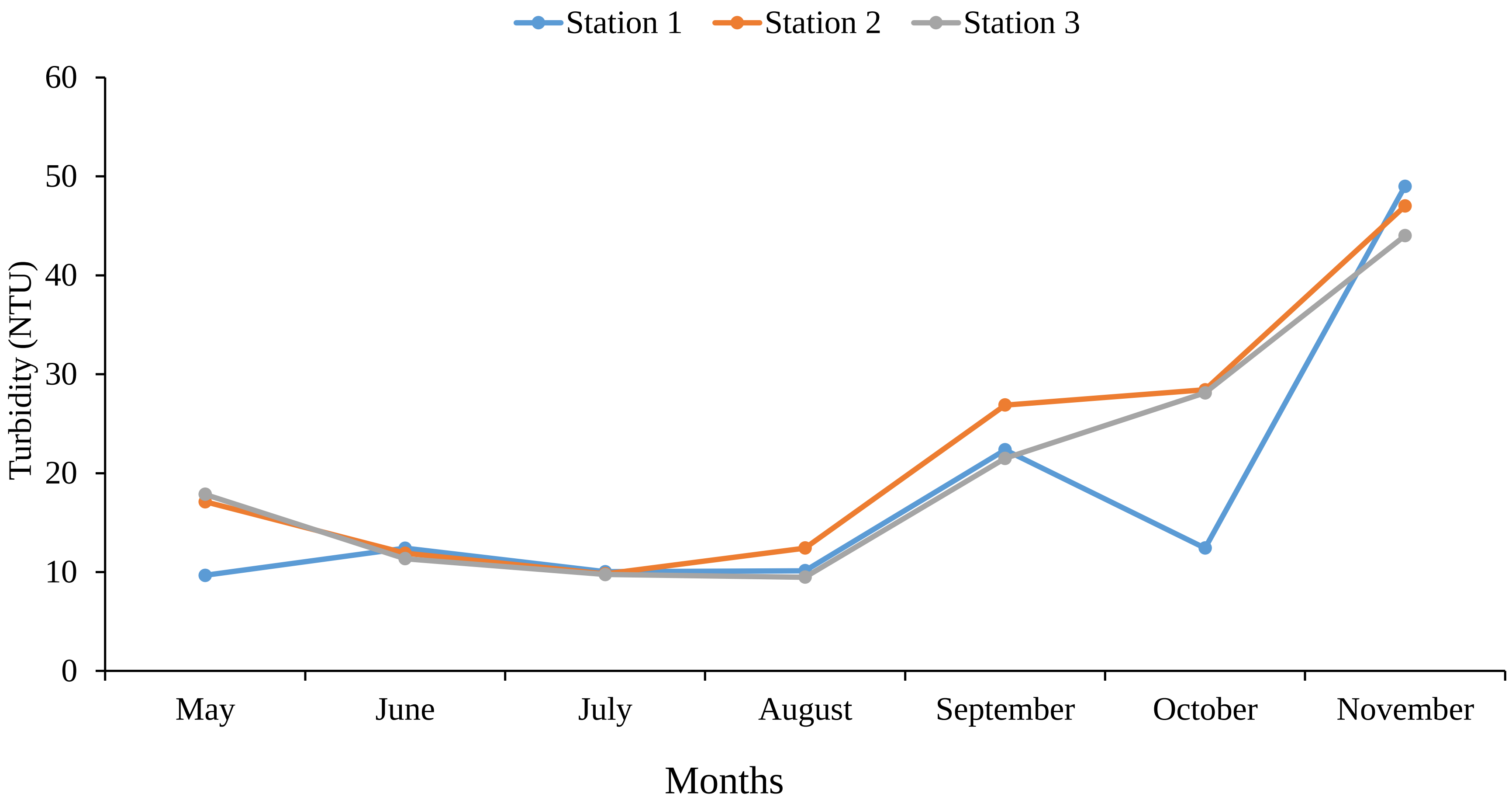

Figure 4.8: Spatial and Temporal variation in Turbidity of Obazuwa Lake from May to November 2024

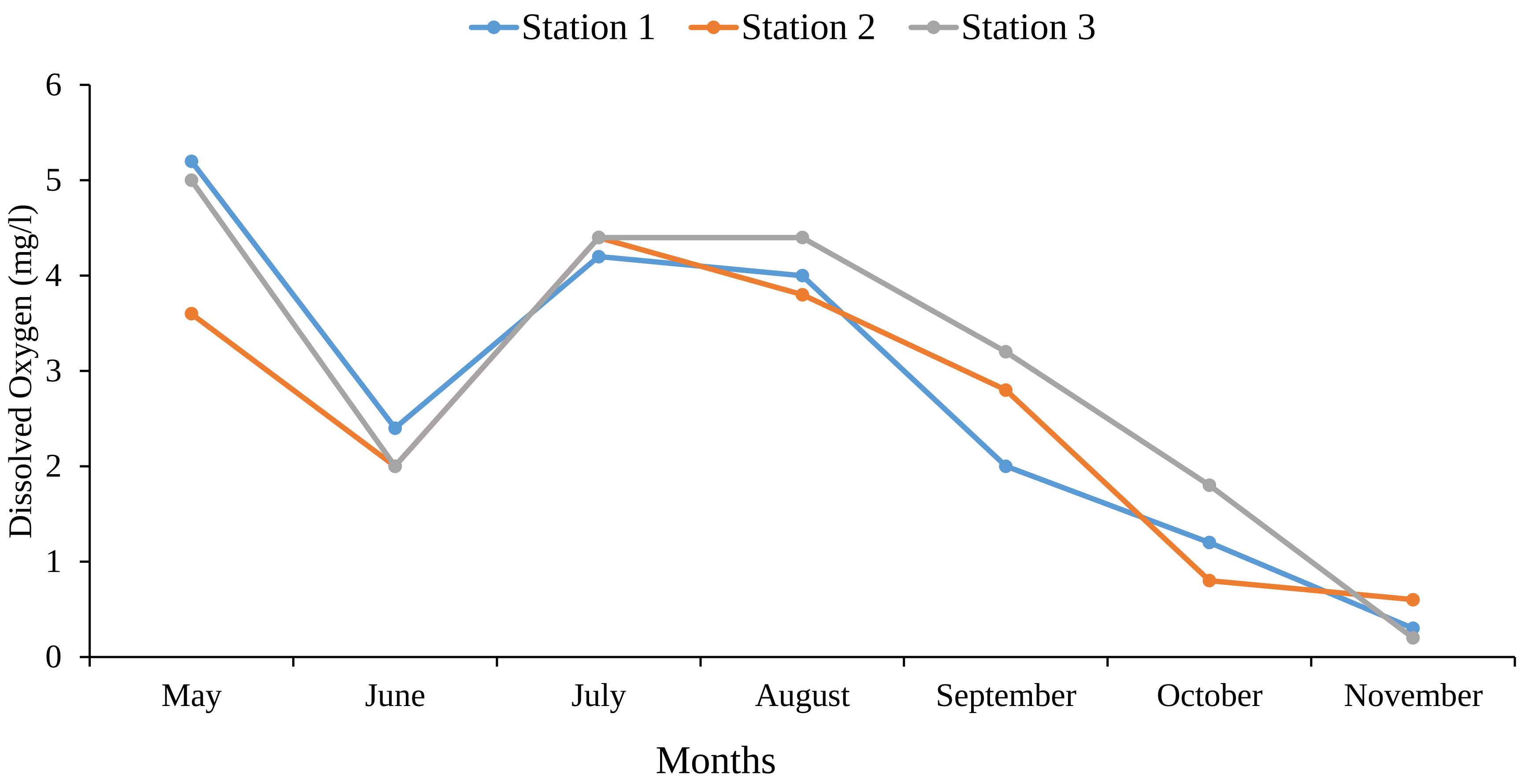

Figure 4.9: Spatial and Temporal variation in Dissolved Oxygen of Obazuwa Lake from May to November 2024

In May, Station 1 had the highest concentration and maintained this concentration from June to November recording its maximum in May. The pattern was almost similar for the other stations. In station 1, peak dissolved oxygen was recorded in May while the lowest concentration was recorded in November. Dissolved oxygen declined from May to June before increasing in July. DO remained stable from July to August before declining rapidly till November. Station 2 recorded decline in dissolved oxygen from 3.60 mg/l in May to 2.00 in June, increased in July and subsequently declining from August till November.

The highest and lowest dissolved oxygen for station 2 was recorded in July and November respectively. Station 3 accounted for the highest dissolved oxygen content in May and recounted a sharp decline in June before bouncing back to normality in July and August respectively. During these two months, dissolved oxygen content were fairly constant. In September, dissolved oxygen content declined and subsequently declined throughout the remaining duration of the study. Generally, Station 1 and 3 exhibited maximum and minimum concentration levels in May and November respectively and follow similar trend of slight decline in June, increase in July and august before declining markedly from September till November. Station 2 showed a rather different pattern with peak dissolved oxygen recorded in July while lowest concentration was measured in November (Figure 4.9).

4.1.10 Biological Oxygen Demand

Mean Biochemical oxygen demand (BOD) of 6.67 mg/l was recorded in station 1, 6.70 in station 2, and 5.59 in station 3. The highest BOD was observed in station 3 while the lowest was observed in station 2. There was no statistical significance ($p > 0.05$) in the mean BOD of the three stations (Table 4.1). BOD showed variation in June, September, October and November. Station 3 accounted for the highest BOD in June. All other stations recorded similar trend of higher biological demand in June. In October, BOD increased swiftly before declining again in November. In May, July, and August, BOD levels generally was low in comparison to June, September, October and November which were described in this study as biologically rich months**.** (Figure 4.10). In Station 1, 2, 3 respectively, BOD levels was lower during the start of the study but gradually reached a heightened level in July with station 1 and 3 recording their maximum levels of concentration respectively. In later months of July and August, BOD levels declined drastically to lower levels before increasing markedly in September and reaching another peak in October

Biological oxygen demand levels in Station 2 attained maximum levels in October. Station 1 also had a bimodal peak in October and June as both Months recorded peak levels of 10.40 mg/l in these months respectively. During the end of the study, biological oxygen demand levels were seen to drop sharply especially in station 2 and 3 while decrease in station 1 was minimal (Figure 4.10).

4.1.11 Chemical Oxygen Demand

Chemical Oxygen Demand concentrations was 106.34 mg/l in station 1, 117.29 in station 2 and 106.00 in station 3. The highest COD concentration (174) was in station 2 while the lowest concentration (64) was in station 2. There was no significance difference ($p > 0.05$) in the mean COD of the three stations (Table 4.1).

Spatially and temporarily, COD levels varied across stations throughout the sampling period. Station 3 recorded its minimum concentration levels in August, while station 2 and 1 recorded lowest concentration levels in May (Figure 4.11). At the start of the study, COD levels were relatively high, with station 3 recording the highest concentration. In June, COD levels increased with Station 1 and 3 recording maximum concentration. In July, COD levels reduced, and increased August and October.

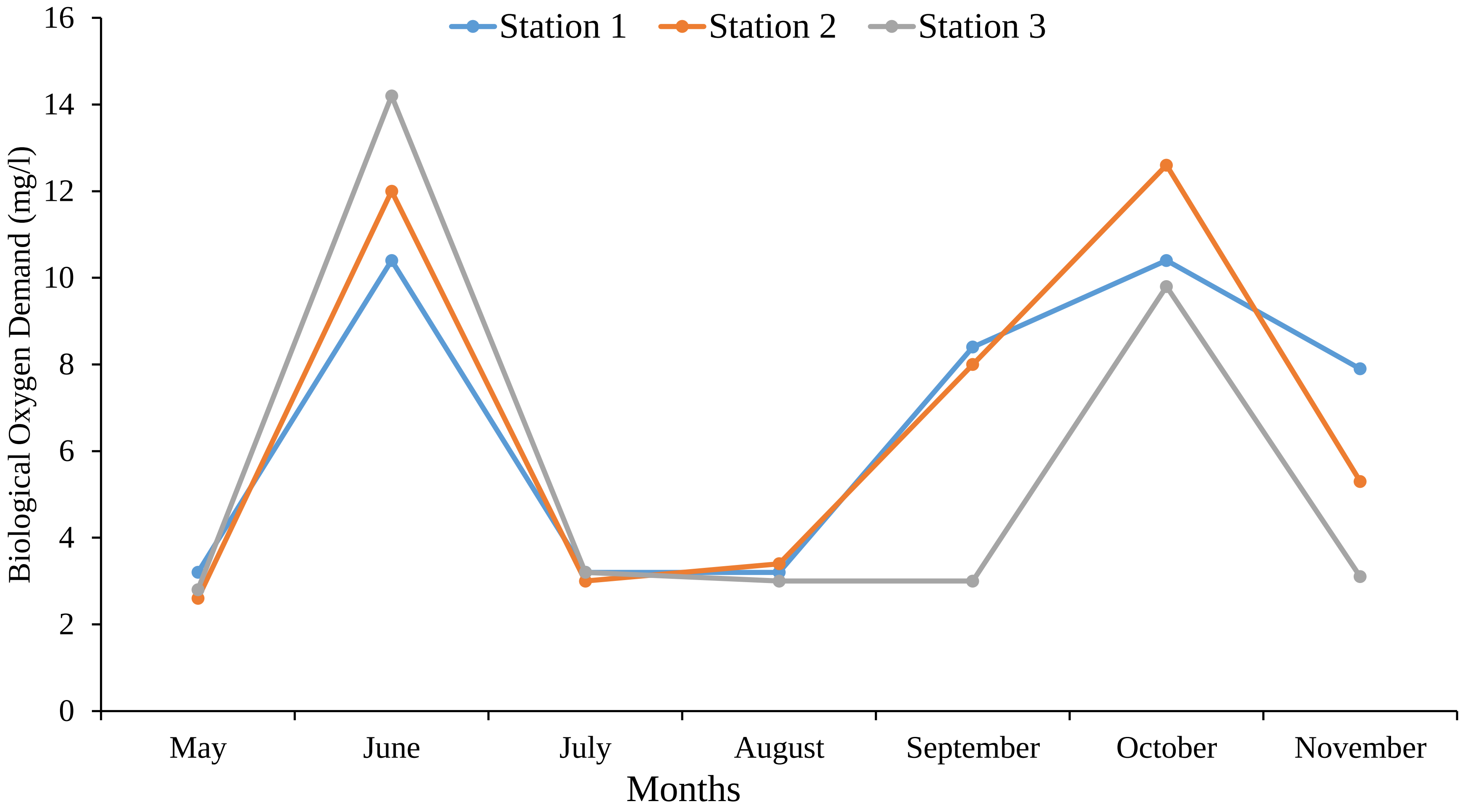

Figure 4.10: Spatial and Temporal variation in Biological Oxygen Demand of Obazuwa Lake from May to November 2024

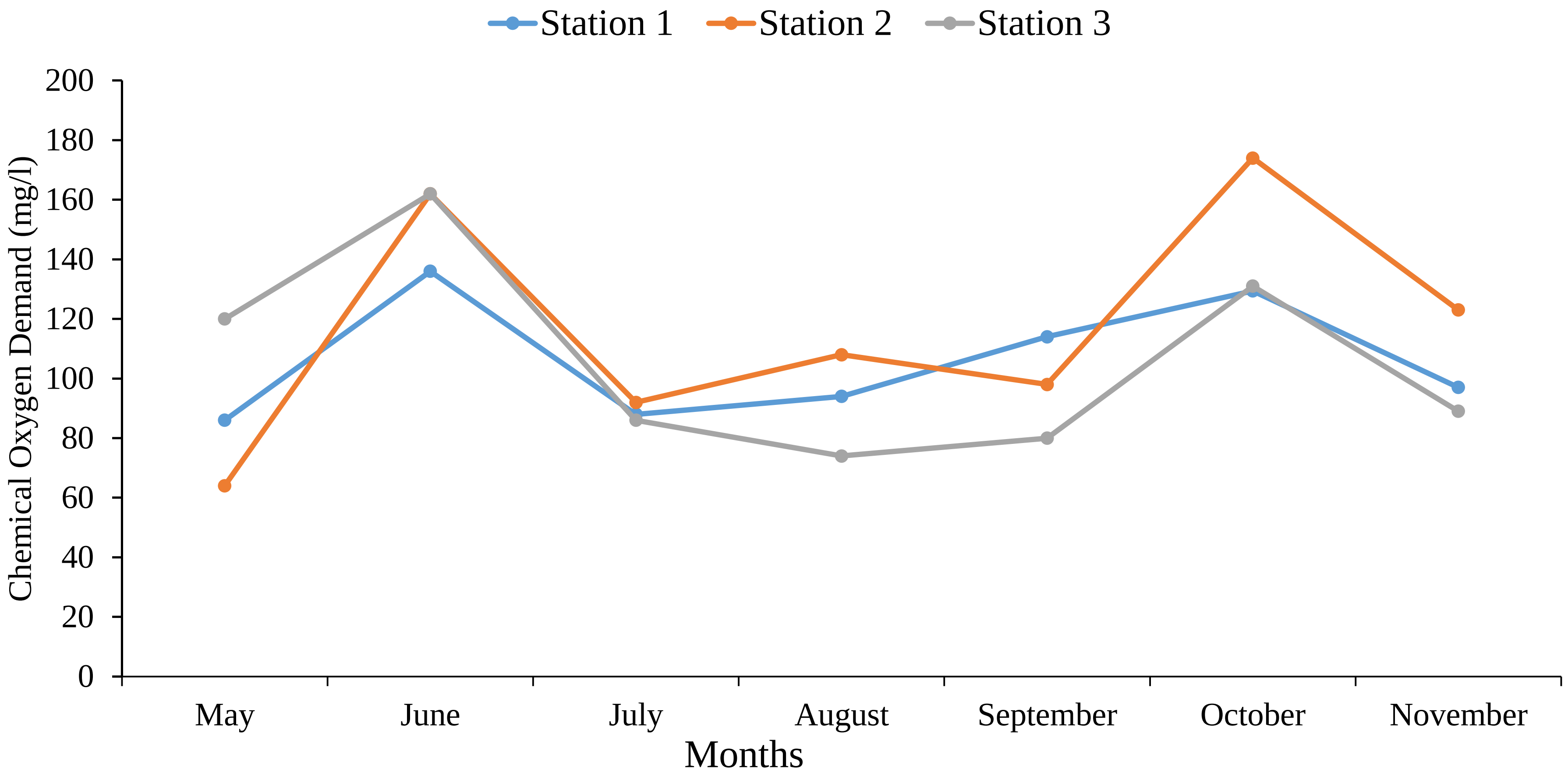

Figure 4.11: Spatial and Temporal variation in Chemical Oxygen Demand of Obazuwa Lake from May to November 2024

Chemical Oxygen demand in Station 2 peaked in October while in November COD reduced slightly. All stations recorded a zig-zag movement in concentration with intermittent levels of high and low concentration respectively.

4.1.12 Alkalinity

Mean Alkalinity concentration of 21.69 mg/l was recorded in station 1, 19.16 mg/l in station 2 and 21.80 mg/l in station 3. The highest Alkalinity (21.80 mg/l) was recorded in station 3 while the lowest concentration was recorded in station 2. Test of significant difference revealed that there was no significant difference ($p > 0.05$) in the mean alkalinity concentration of the three stations (Table 4.1). Alkalinity concentration across the three stations showed both temporal and spatial variations. Station 3 recorded the highest concentration in October while Station 1 recorded a bimodal peak in October and November with alkalinity concentration of 32.00 mg/l in both months. Station 2 recorded the maximum alkalinity concentration in November and the lowest in October (Figure 4.12).

Station 1 exhibited stable concentration in alkalinity from May to August, declining in September and increasing in October and November. Station 2 also showed similarly pattern of stability in station 1, as concentration increased from May to August before declining in September and October and increasing peak at November. Alkalinity in Station 3 increased from May to July followed by decrease in August and September. A sharp increase was recorded between September and October (16.25 mg/l – 50.00 mg/l) before declining again gradually to 28.00 mg/l in November. Spatially, Alkalinity remained consistent across all stations during the months of May to September and November. The only exception to this trend was recorded in October where Station 2 recorded a very low Alkalinity concentration (Figure 4.12).

4.1.13 Salinity as Chloride

Chloride concentration varied in the three stations with 17.43 in station 1, 16.41 in station 2 and 13.58 in station 3. The highest mean chloride concentration was in station 1 while the minimum mean chloride was in station 3. Test of significant difference showed no significant difference ($p > 0.05$) in the mean chloride concentration of the three stations (Table 4.1). The maximum concentration was observed in station 1 while the least concentration was recorded in station 2. In May, Chloride levels remained stable with station 2 recording peak concentration level of 14.18 mg/l. In June, station 2 experienced a decline in concentration while station 1 and 3 remained the same.

Chloride remain consistent during the months of July and August only increasing slightly in August for station 2. Concentration level for Station 1 and 3 remained the same (Figure 4.13). September recorded a high increase in chloride levels in all stations while October recorded a decline in station 1, increased levels in station 2 and slight decrease in station 3. All stations recorded peak concentration in November. Station 1 and 3 recorded increased chloride throughout the duration of the study. Subsequently, both stations experienced decline in October and another wave of increase in November. Both stations peaked in November. Station 2 showed variability in July and increased from July till the end of the study (Figure 4.13).

4.1.14 Total Hardness

Mean total Hardness concentration of 34.30 mg/l in station 1, 32.36 in station 2 and 31.56 in station 3 were reported during this study. Maximum mean hardness was in station 1 while the lowest total hardness was in station 3. Test of significant difference displayed no significant difference ($P > 0.05$) in the mean total hardness of stations (Table 4.1).

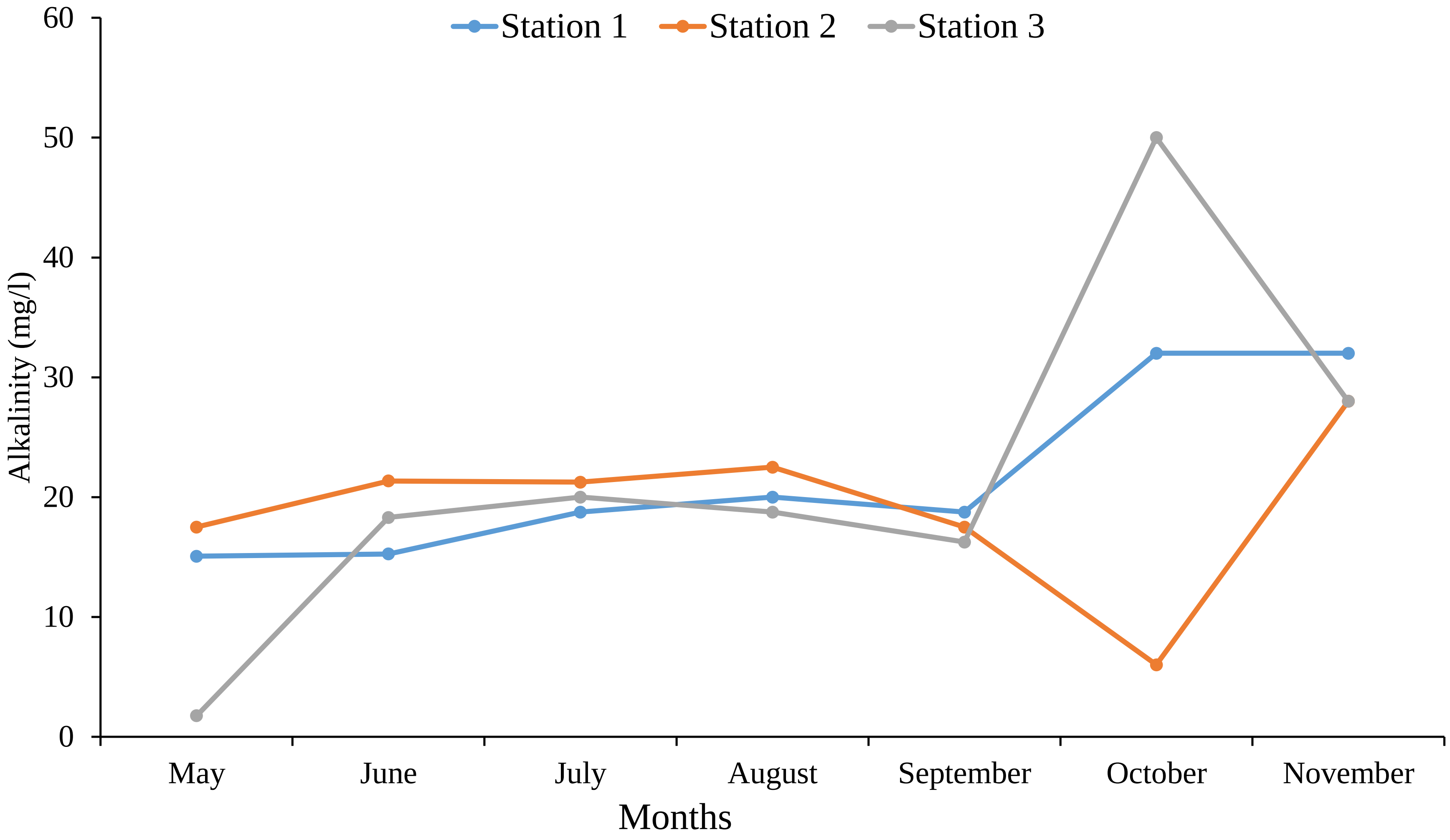

Figure 4.12: Spatial and Temporal variation in Alkalinity of Obazuwa Lake from May to November 2024

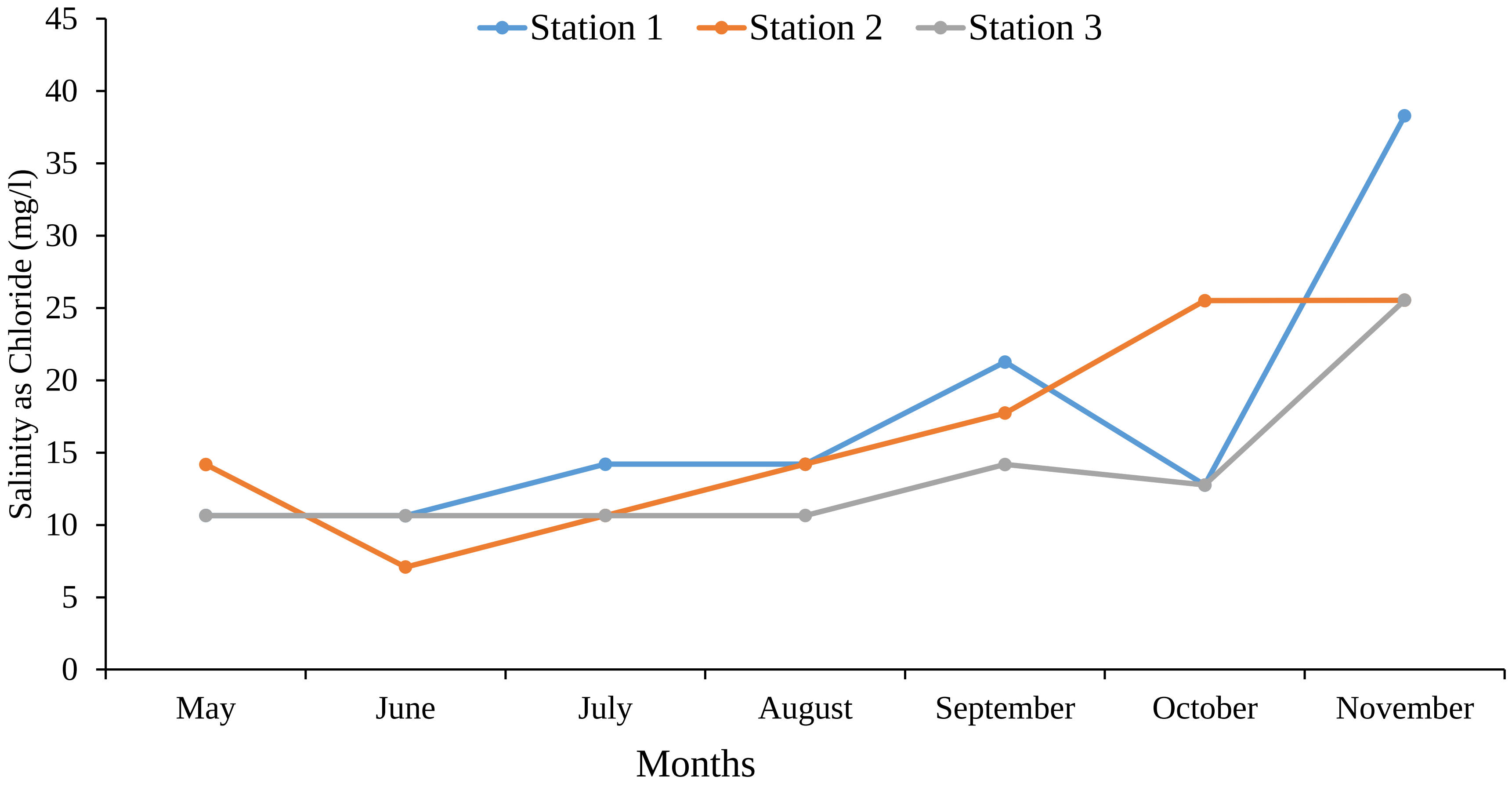

Figure 4.13: Spatial and Temporal variation in Salinity as Chloride of Obazuwa Lake from May to November 2024

Hardness concentration during the study showed spatial and temporal variation. The highest and lowest concentration for total hardness for the study was recorded in station 2. In May, total hardness was relatively the same with slight variation in station 1. Station 2 and 3 had the lowest concentration in June while in July, station 3 had the least concentration. August and September recorded similar trend of concentration levels with slight decline in station 3 for September (Figure 4.14). October recorded increased concentration for station 1 and 3 respectively while a decline in station 2 was noticeable. All stations recorded peak concentration levels in November.

Station 1 generally showed little to no variations with concentration levels remaining steady between May and September only rising in October and November. Station 2 showed variability in June declining drastically from May. Total hardness for station 2 remained stable between July and September. A noticeable decline was seen in October before bouncing off markedly in November. Station 3 showed variability in June before increasing in July and August. A slow decline was encountered in September, while increases were recorded in October and November (Figure 4.14).

4.1.15 Nitrate

Nitrate concentration ranges from 3.53 in station 1, 4.24 in station 2 and 2.38 in station 3. The highest nitrate concentration (4.24) was in station 3 and lowest (2.38) was recognized in station 3. Test of significant difference displayed no significant difference ($p > 0.05$) in the nitrate concentration (Table 4.1). Nitrate levels were significantly low in station 1, while station 2 and 3 remained the same in May. June recorded a slight increase in nitrate concentration in station 1 while station 2 and 3 declined (Figure 4.15).

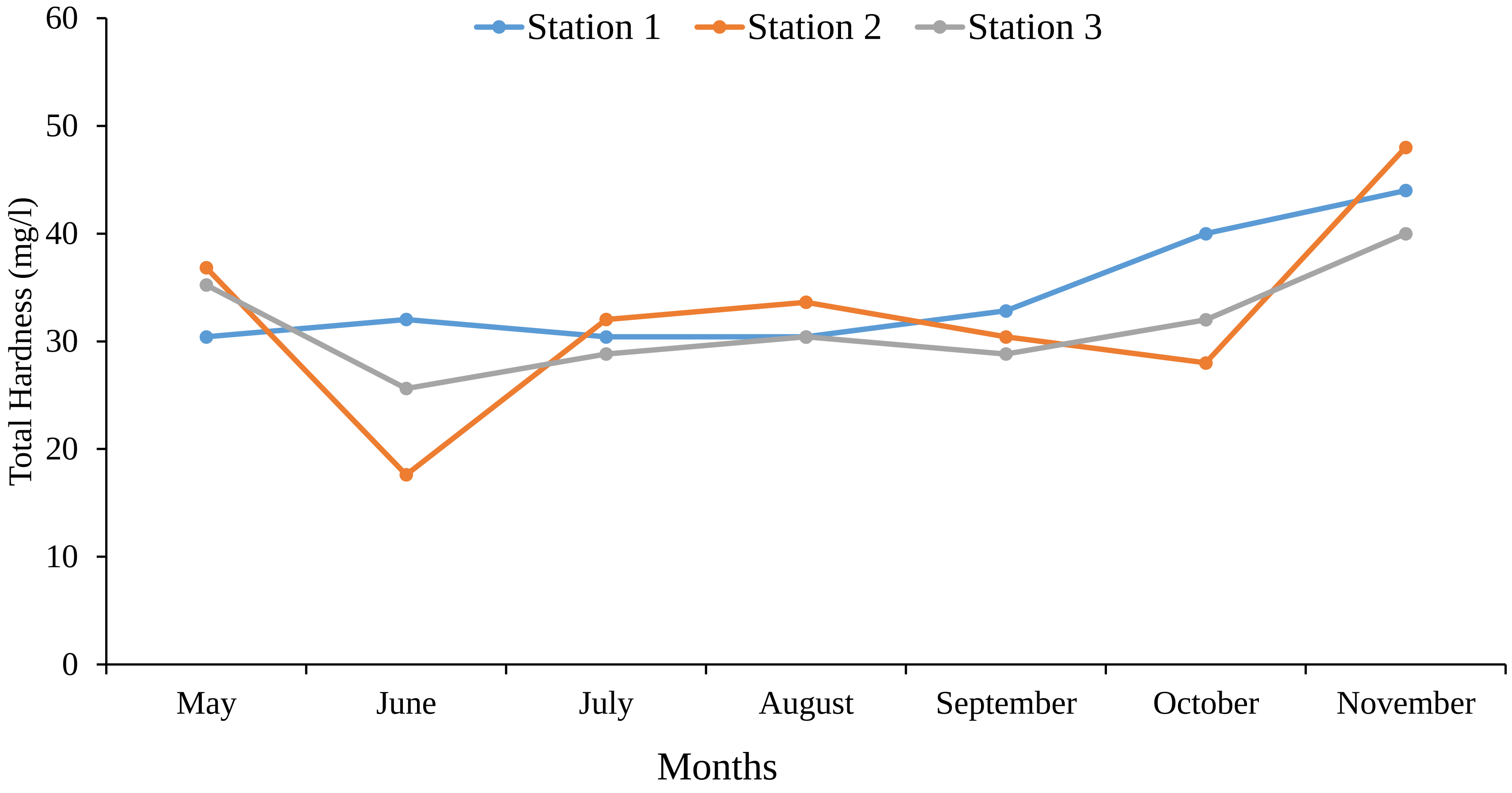

Figure 4.14: Spatial and Temporal variation in Total Hardness of Obazuwa Lake from May to November 2024

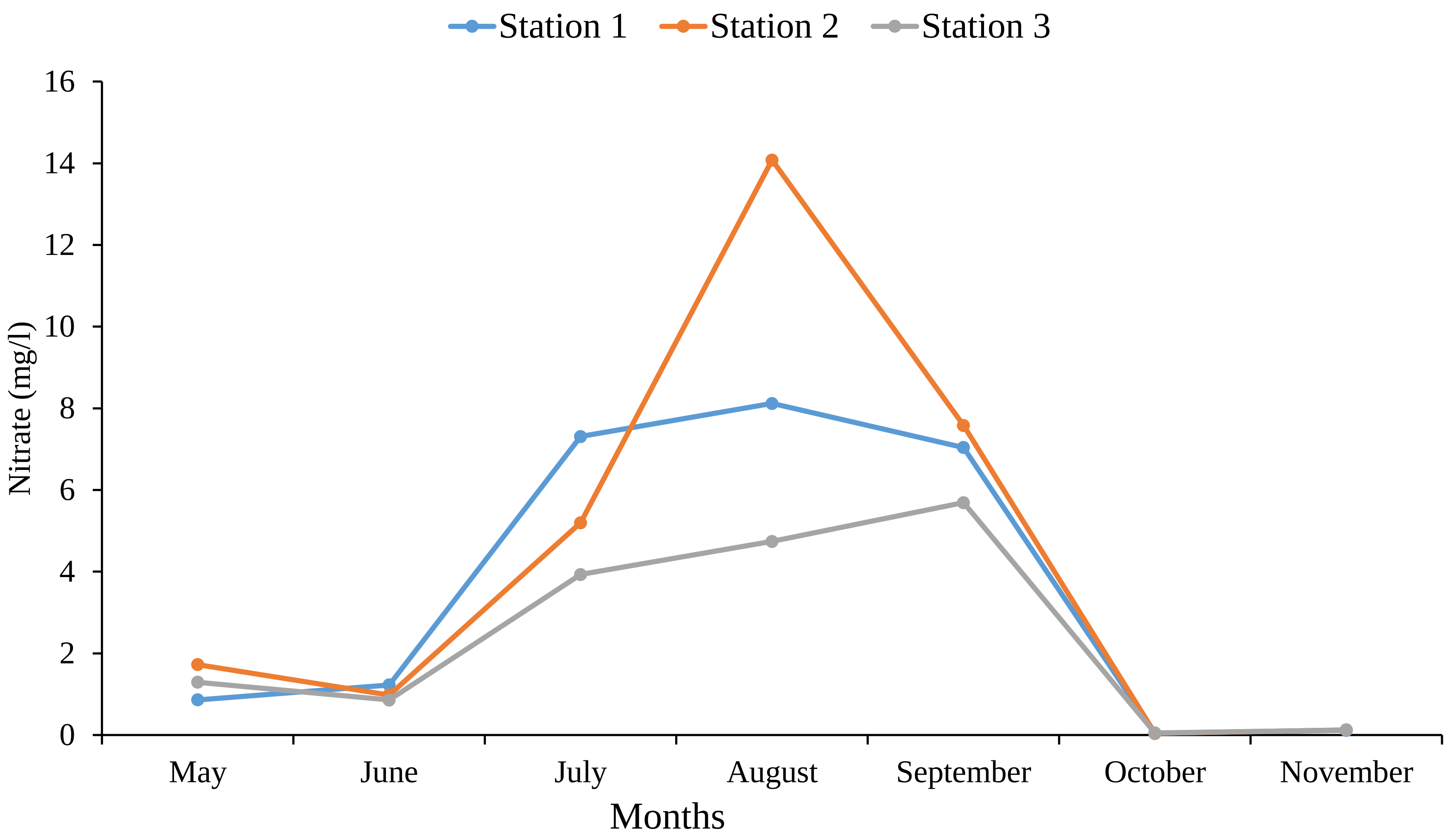

Figure 4.15: Spatial and Temporal variation in Nitrate of Obazuwa Lake from May to November 2024

July recorded an increase in nitrate levels across all stations and further increased markedly in August across all stations before declining in September and decline in October and November. The maximum concentration in nitrate was recorded in August for Station 1 and 2 while station 3 recorded the peak concentration in station 3. The lowest concentration level was recorded in October across all levels. Overall, Nitrate levels increased in June till August across all stations while a decline was recorded in October and November respectively (Figure 4.15).

4.1.16 Phosphate

Phosphate concentration varied between 0.080 in station 1, 0.83 in station 2 and 0.79 mg/l in station 3. The maximum mean concentration (0.83 mg/l) was in station 2 while the lowest concentration was in station 1. Statistical analysis revealed the there was no significant difference ($p > 0.05$) in the mean phosphate of the three stations (Table 4.1). Phosphate showed spatial and temporal variation during the study (Figure 4.16). The highest values were observed in station 2 while the lowest values were recorded in station 3. Phosphate in station 2 and 3 showed sharp decline in June and steadily reduced till July before increasing steadily in August, September and November and declining in November**.** Station 1 showed variation in May, increased in June, decreased in July before increasing between the months of August till October and declined in November (Figure 4.16).

4.1.17 Sulphate

Mean sulphate concentration of 42.34 mg/l was recorded in station 1, 43.67 in station 2 and 38.58 in station 3. The peak sulphate concentration was recorded in station 2 while the least concentration was recorded in station 3. Test of significant difference using one-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean sulphate concentration of the three stations (Table 4.1). Sulphate showed spatial and temporal variation during the study (Figure 4.17).

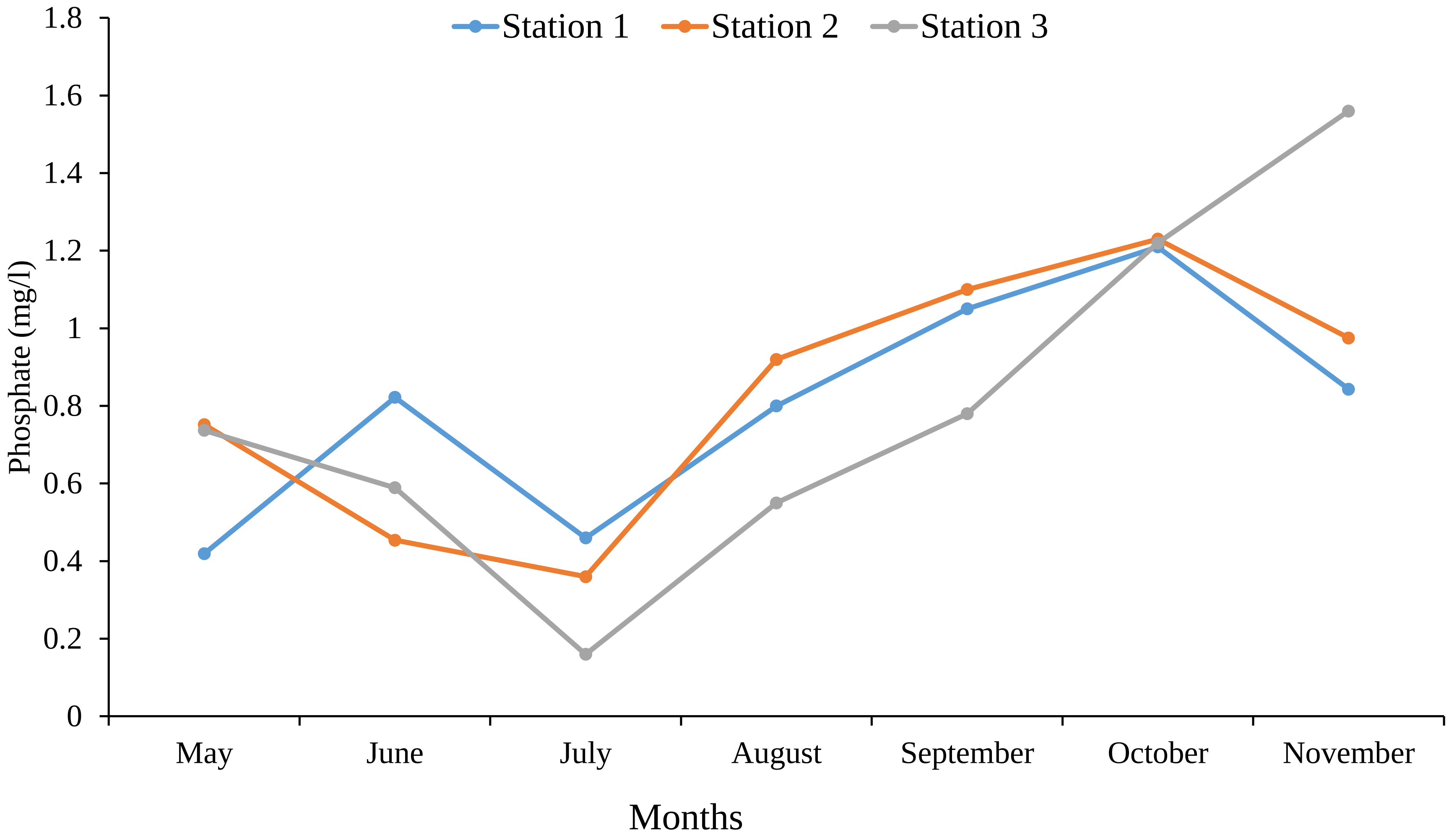

Figure 4.16: Spatial and Temporal variation in Phosphate of Obazuwa Lake from May to November 2024

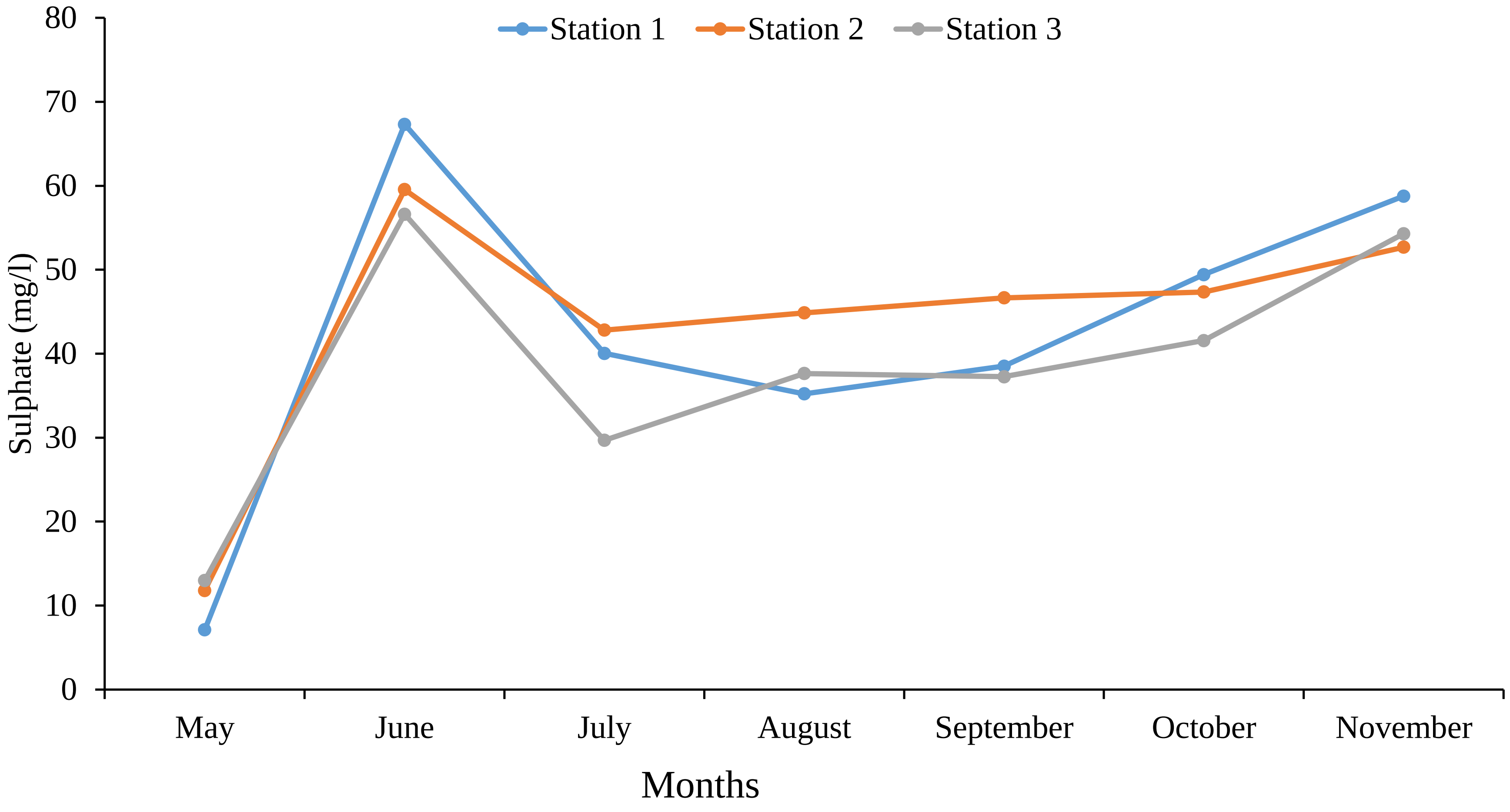

Figure 4.17: Spatial and Temporal variation in Sulphate of Obazuwa Lake from May to November 2024

In June, stations 1, 2, and 3 recorded the highest concentration in this study. Stations 1 and 3 recorded slight decline between July and August while station 2 showed slight increase between the two months. All stations recorded decline between June and September before increasing in October and November. Similarly stations 1, 2 and 3 recorded increases between the months of September till November. All stations generally recorded lower concentration in May. The lowest concentration across all stations were recorded in May

In October and November, all stations record steady concentration level with Station 1 and 2 recorded higher concentration level in October while station 3 recorded a lower concentration. In November, stations 1 and 3 recorded higher levels of sulphate while stations 2 recorded. Station 1 recorded steady decline in sulphate levels between June and September before increasing in October and November. Station 3 records a slight increase between July and October before increasing Markedly in November (Figure 4.17).

4.1.18 Calcium

Calcium concentration varied from 7.47 mg/l in station 1, 7.40 mg/l in station 2 and 7.05 in station 3. The maximum calcium concentration was found in station 1 while the least concentration was recorded in station 3. Test of significant difference revealed that no difference existed ($p > 0.05$) in the mean calcium concentration of the three stations (Table 4.1).

Station 1 witnessed the maximum concentration in November. In May, Calcium concentration was similar in stations 2 and 3 with slight difference in station 1. In June station 1 and 3 recorded higher calcium concentration compared to station 2. In July and August, station 2 recorded the highest calcium concentration. This was followed by station 1 and then station 3 respectively. In September, stations 1 and 2 were higher compared to station 3 whereas in

October, concentration levels for station 3 was the highest. All stations recorded the maximum calcium concentration in November (Figure 4.18).

All stations recorded spatial variability during the course of this study. Station 1 recorded low levels of calcium concentration in May before increasing in June and subsequently declining from July till August. Slow increase in calcium concentration was accounted for in September and October before a sharp increase in November.

Station 2 recorded a high concentration in May followed by a sudden decline in June. Station 2 also recorded constant concentration in July and August before declining slowly into September. October and November recorded increase in calcium level with peak concentration in November. Station 3 recorded high concentration in both May and June and declined in July. August and September remained constant before increasing in October and November (Figure 4.18).

4.1.19 Magnesium

Mean magnesium concentration of 3.74 in station 1, 3.38 in station 2 and 3.36 in station 3. The maximum concentration was recorded in station 1 while the least concentration was recorded in station 3. Statistical test of significance showed that there was no significant difference ($p > 0.05$) in the mean magnesium concentration of the three stations (Table 4.1).

Across all stations, Magnesium levels were fairly similar with slight variations (Figure 4.19**).** In May, the concentration was almost the same with station 2 recording its peak concentration level during the course of the study. A successive decline in magnesium level was recorded in June whereas in July and August, levels of magnesium increased. July and august recorded maximum concentration levels for station 3 whereas in September, station 1 and 3 remained constant.

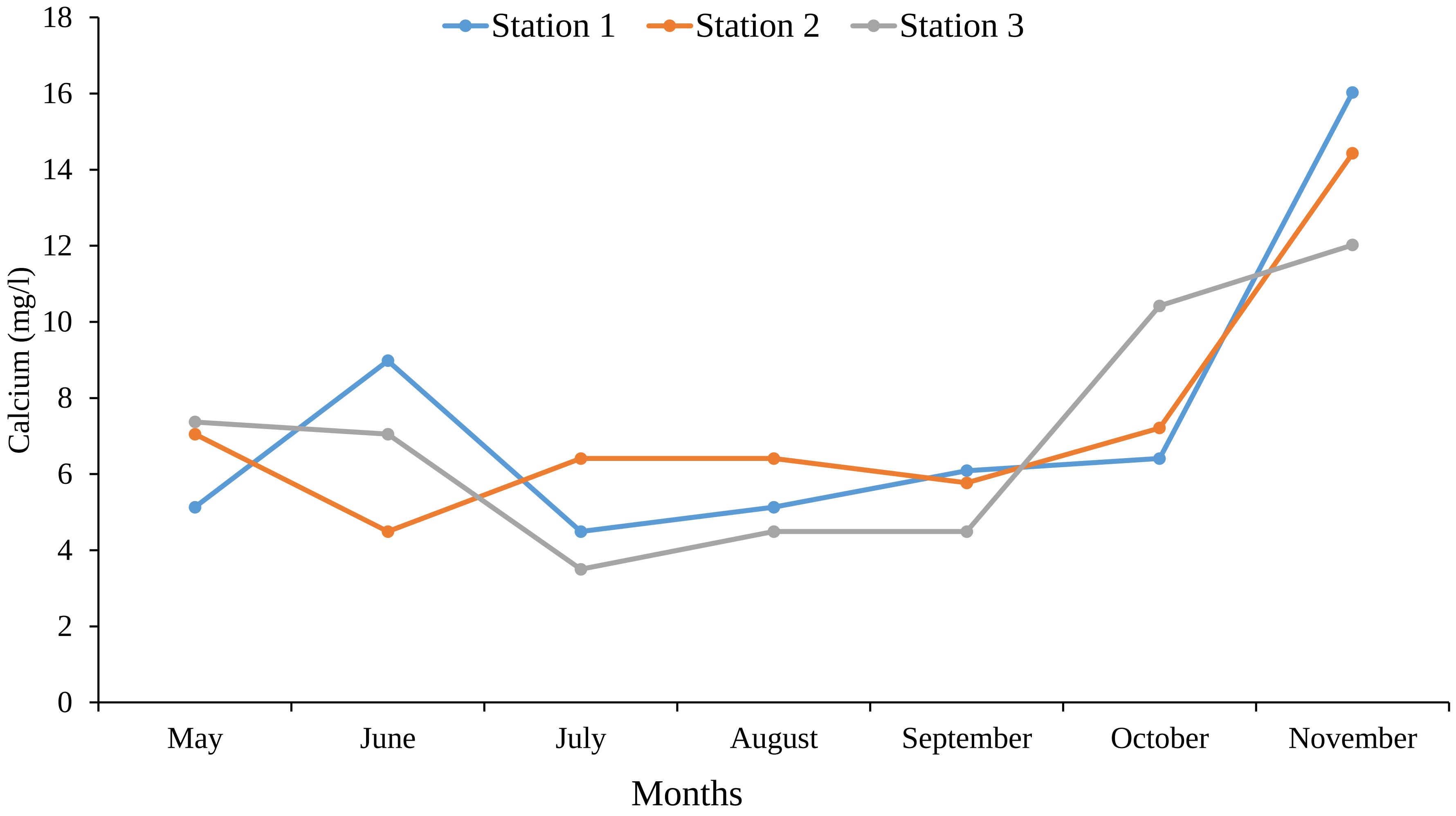

Figure 4.18: Spatial and Temporal variation in Calcium of Obazuwa Lake from May to November 2024

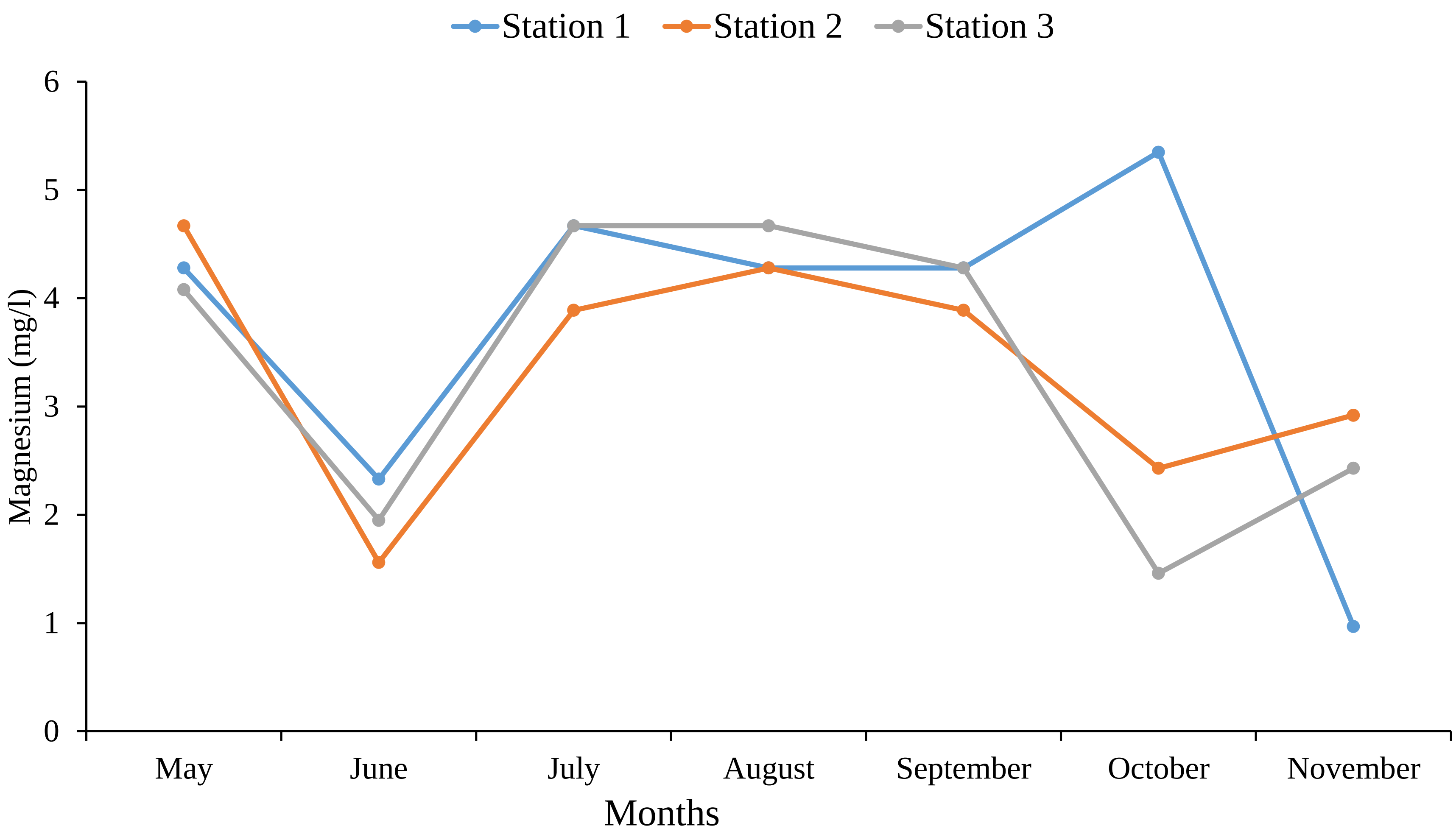

Figure 4.19: Spatial and Temporal variation in Magnesium of Obazuwa Lake from May to November 2024

Station 1 recounted a slight increase in magnesium levels in September while stations 2 and 3 respectively experienced decline in concentration levels. The lowest concentration level for station 1 was recorded in November while the minimum magnesium level in stations 2 and 3 was recorded in June and October respectively (Figure 4.19).

Station 1 recorded similar concentration in July, August and September while months like June and November experienced increased reduction in concentration levels. In Station 2, concentration levels plummeted from August to October before increasing in November. Station 2 also experienced reduction in concentration levels from May to July. Station 3 recorded stable magnesium concentration between July till September before declining in October and increasing in November (Figure 4.19).

4.1.20 Potassium

Mean potassium concentration of 3.27 mg/l was recorded in station 1, 3.31 mg/l in station 2 and 2.93 in station 3. The highest mean potassium concentration (3.31 mg/l) was recorded in station 2 while the lowest concentration was recorded in station 3. Test of significant difference using ANOVA reported no significant difference ($p > 0.05$) in the mean potassium concentration of the three stations. Potassium concentration was high during the beginning of the study and peaked at station 3 during May (Figure 4.20).

Potassium decreased in June and July respectively with greater variability in station 2 in June. Potassium concentration was constant across all stations during the month of July but increased in August and September. Peak values of station 1 and 2 were recorded in September. In the ending months of October and November, concentration of potassium declined sharply across the months.

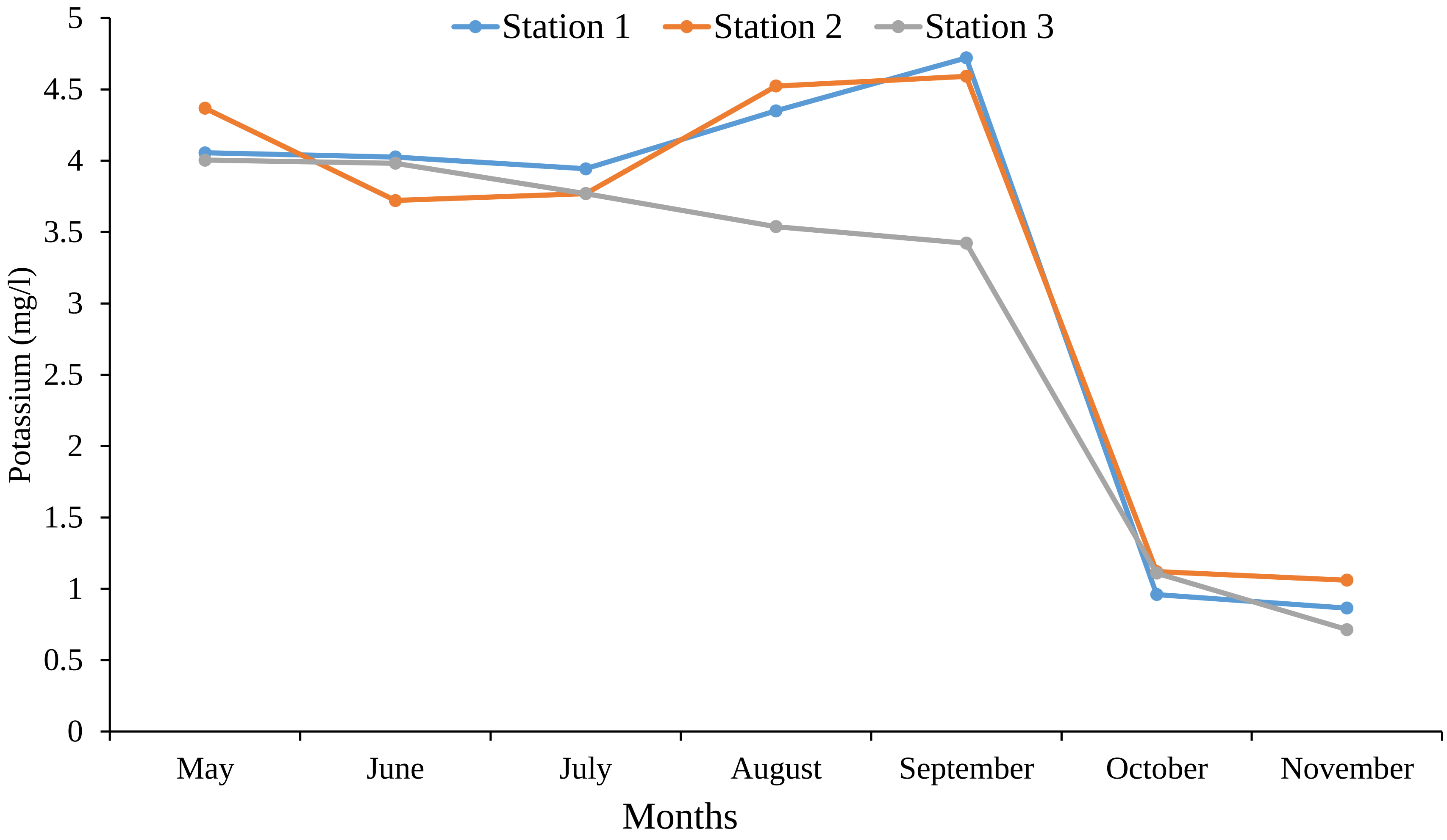

Figure 4.20: Spatial and Temporal variation in Potassium of Obazuwa Lake from May to November 2024

All stations recorded their lowest concentration in the month of November. All stations showed spatial variations across all stations. Station 1 declined slowly in June and July, increased slowly in August and September, then declined in October and November. Station 2 showed similar trajectory while station 3 showed decline across all months of the study (Figure 4.20).

4.1.21 Sodium

Sodium concentration variation in the stations between 5.92, 5.77 and 5.28 mg/l was recorded in stations 1,2 and 3 respectively. The maximum sodium concentration was in station 1 while the lowest concentration was in station 3. Statistical analysis using ANOVA revealed that there was no significant difference ($p > 0.05$) in the mean sodium concentration of the three stations (Table 4.1).

Sodium concentration was highest in May across all stations. Station 2 recorded the highest concentration in this month whereas the lowest concentration was recorded in station 3 (Figure 4.21). All stations showed spatial and temporal variations across the duration of the study. Station 1 recorded a bimodal concentration peak in May and June and decreased slightly in July before increasing slowly in August and September. October and November recorded a sharp decline in sodium levels of the study area. Station 3 on the other hand recorded its peak in May and declined successively throughout the study duration. This declined was slow but rapid in the months of October and November towards the end of the study. Station 2 recorded a peak sodium concentration in May followed by a decline in June and slowly increased throughout July till September before declining y in October and November. Across Months, May and June showed increases in all stations before declining in July and remaining stable between August and September. Thereafter a decline was recorded in October and November (Figure 4.21).

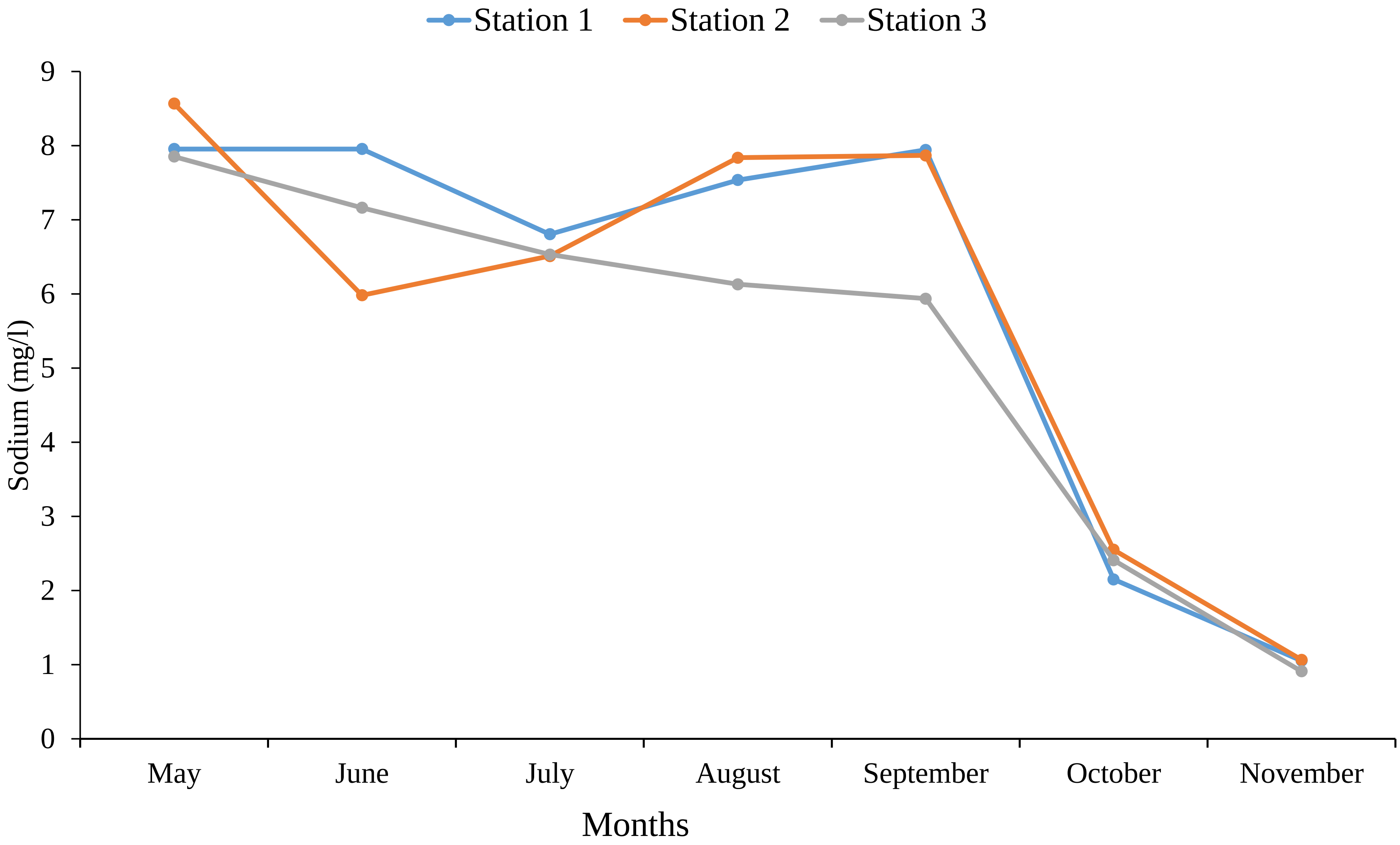

Figure 4.21: Spatial and Temporal variation in Sodium of Obazuwa Lake from May to November 2024

4.1.22 Manganese

Manganese concentration ranges between 0.090 in station 1, 0.061 in station 2 and 0.072 mg/l in station 3. The highest (0.090) mean manganese concentration was in station 1 and lowest (0.061) mean manganese concentration was in station 2. Test of significant difference using one-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean concentration of the three stations.

Manganese recorded spatial and temporal variability across all stations of the study. In station 1, manganese levels increased between May and June. This was shortly followed by a slow decline and increase in July and August respectively (Figure 4.22). Manganese levels remained fairly constant in September before declining in October and increasing in November

The maximum and minimum concentration for station 1 were recorded in May and October respectively. In station 2, a decline was observed in concentration levels from May to June before another round of slow rise in July, August, and September. Concentration levels of manganese fell to its lowest level in October before increasing slowing in November. Station 3 recorded increase in manganese levels between May and June peaking in June before declining from June throughout till November reaching its lowest in October. Normalcy returned to the station as concentration level increased back in November.

Across stations, there was a steady decline of manganese concentration in station 3 during the months of July to October whereas irregular patters of increases and decreases were noticeable in stations 1 and 2 respectively. The overall peak concentration for manganese for this study was recorded om June of station 1 while the lowest concentration was recorded in October of Station 3 (Figure 4.22**).**

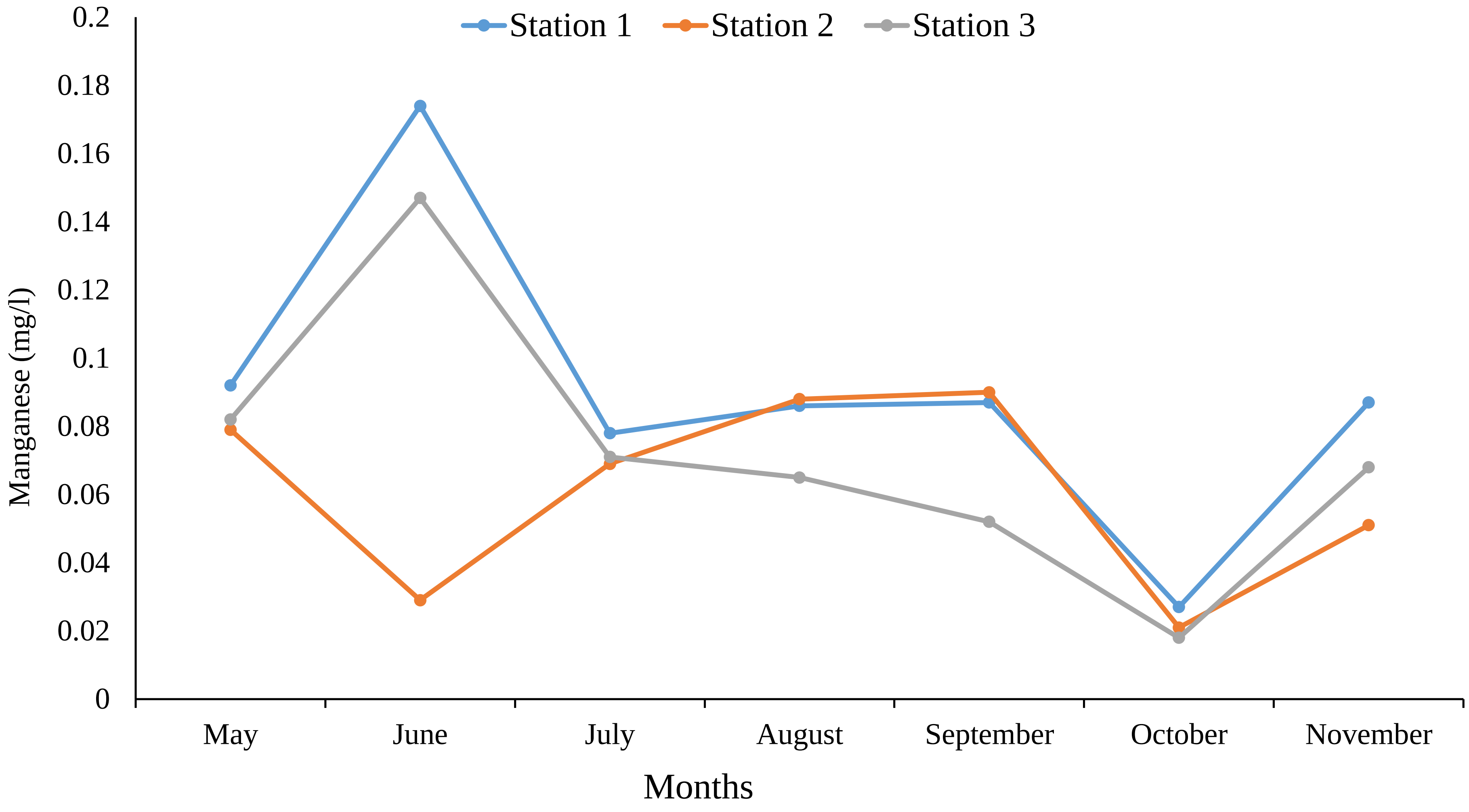

Figure 4.22: Spatial and Temporal variation in Manganese of Obazuwa Lake from May to November 2024

4.1.23 Chromium

Chromium concentration ranges between 0.089 in station 1, 0.087 in station 2 and 0.087 in station 3. The highest (0.089) mean iron concentration was in station 1 and lowest (0.087 mg/l) was in station 2 and 3 respectively. Test of significant difference using one-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean concentration of the three stations (Table 4.1).

The lowest and highest concentration respectively in this study was recorded in station 3 (Figure 4.23**).** At the start of the study in May, concentration levels of Chromium showed variability with highest and lowest concentration recorded in station 2 and 3 respectively. Concentration levels increased slowly in station 1 and 3 respectively whereas a decline was recorded in station 2 during the month of June. In July, both stations 1,2. And 3 exhibited declined marked by an increase in concentration levels in August, September, October and November respectively. Concentration levels in all stations peaked in November after increases from July till November. Station 1 experienced increases in chromium concentration while station 2 experienced burst of increases from June till September before declining in October and increasing in November. Station 3, on the other hand experienced increase in June, decrease in July and August before increasing in September, October and November (Figure 4.23).

4.1.24 Iron

Iron concentration ranges between 1.33, 1.51, 1.11 mg/l in stations 1.2 and 3 respectively. The highest (1.51) and lowest (1.11) mean iron concentration was in station 2 and 3 respectively. Test of significance obtained from one-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean iron of the three stations

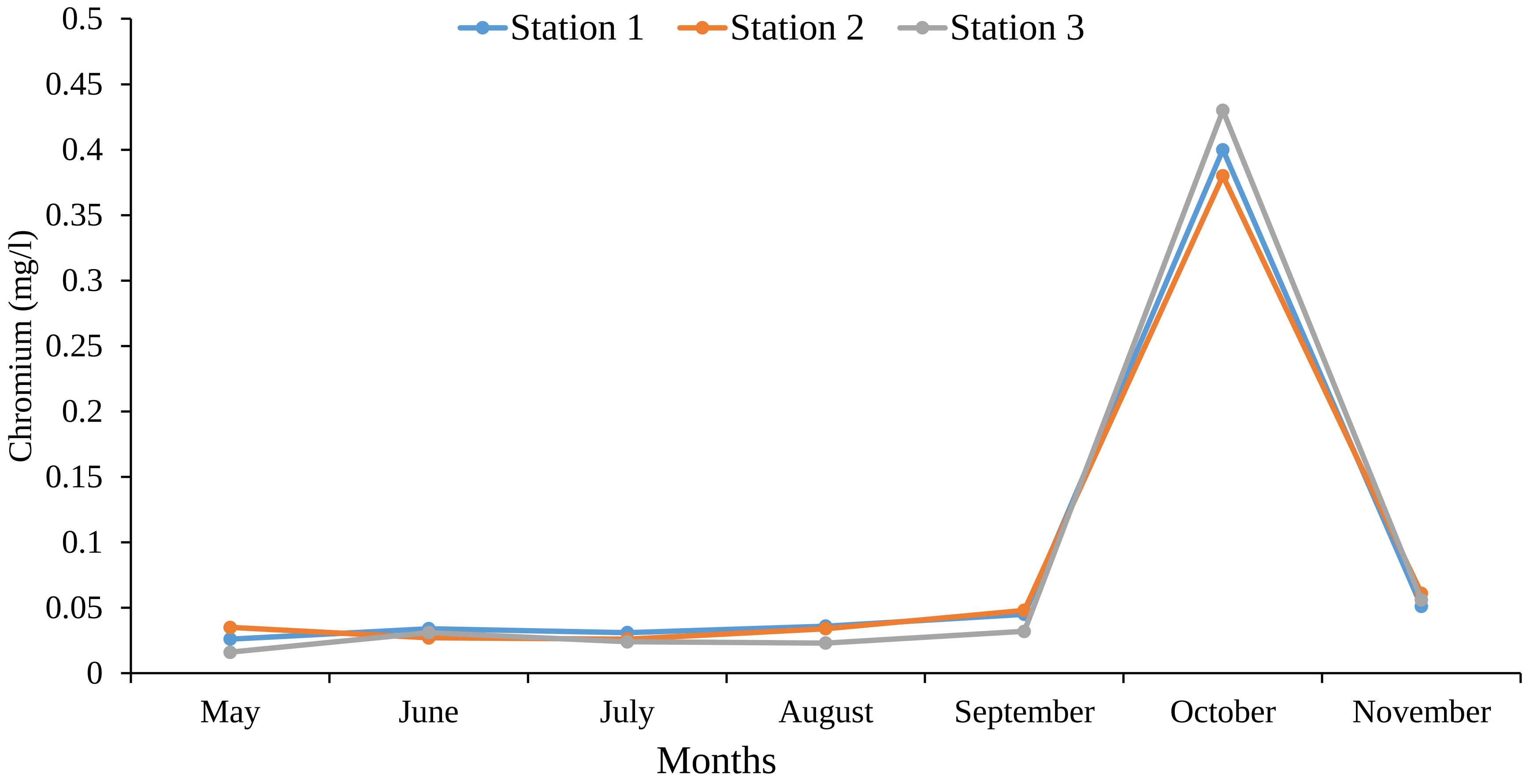

Figure 4.23: Spatial and Temporal variation in Chromium of Obazuwa Lake from May to November 2024

(Table 4.1). Iron highest concentration was in station 2 in August while the lowest concentration was in station 1. At the start of the study, Iron recorded high concentration levels across all stations. Peak concentration of iron in station 3 was recorded in May and this declined in the months of June and July respectively before increasing in August and September and declined in October and November (Figure 4.24).

In station 2, iron declined rapidly between the months of May and June and remained stable in July. August and September recorded elevated levels of iron before declining in October and November. In station 1, iron also showed marked decline from May till July before increasing in August and peaking in September. Iron concentration in station 1 further declined in October and November. Temporarily, all stations exhibited constant concentration levels in May, June, July, August, September October and November with the exception of offshoots in station 2 in August and decline in station 3 of September (Figure 4.24).

4.1.25 Lead

Lead concentration ranges between 0.021 in station 1, 0.017 in station 2 and 0.017 in station 3. The highest (0.021 mg/l) mean lead concentration was in station 1 and lowest (0.017 mg/l) mean lead concentration was in station 2 and 3 respectively. One-way analysis of variance revealed that there was no significant difference ($p > 0.05$) in the mean concentration of the three stations. Lead concentration showed variation spatially and temporally across all stations. At the start of the study, lead concentration reached its highest peak in station 1 and gradually declined from May till August before increasing in September and subsequently decreasing in October and November (Figure 4.25). In station 2, there was an increase in lead concentration in the month of June.

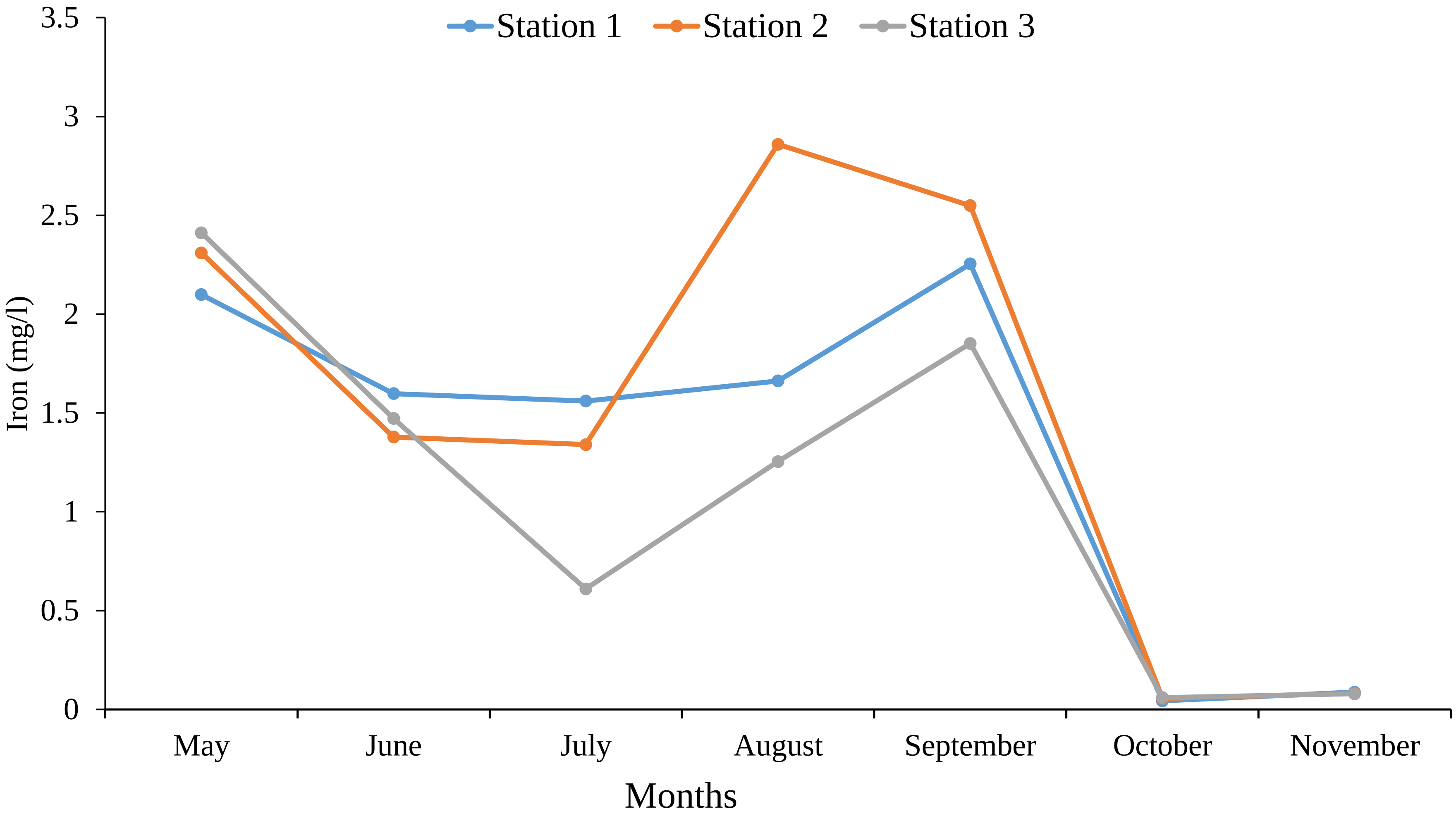

Figure 4.24: Spatial and Temporal variation in Iron of Obazuwa Lake between May and November 2024

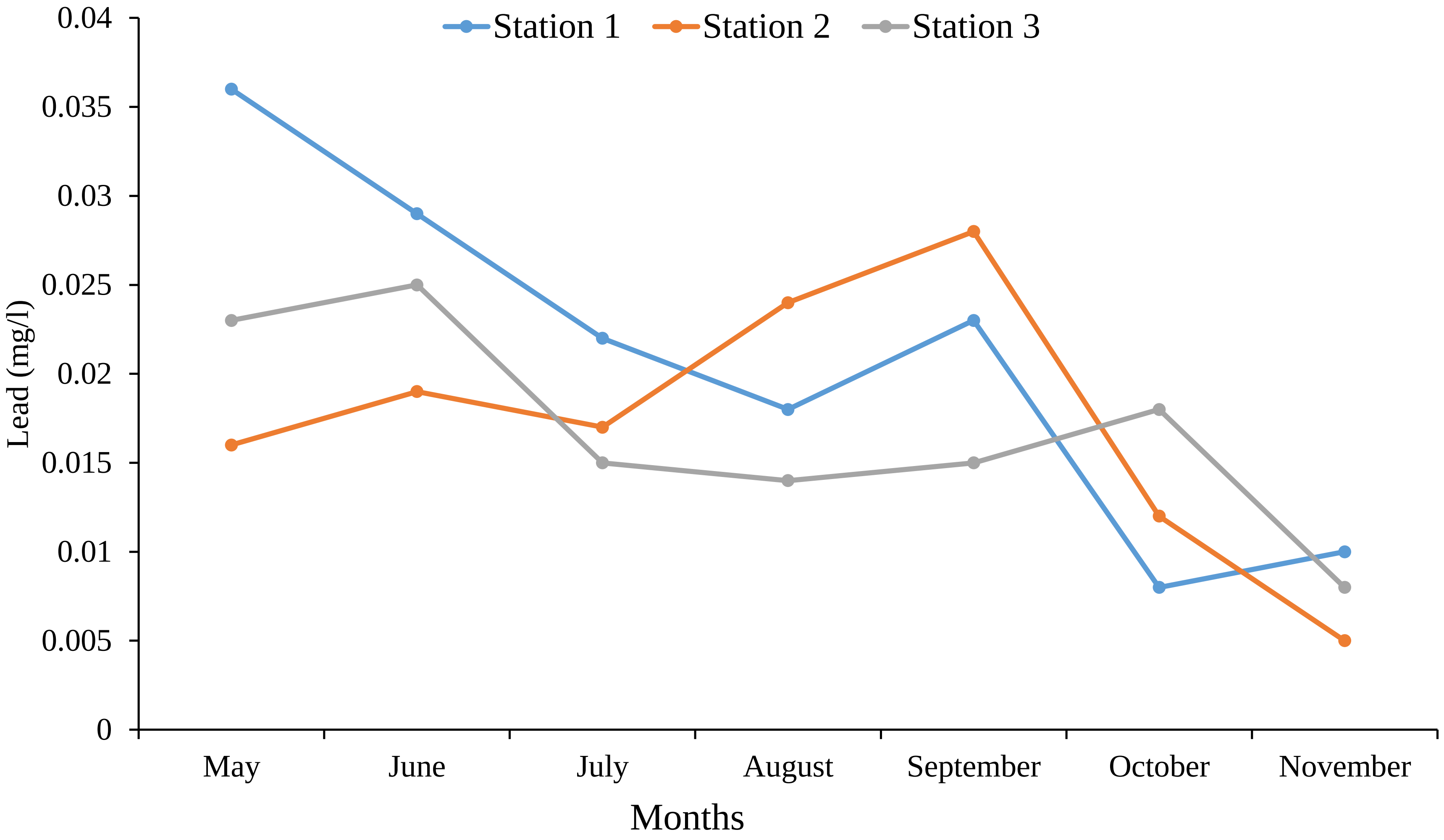

Figure 4.25: Spatial and Temporal variation in Lead of Obazuwa Lake between May and November 2024

This concentration decreased and increased successively in July and August before peaking in September. Thereafter a noticeable decline was observed in October and November where lead concentration in station 2 reached its lowest concentration level. In station 3, slight increases were observed between the starting months of May and June and a successive decline in lead concentration was observed up till September. In October lead concentration increased slowly before reaching and absolute lowest in November for station 3 (Figure 4.25)

4.1.26 Copper

Copper concentration ranges between 0.055 in station 1, 0.053 in station 2 and 0.046 mg/l in station 3. The highest (0.055) mean copper concentration was in station 1 and lowest (0.046) mean copper concentration was in station 3. one-way analysis of variance opined that there was no significance disparity ($p > 0.05$) in the mean concentration of the three stations. All stations showed spatial and temporal variations across the study duration (Figure 4.26**)**. Station 1 recorded a fairly stable amount of copper concentration from May till September. During this period only slow increased and decreases were noticeable in the months studied. Slight increase was noticed in June and July before declining slowly in August and increasing slowing again in September. October recorded a decrease in iron concentration of Station 1 before reaching highest concentration levels in November. During the course of the study, the lowest and highest concentration were recorded in October and November respectively. In station 2, copper concentration recorded a decline from May to June. Immediately, copper concentration increased in successively from July to September before declining in October and peaking in November. Similar trajectory was recorded in station 3 with slow decline and increase in June, July and August respectively. Station 3 also witnessed a decline in October before also peaking in November (Figure 4.26).

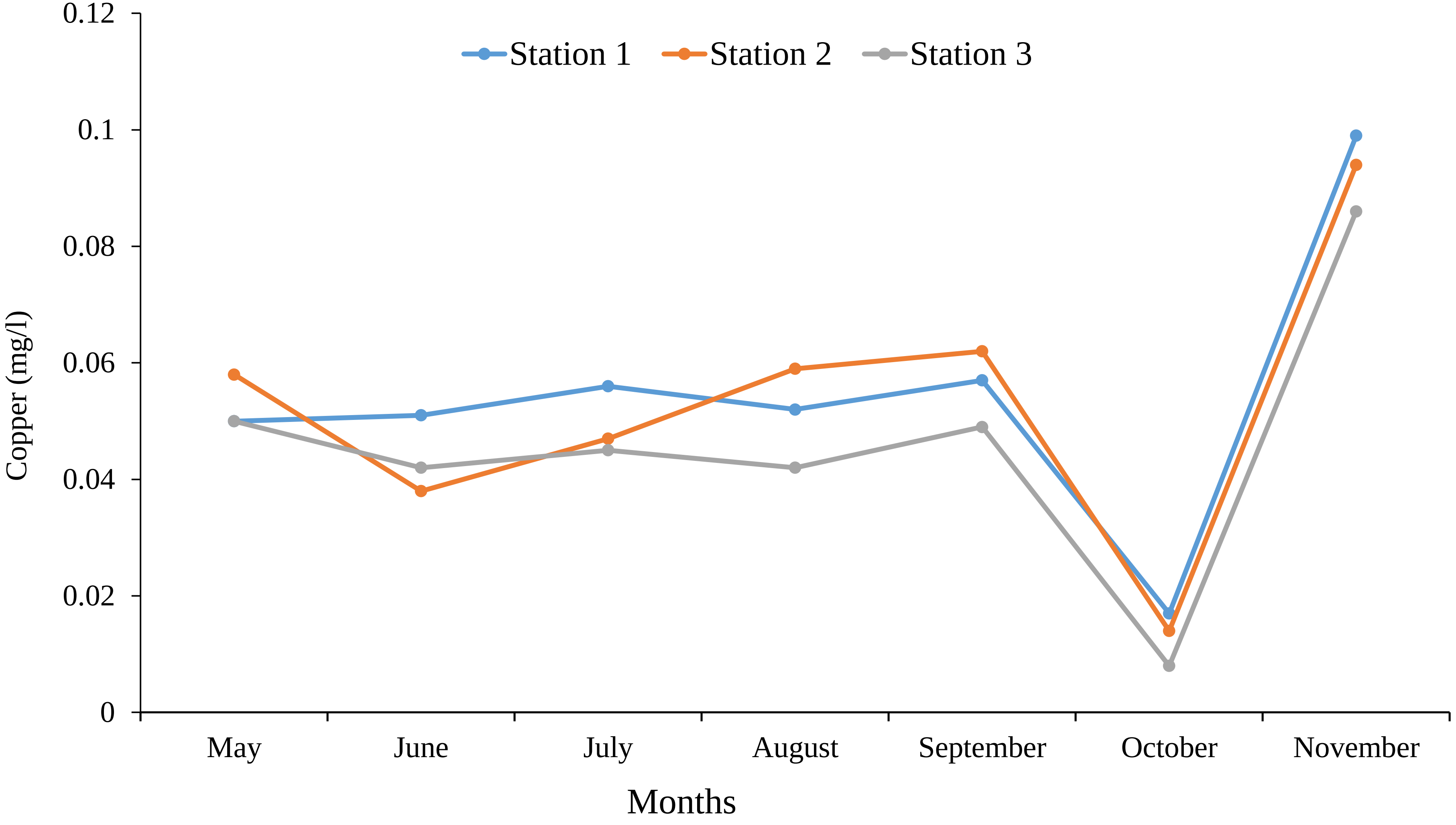

Figure 4.26: Spatial and Temporal variation in Copper of Obazuwa Lake between May and November 2024

4.1.27 Zinc

Zinc ranged between 0.083 in station 1, 0.078 in station 2 and 0.071 mg/l in station 3. The highest (0.083 mg/l) mean zinc concentration was observed in station 1 and lowest (0.071) mean zinc concentration was in station 3. one-way ANOVA revealed the absence of statistical significance ($p > 0.05$) in the mean zinc concentration. Zinc concentration levels were constant in stations 2 and 3 in both May and June while relatively high levels relatively high levels of zinc concentration were observed in station 1.

This increased concentration increased and decreased in June and July respectively before steadily increasing in August and September. Thereafter, slow decline was recorded in October. Zinc concentration levels reached its peak in November (Figure 4.27). In station 2 there was a decline in zinc concentration from may till June and then steady increases in July, august and September before declining in October and reaching its maximum level in November. In Station 3, zinc levels increased between May and June and decreased in July followed by successive increases in August and September. Thereafter a slow decline was observed before reaching peak station 3 levels in November. All stations reached maximum levels in November and minimum concentration in October (Figure 4.27).

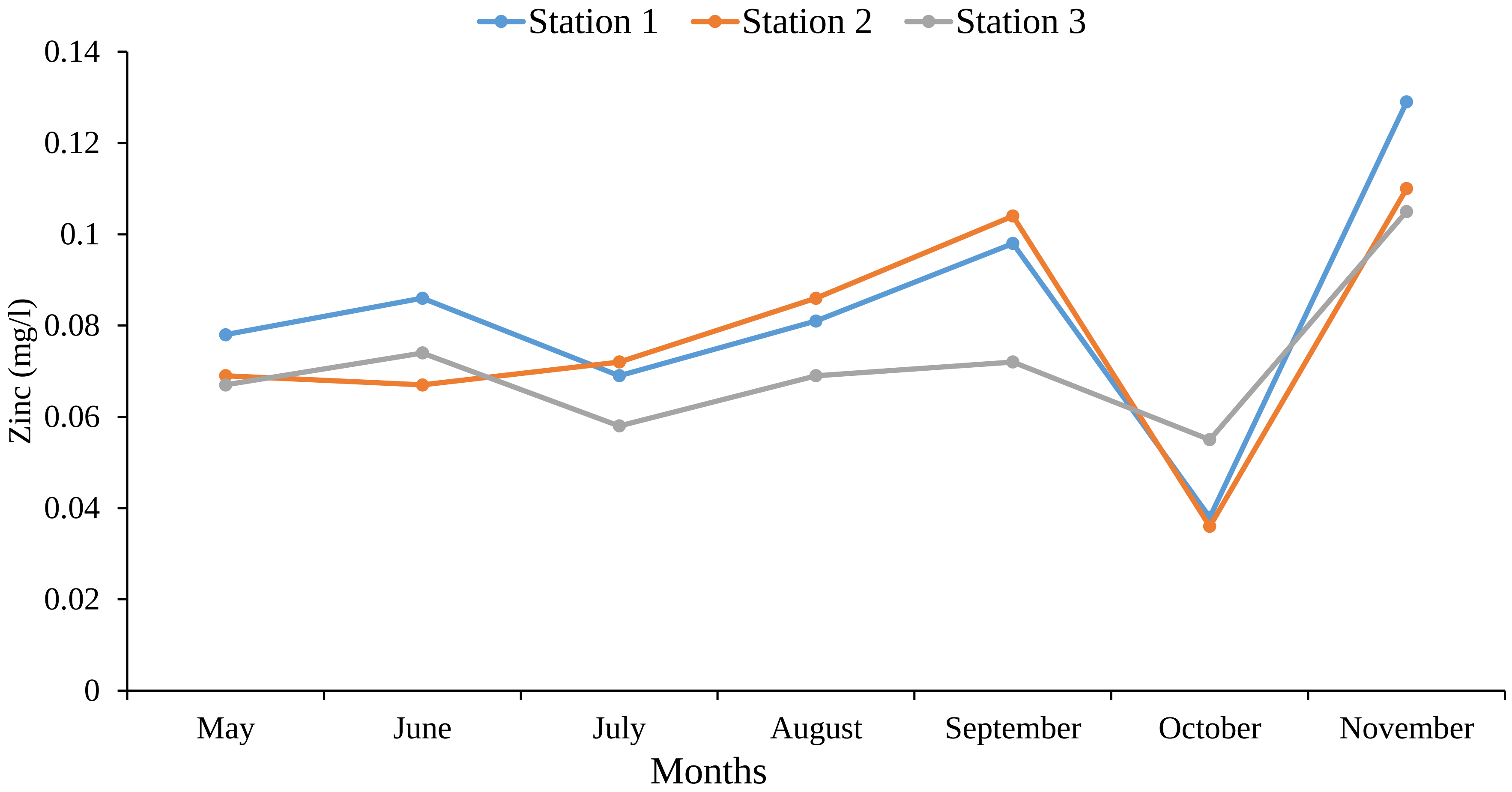

Figure 4.27: Spatial and Temporal variation in Zinc of Obazuwa Lake between May and November 2024

4.2. Zooplankton Composition, Abundance, Distribution and Dominance

4.2.1 Zooplankton Composition

A total of 3771 zooplankton individuals were identified in this study comprising of 9 orders, 18 families and 48 species. Zooplankton community comprised of several orders. Order Cyclopoida included two (2) suborders namely, Cyclopida and Ergasilida with three (3) families identified: Cyclopidae, Halicyclopidae, and Ergasilidae. Within this order, ten (10) genera and fourteen (14) species were recorded. Other Crustacean orders included, Calanoida (Families Aetideidae and Diaptomidae) with four (4) genera and seven (7) species recorded, Order Anomopoda (Families Moinidae, Daphniidae, and Chydoridae) with eight (8) genera and eleven (11) species identified. Order Ctenopoda (Family Sididae) was represented by two (2) genera and three (3) species while Order Plioma (Families Gastropodidae, Asplanchnidae, Branchionidae and Proalidae) were represented by eight (8) genera and nine (9) species. The composition of zooplankton taxonomic groups and orders are represented in Figure 4.1 - 4.2 while, percentage composition of copepoda, cladocera and rotifera is presented in Table 4.3 – 4.5.

Order Hapacticoida (Family Canthocamptidae) was represented singly by one (1) genera and one (1) specie whereas Order Flosculariaceae (Families Trochosphaeridae and Epiphanidae) were represented by one (2) genera and three (3) species. Lastly, Order Ostracoda (Family Podocopida). was represented by one (1) genera and (1) species. Unidentified fish juveniles were recorded at group level and were represented by one (1) species only. Copepoda recorded the highest species richness with 20 taxa (41.67% of the total species) followed by Cladocera (14 taxa, 29.17%), Rotifera (12 taxa, 25%), Ostracoda (1 taxon, 2.08%) and Unidentified Fish Juveniles (1 taxon, 2.08%). A detailed checklist of zooplankton species recorded during the study period is presented in Table 4.2

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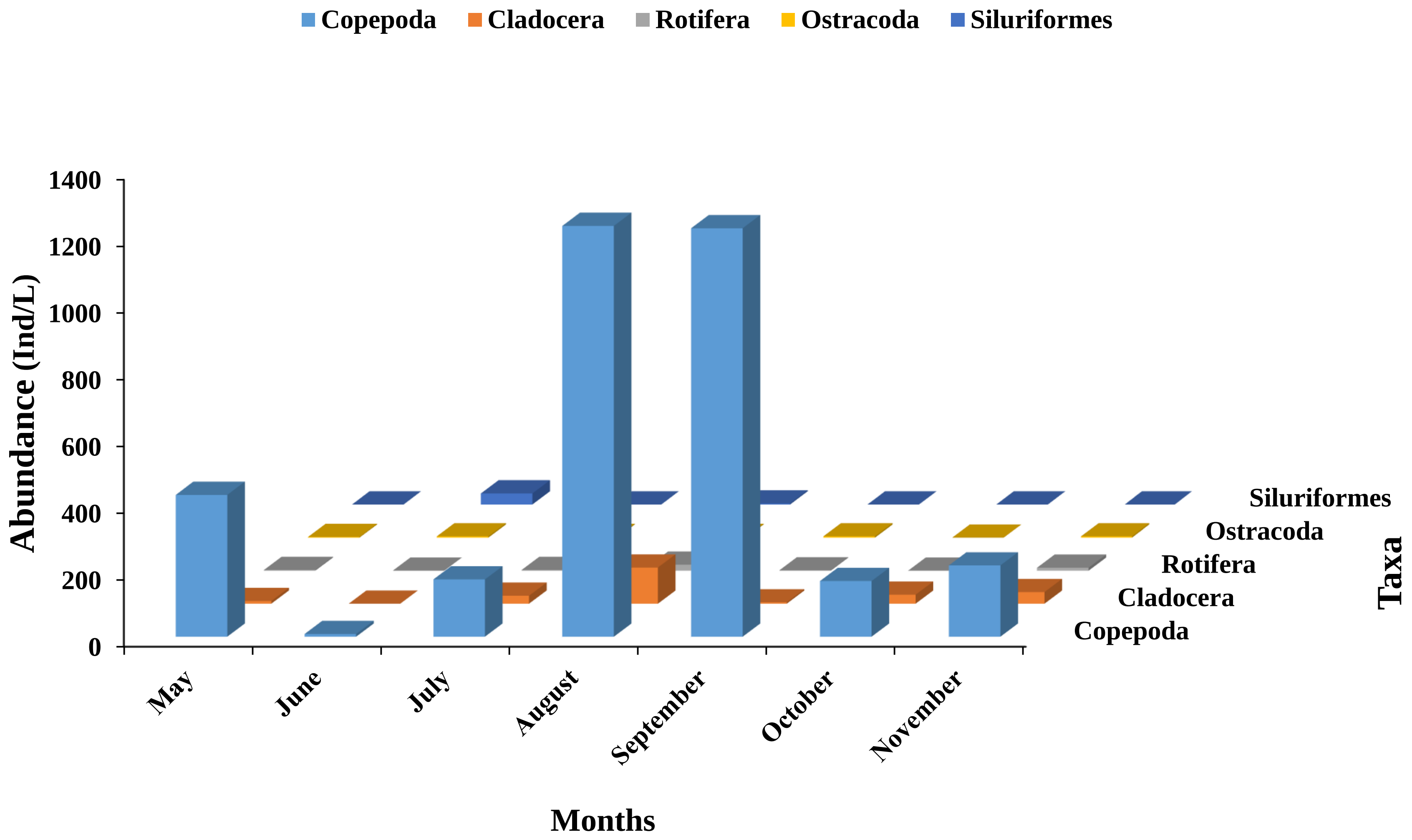

Figure 4.28:Composition of Zooplankton taxa in Obazuwa Lake

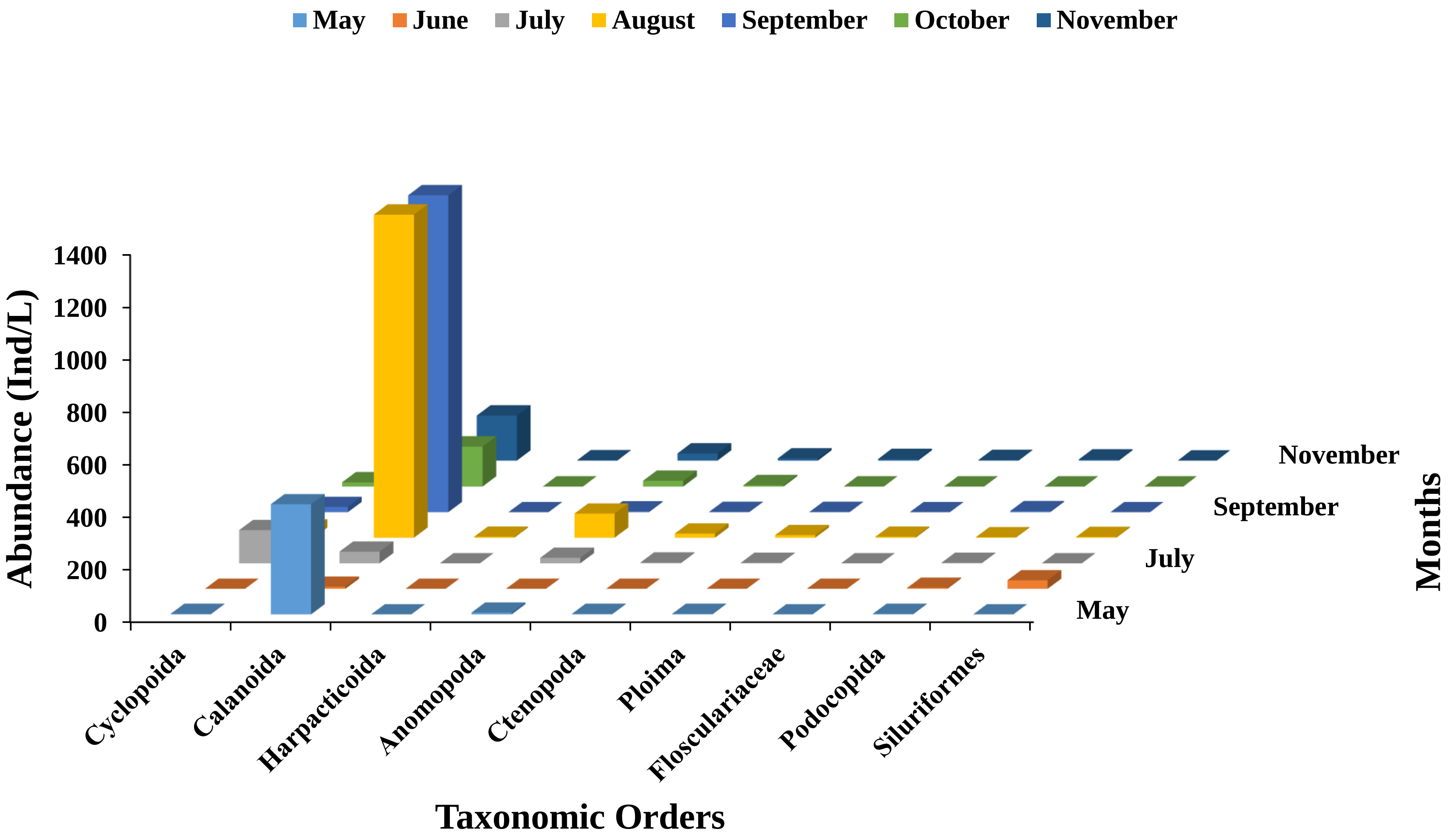

Figure 4.29: **Composition of Zooplankton Orders in Obazuwa Lake**

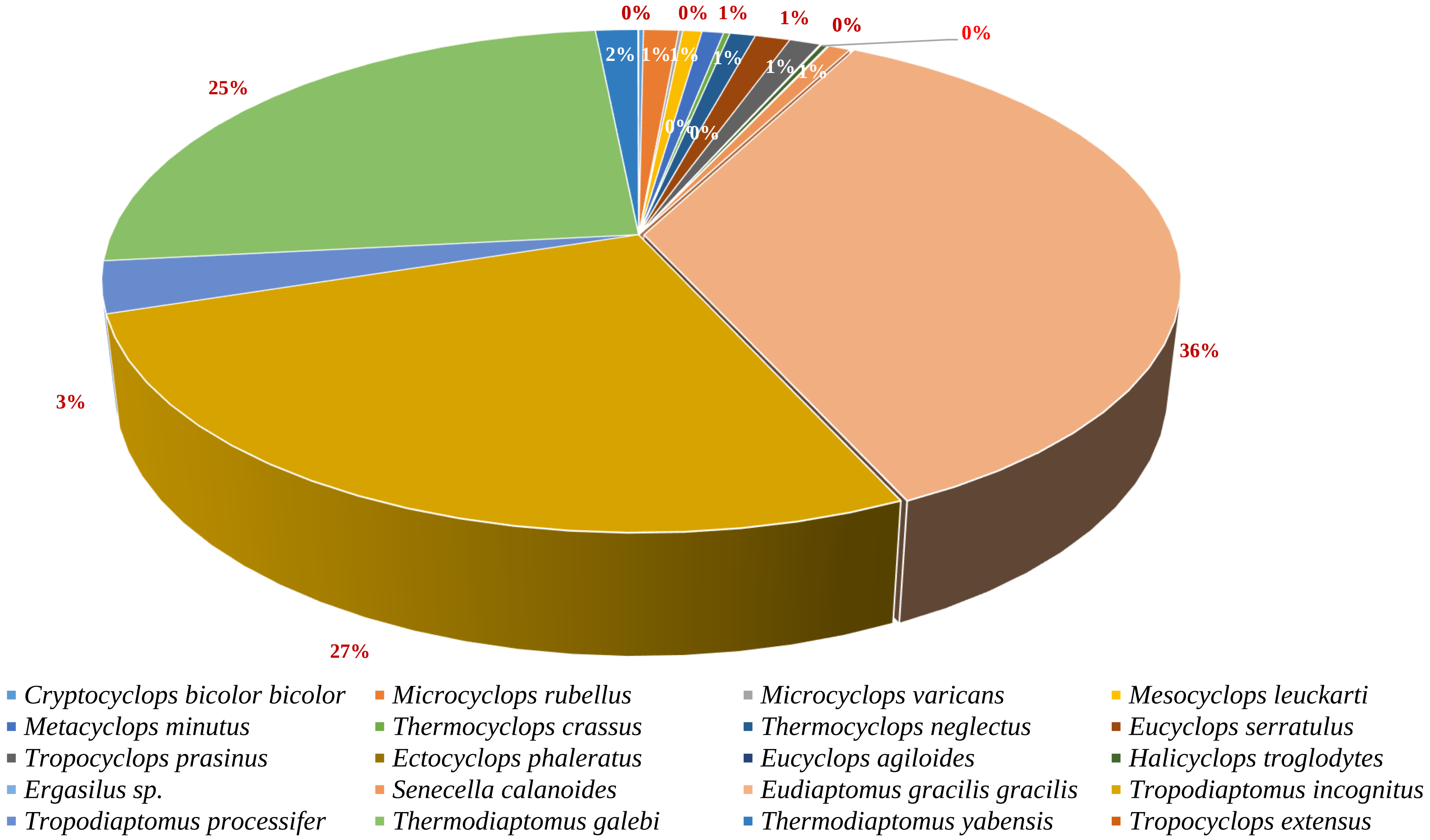

Figure 4.30: Percentage Composition of Copepoda species in Obazuwa lake between May and November 2024

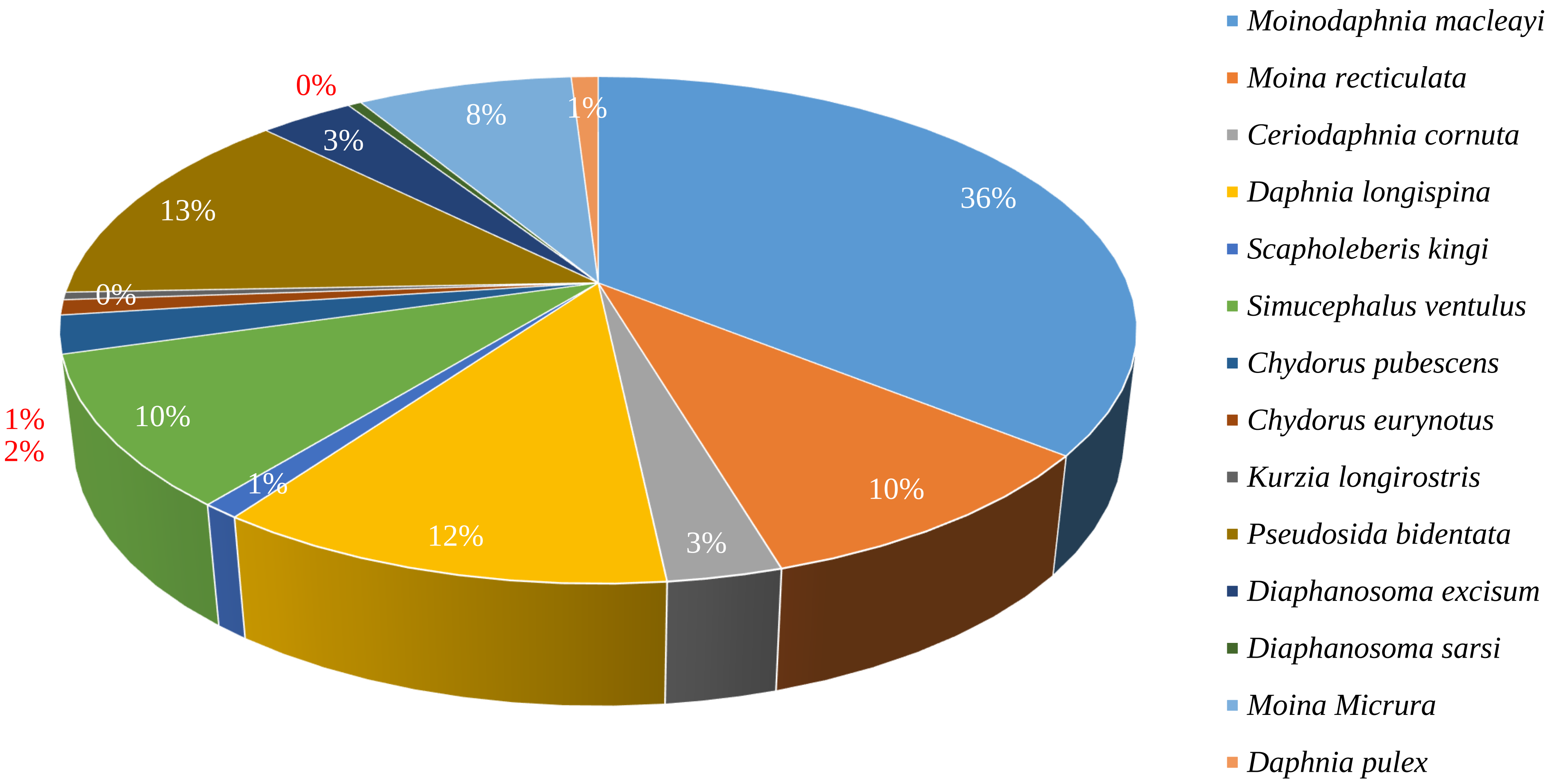

Figure 4.31: Percentage Composition of Cladocera species in Obazuwa lake between May and November 2024

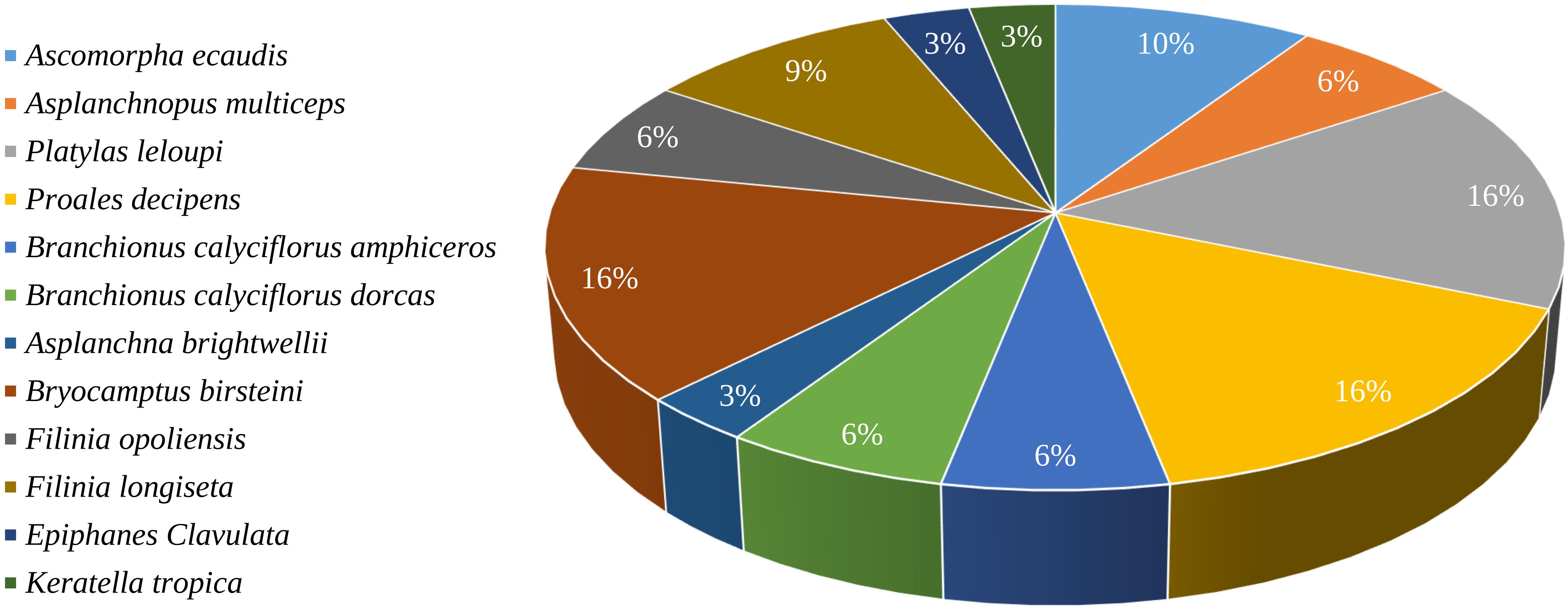

Figure 4.32: Percentage Composition of Rotifera species in Obazuwa lake between May and November 2024

TABLE 4.2: CHECKLIST OF ZOOPLANKTON FAUNA

Kingdom	Animalia		
Phylum	Arthropoda		
Subphylum	Crustacea		
Superclass	Multicrustacea		
Class	Copepoda		
Infraclass	Neocopepoda		
Superorder	Podoplea		
Order	Cyclopoida		
Suborder	Cyclopida		
Family	Cyclopidae		
SUBFAMILY	CYCLOPINAE		
Genus	*Cryptocyclops*		
Species	*Cryptocyclops bicolor*	Sars G.O 1863	Plate 4.1
	Microcyclops		
	Microcyclops rubellus	Lilljeborg, 1901	Plate 4.2
	Microcyclops varicans	Sars G.O 1863	Plate 4.3
	Mesocyclops		
	Mesocyclops leuckarti	Claus 1857	Plate 4.4
	Metacyclops		
	Metacyclops minutus	Claus 1863	Plate 4.5
	Thermocyclops		
	Thermocyclops crassus	Fischer, 1853	Plate 4.6
	Thermocyclops neglectus	Sars, 1909	Plate 4.7

SUBFAMILY	EUCYCLOPINAE		
Genus	*Eucyclops*		
Species	*Eucyclops serratulus*	Fischer, 1851	Plate 4.8
	Eucyclops agiloides	Sars G.O. 1909	Plate 4.9
	Ectocyclops		
	Ectocyclops phaleratus	Koch, 1838	Plate 4.10
	Tropocyclops		
	Tropocyclops prasinus	Fischer, 1860	Plate 4.11
	Tropocyclops extensus	Kiefer, 1931	Plate 4.12
FAMILY	HALICYCLOPIDAE		
Genus	*Halicyclops*		
Species	*Halicyclops troglodytes*	Kiefer, 1955	Plate 4.13
SUBORDER	ERGASILIDA		
FAMILY	ERGASILIDAE		
	Ergasilus sp.	Von Nordman, 1832	Plate 4.14
SUPERORDER	GYMNOPLEA		
ORDER	CALANOIDA		
FAMILY	AETIDEIDAE		
	Senecella		
	Senecella calanoides	Juday, 1923	Plate 4.15
FAMILY	DIATOMIDAE		
Genus	*Eudiaptomus*		
Species	*Eudiaptomus gracilis*	Sars G.O 1863	Plate 4.16

	Tropodiaptomus		
	Tropodiaptomus incognitus	Dussart and Gras, 1966	Plate 4.17
	Tropodiaptomus processifer	Kiefer, 1926	Plate 4.18
	Thermodiaptomus		
	Thermodiaptomus galebi	Barrois, 1891	Plate 4.19
	Thermodiaptomus yabensis	Kiefer, 1932	Plate 4.20
Superclass	Allotriocarida		
Class	Branchiopoda		
Subclass	Phyllopoda		
Superorder	Diplostraca		
Order	Anomopoda		
FAMILY	MOINIDAE		
Genus	*Moinodaphnia*		
Species	*Moinodaphnia macleayi*	King, 1853	Plate 4.21
	Moina		
	Moina recticulata	Daday, 1905	Plate 4.22
	Moina micrura	Kurz, 1875	Plate 4.23
FAMILY	DAPHNIIDAE		
Genus	*Ceriodaphnia*		
Species	*Ceriodaphnia cornuta*	G.O. Sars 1885	Plate 4.24
	Daphnia		
	Daphnia longispina	O.F. Muller, 1776	Plate 4.25
	Daphnia pulex	Leydig, 1860	Plate 4.26

	Scapholeberis		
	Scapholeberis kingi	Sars G.O 1888	Plate 4.27
	Simucephalus		
	Simucephalus ventulus	O.F. Muller, 1776	Plate 4.28
FAMILY	CHYDORIDAE		
Genus	*Chydorus*		
Species	*Chydorus pubescens*	G.O. Sars 1901	Plate 4.29
	Chydorus eurynotus	G.O. Sars 1901	Plate 4.30
	Kurzia		
	Kurzia longirostris	Daday, 1898	Plate 4.31
ORDER	CTENOPODA		
FAMILY	SIDIDAE		
Genus	*Pseudosida*		
Species	*Pseudosida bidentata*	Herrick, 1884	Plate 4.32
	Diaphanosoma		
	Diaphanosoma excisum	Sars G.O 1885	Plate 4.33
	Diaphanosoma sarsi	Richard, 1894	Plate 4.34
Phylum	Rotifera		
Class	Eurotatoria		
Subclass	Monogononta		
Superorder	Pseudotrocha		
Order	Ploima		
Family	Gastropodidae		

Genus	*Ascomorpha*		
Species	*Ascomorpha ecaudis*	Perty, 1850	Plate 4.35
FAMILY	ASPLANCHNIDAE		
Genus	*Asplanchnopus*		
Species	*Asplanchnopus multiceps*	Schrank, 1793	Plate 4.36
	Asplanchna		
	Asplanchna brightwellii	Gosse, 1850	Plate 4.37
FAMILY	*BRANCHIONIDAE*		
Genus	*Platylas*		
Species	*Platylas leloupi*	Gillard, 1957	Plate 4.38
	Branchionus		
	Branchionus calyciflorus amphiceros	Pallas, 1766	Plate 4.39
	Branchionus calyciflorus dorcas		Plate 4.40
	Keratella		
	Keratella tropica	Apstein, 1907	Plate 4.41
FAMILY	PROALIDAE		
Genus	*Proales*		
Species	*Proales decipens*		Plate 4.42
Order	Harpacticoida		
Family	Canthocamptidae		
Subfamily	Canthocamptinae		

Genus	*Bryocamptus*		
Species	*Bryocamptus birsteini*	Borutzy, 1940	Plate 4.43

Superorder	Gnesiotrocha		
Order	Flosculariaceae		
Family	Trochosphaeridae		
Genus	*Filinia*		
Species	*Filinia opoliensis*	Zacharias, 1898	Plate 4.44
	Filinia longiseta	Ehrenberg, 1834	Plate 4.45

FAMILY	EPIPHANIDAE		
	Epiphanes		
	Epiphanes clavulata	Ehrenberg, 1831	Plate 4.46

Superclass	Oligostraca		
Class	Ostracoda		
Subclass	Podocopa		
Order	Podocopida		
Suborder	Cytherocopina		
Superfamily	Cytheroidea		
Family	Bythocytheridae		
Subfamily	Pseudocytherinae		
Genus	*Sclerochilus*		
Species	*Sclerochilus littoralis*	Eagar, 1971	Plate 4.47

Order	Siluriformes		
Family	Bagridae		
Species	Unidentified Juvenile > 2cm		Plate 4.48

Plate 4.1: *Cryptocyclops bicolor*

Plate 4.2: *Microcyclops rubellus*

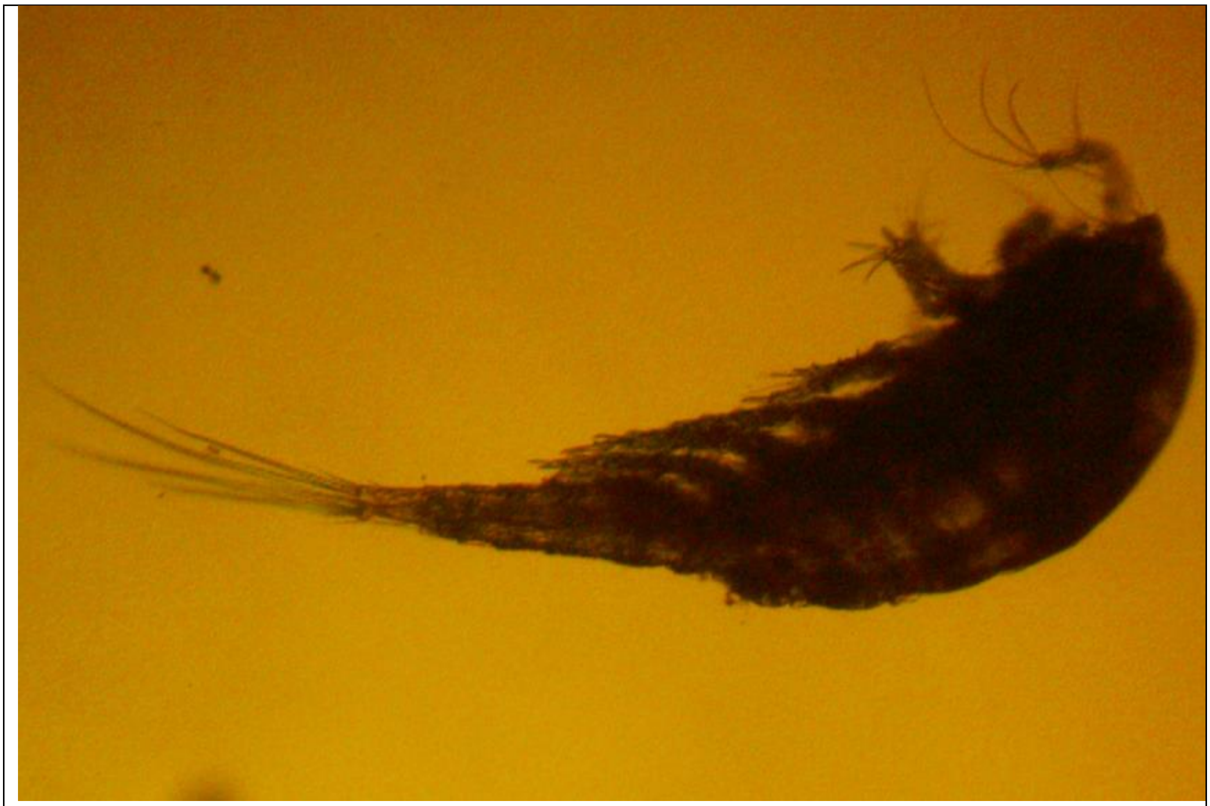

Plate 4.3: *Microcyclops vericans*

Plate 4.4: *Mesocyclops leuckarti*

Plate 4.5: *Metacyclops minutus*

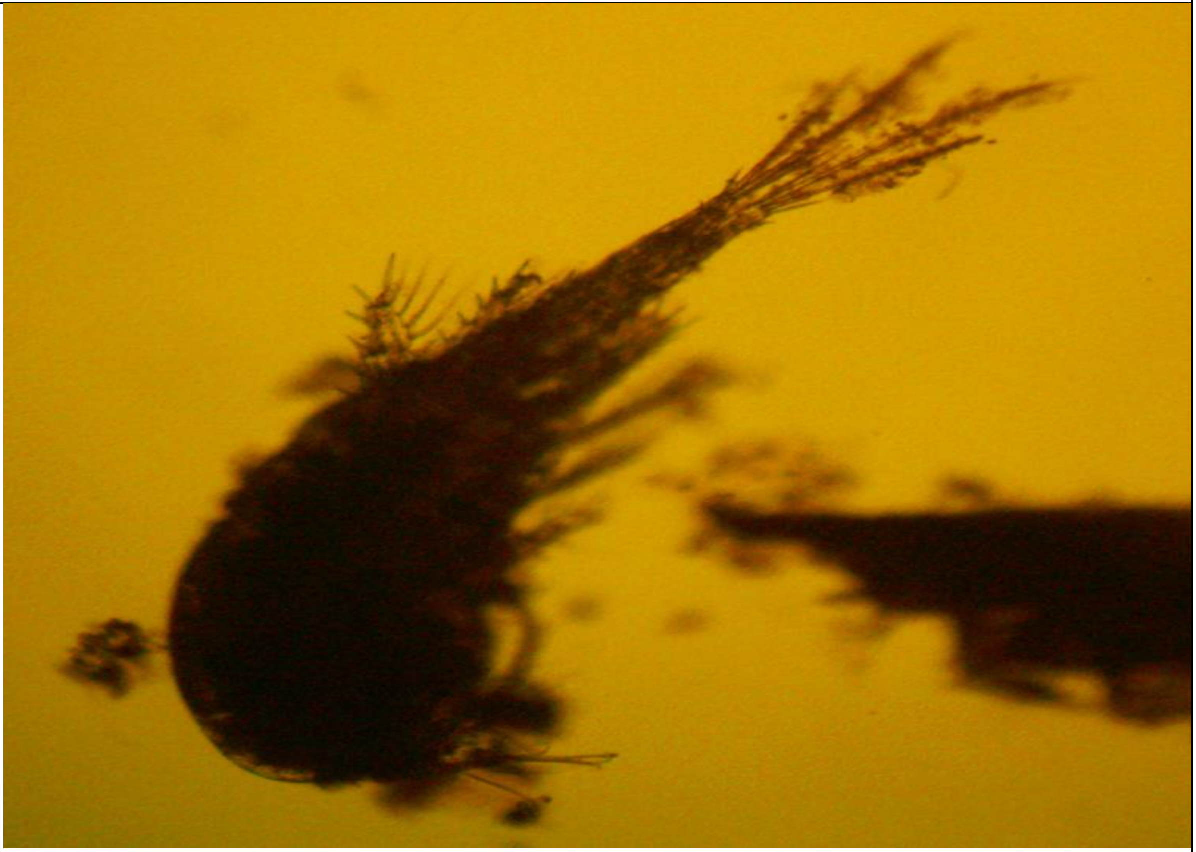

Plate 4.6: *Thermocyclops crassus*

Plate 4.7: *Thermocyclops neglectus*

Plate 4.8: *Eucyclops serrulatus*

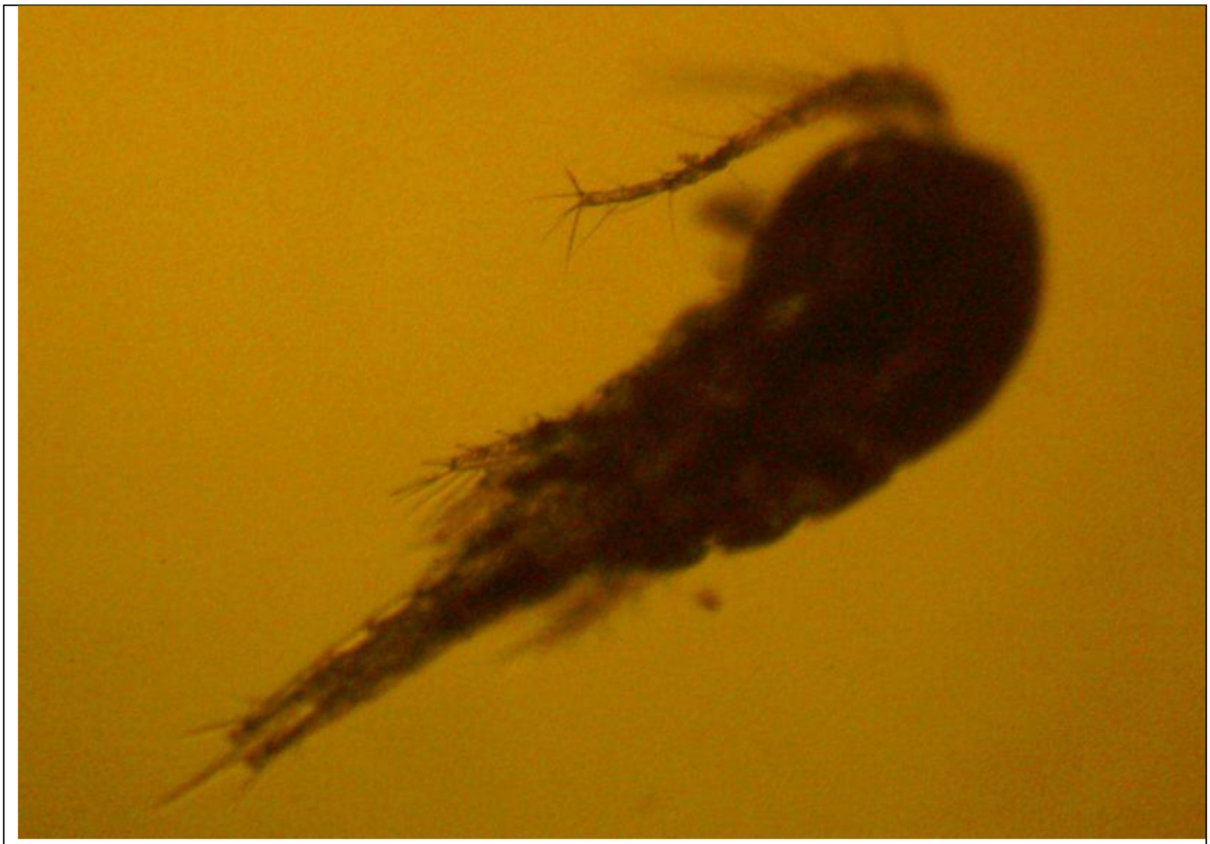

Plate 4.9: *Eucyclops agiloides*

Plate 4.10: *Ectocyclops phaleratus*

Plate 4.11: *Tropocyclops prasinus*

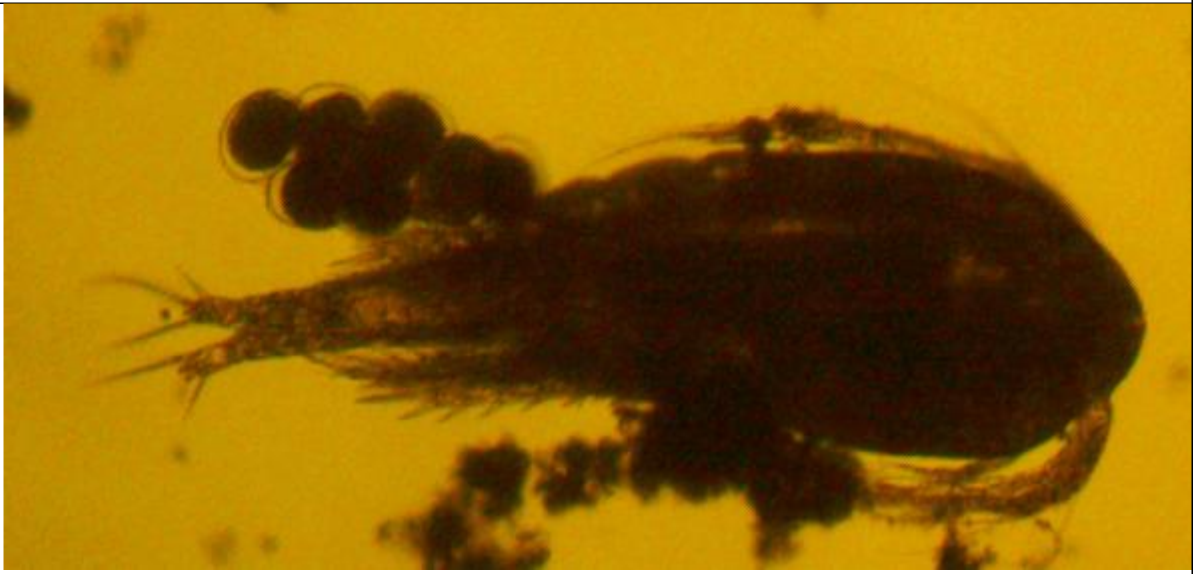

Plate 4.12: *Tropocyclops extensus*

Plate 4.13: *Halicyclops troglodytes*

Plate 4.14: *Ergasilus sp.*

Plate 4.15: *Senecella calanoides*

Plate 4.16: *Eudiaptomus gracilis*

Plate 4.17: *Tropodiaptomus incognitus*

Plate 4.18: *Tropodiaptomus processifer*

Plate 4.19: *Thermodiaptomus galebi*

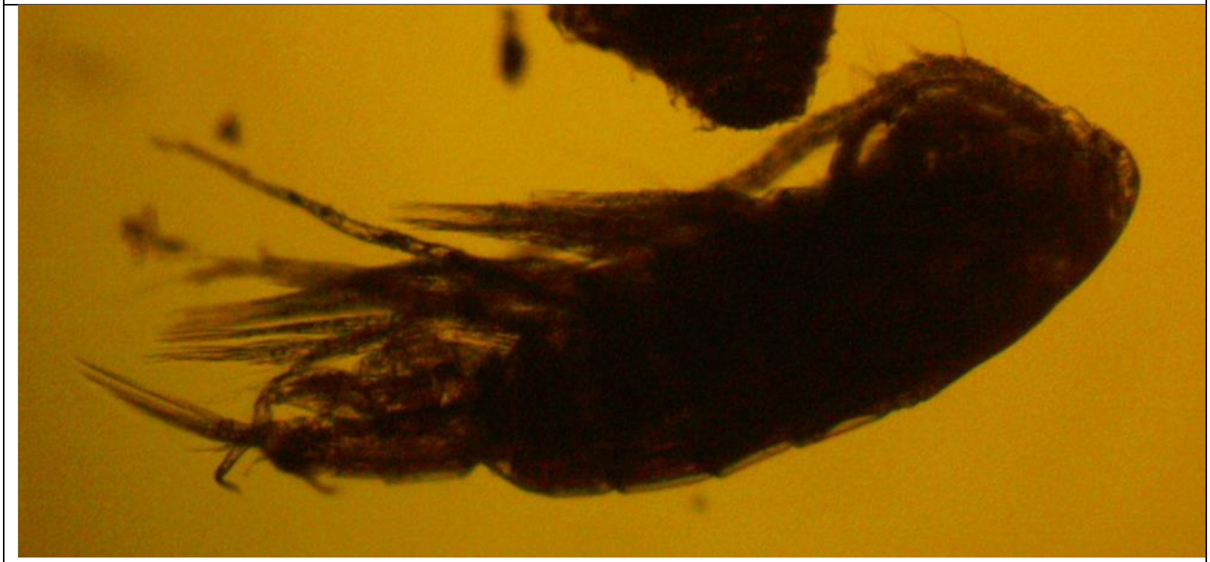

Plate 4.20: *Thermodiaptomus yabensis*

Plate 4.21: *Moinodaphnia macleayi*

Plate 4.22: *Moina recticulata*

Plate 4.23: *Moina micrura*

Plate 4.24: *Ceriodaphnia cornuta*

Plate 4.25: *Daphnia longispina*

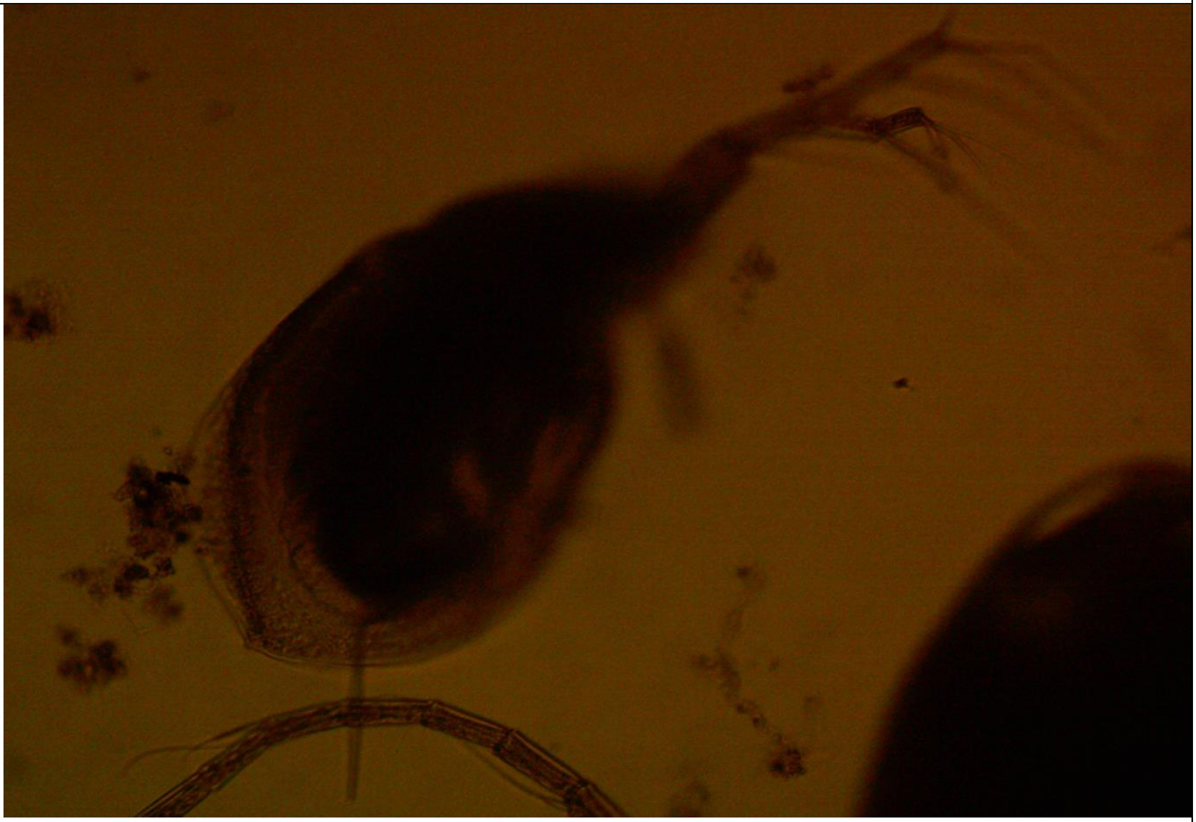

Plate 4.26: *Daphnia pulex*

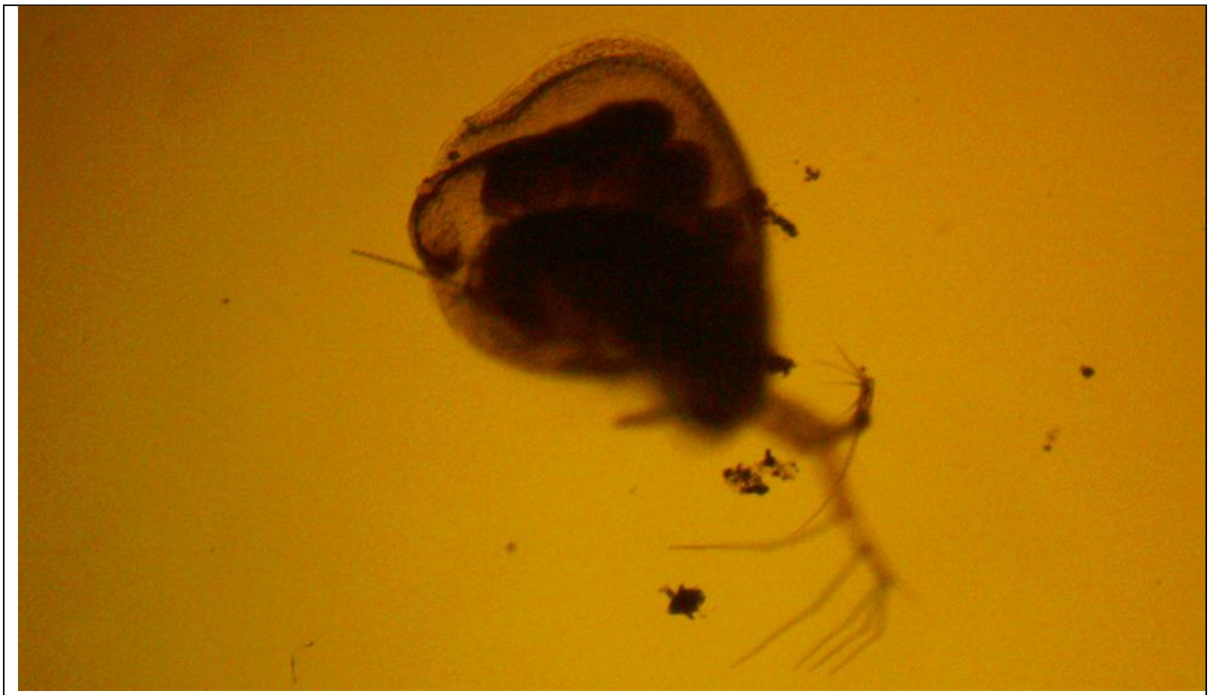

Plate 4.27: *Scapholeberis kingi*

Plate 4.28: *Simucephalus ventulus*

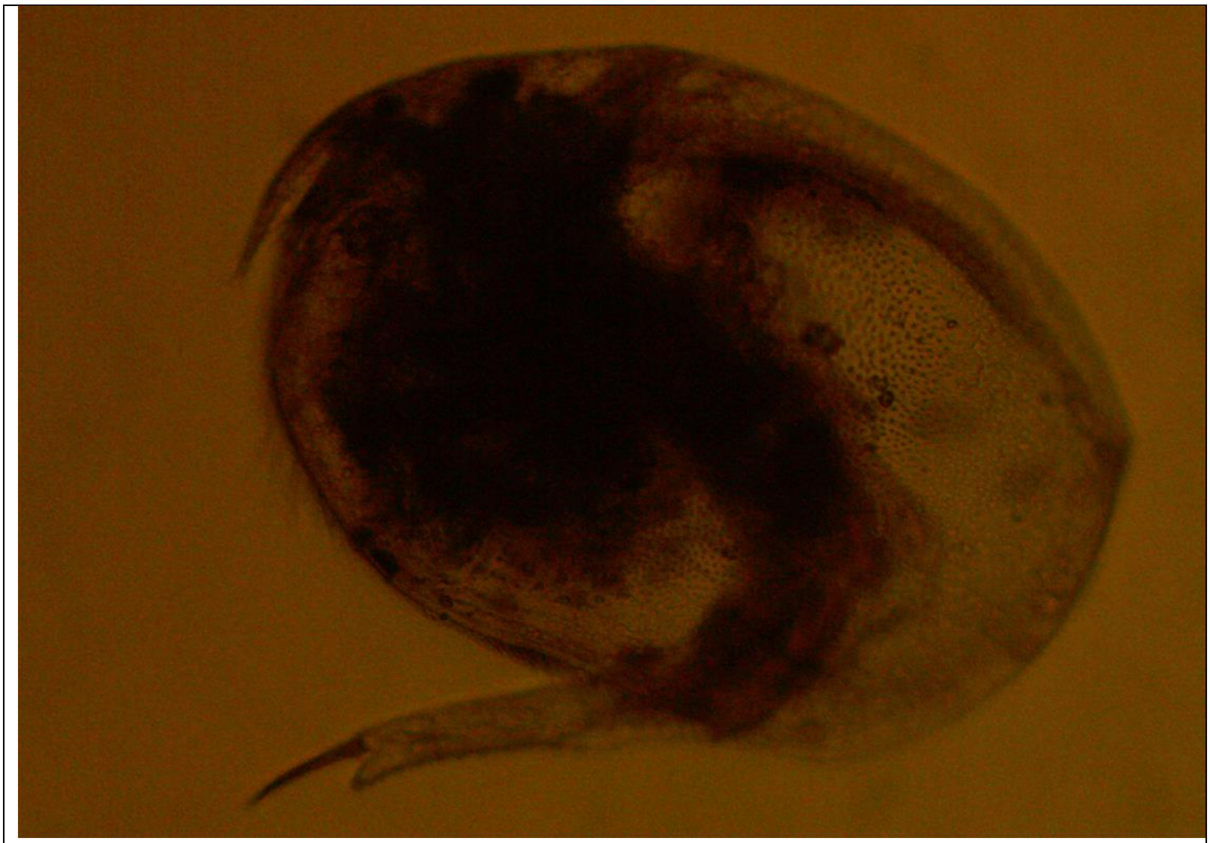

Plate 4.29: *Chydorus pubescens*

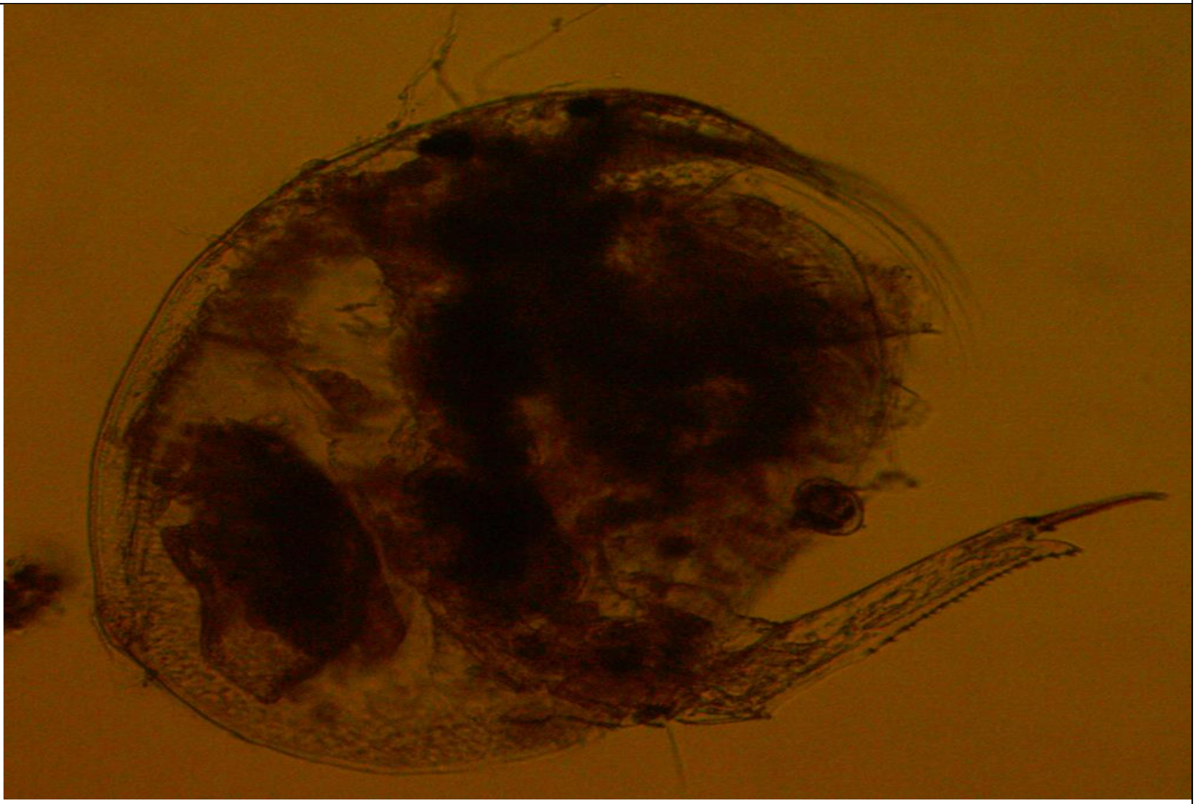

Plate 4.30: *Chydorus eurynotus*

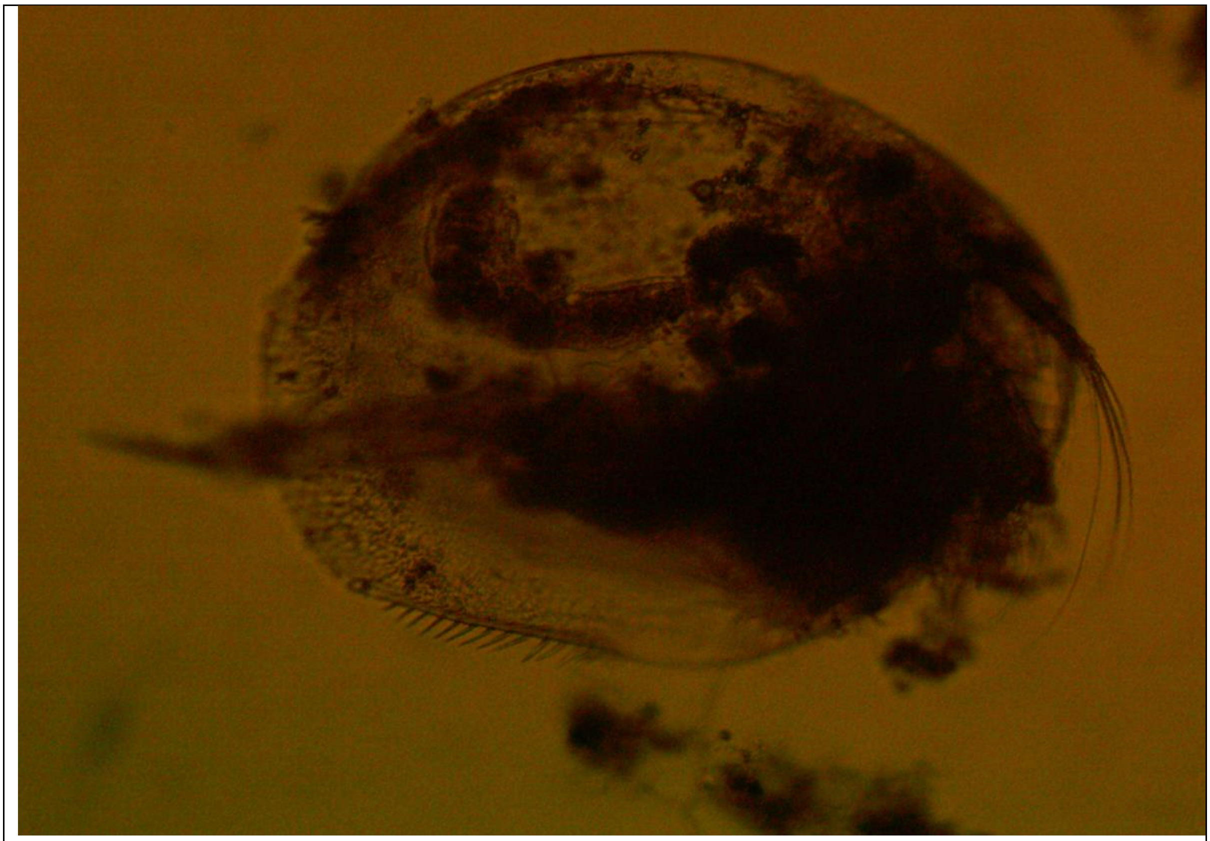

Plate 4.31: *Kurzia longirostris*

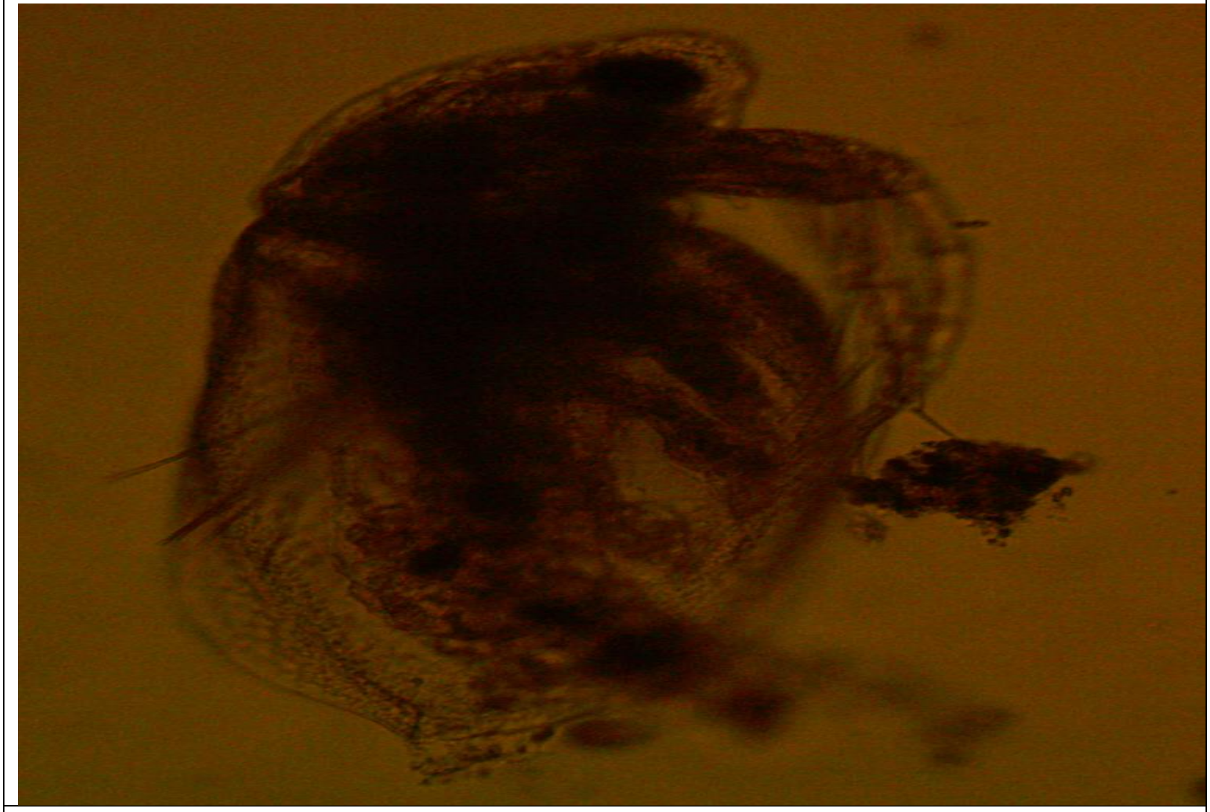

Plate 4.32: *Pseudosida bidentata*

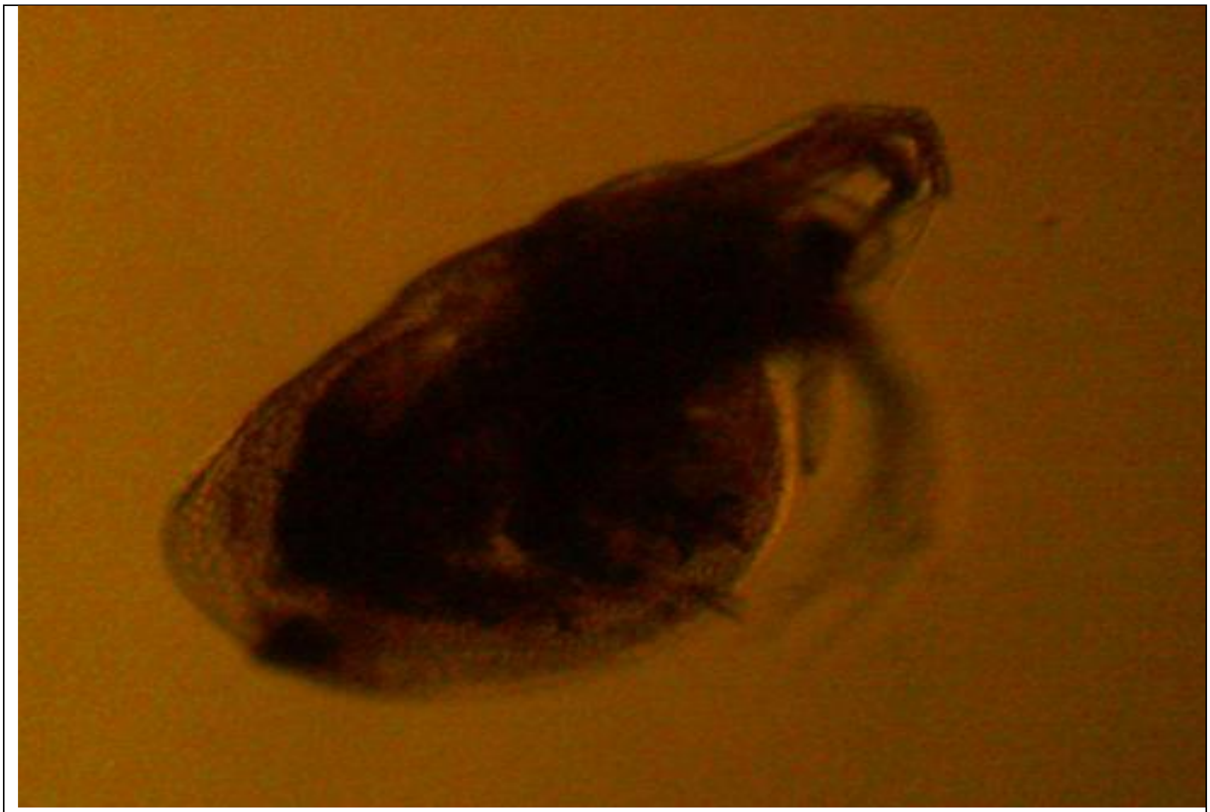

Plate 4.33: *Diaphanosoma excisum*

Plate 4.34: *Diaphanosoma sarsi*

Plate 4.37: *Asplanchna brightwellii*

Plate 4.38: *Platyias leloupi*

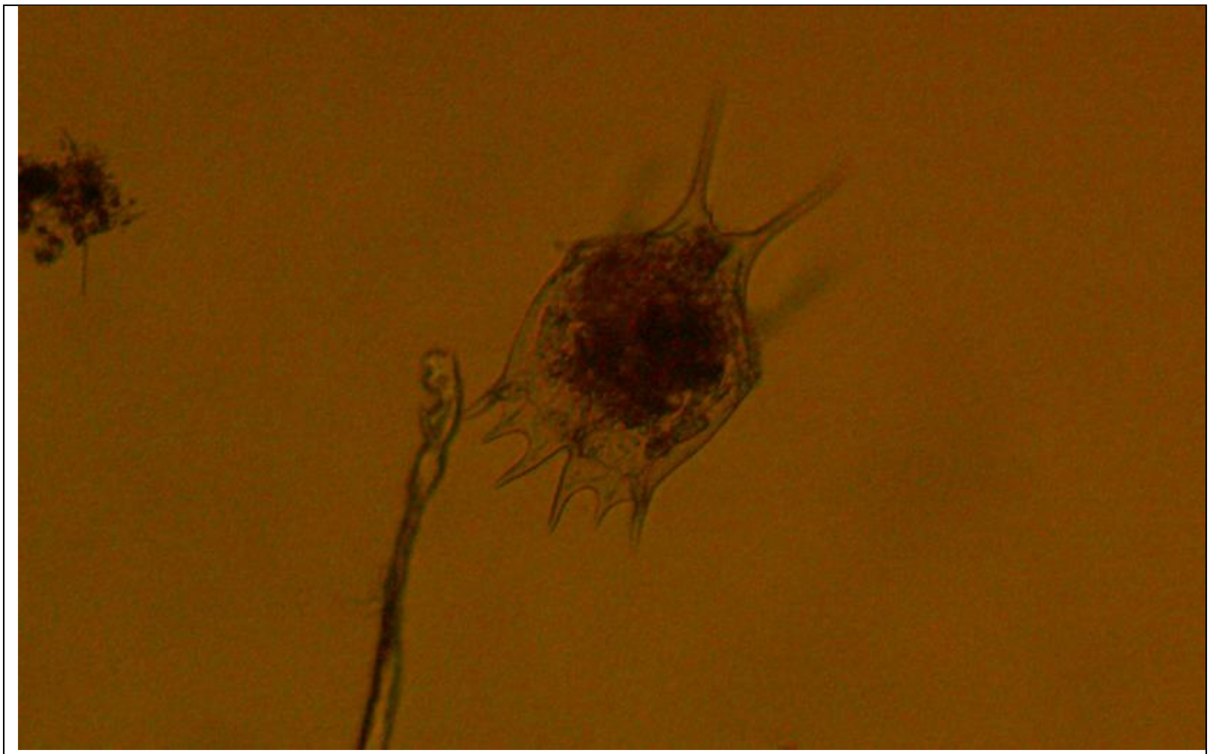

Plate 4.39: *Branchionus calyciflorus amphiceros*

Plate 4.40: *Branchionus calyciflorus dorcas*

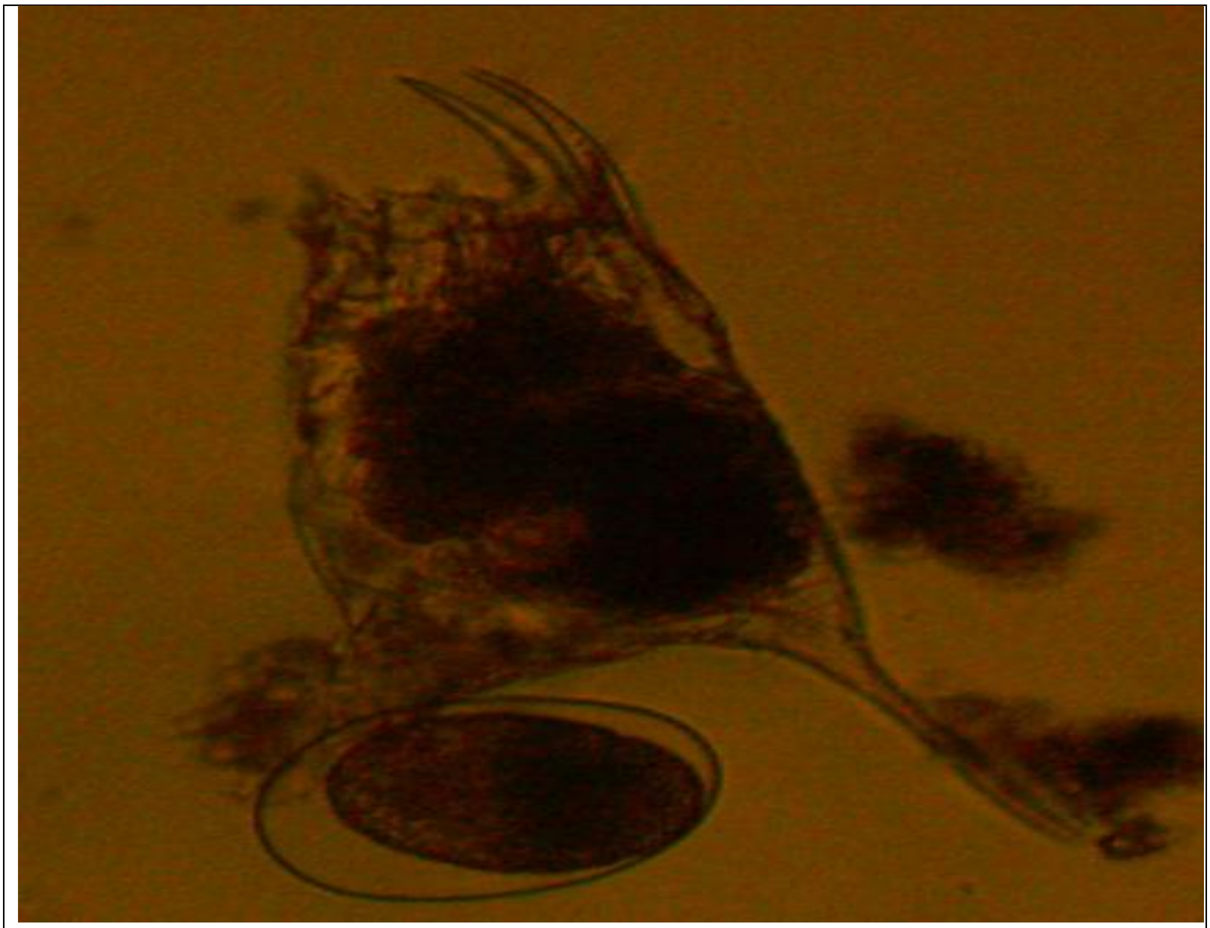

Plate 4.41: *Keratella tropica*

Plate 4.42: *Proales decipens*

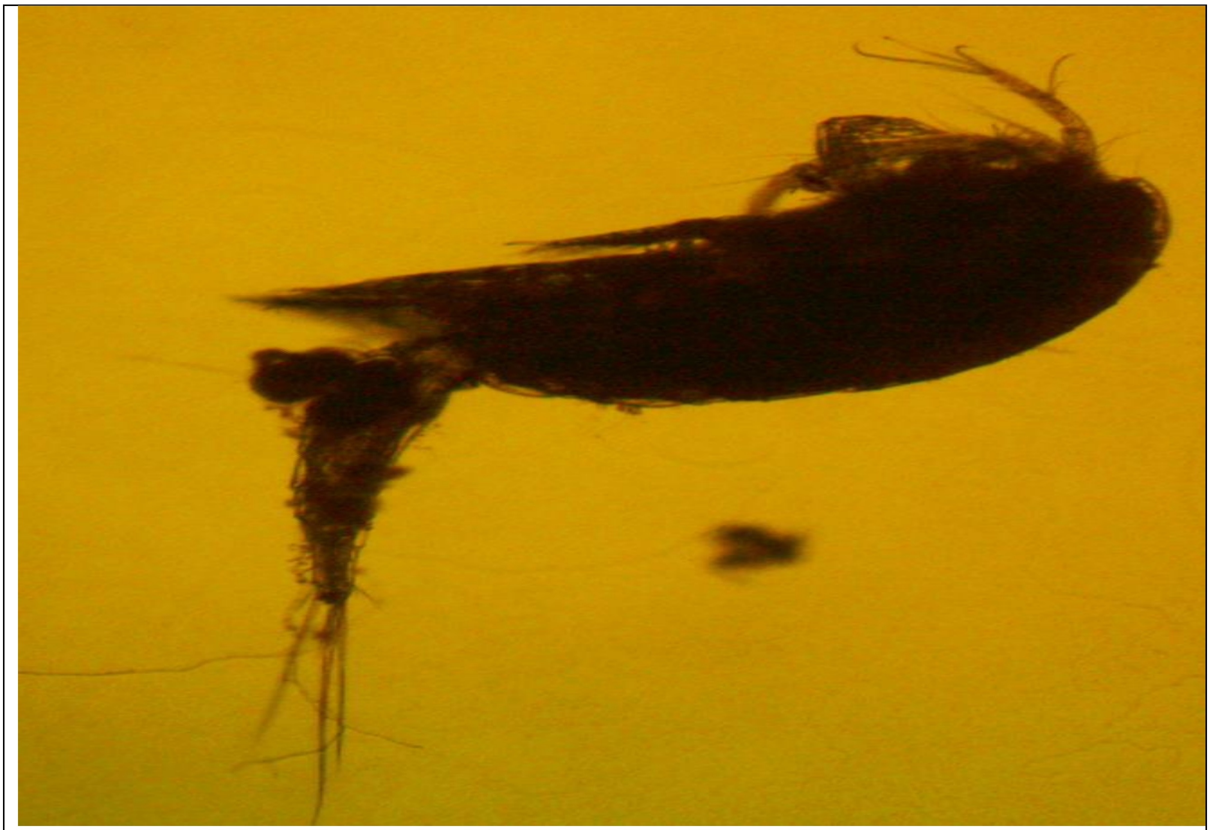

Plate 4.43: *Bryocamptus birsteini*

Plate 4.44: *Filinia opoliensis*

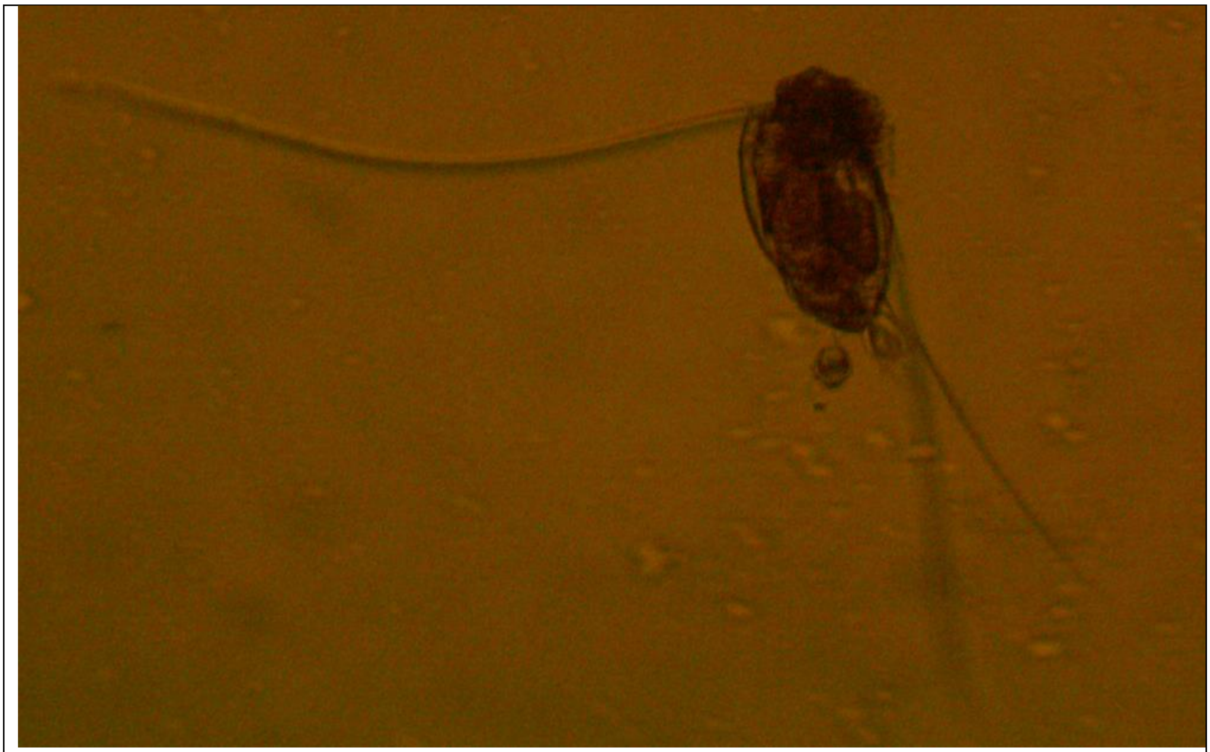

Plate 4.45: *Filinia longiseta*

Plate 4.46: *Epiphanes clavulata*

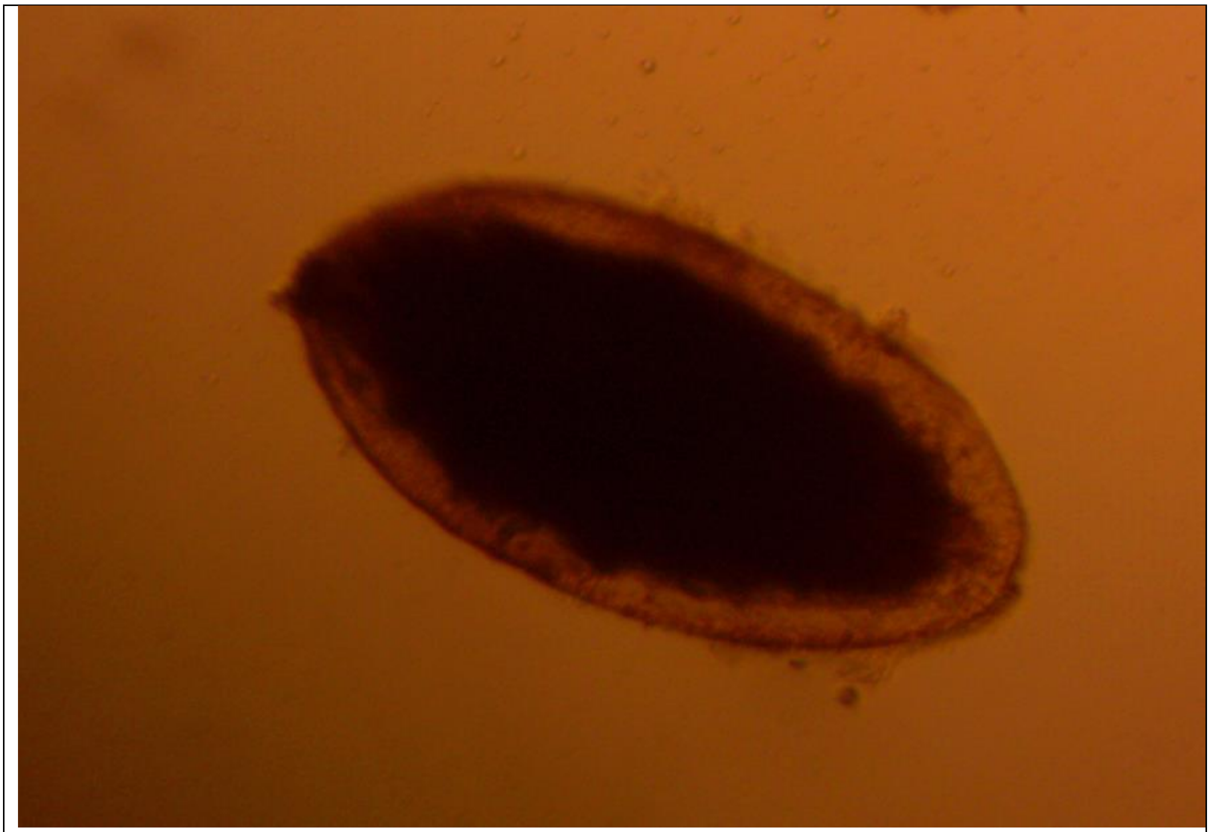

Plate 4.47: *Sclerochilus littoralis*

Plate 4.48: *Unidentified fish Juvenile > 2cm*

Among the Copepoda, *Eudiaptomus gracilis, Tropodiaptomus incognitus* and *Tropodiaptomus galebi* were the most common and contributed more than 80.64% of the total zooplankton community. Moinodaphnia macleayi was the predominant Cladocera. *Moina recticulata, Ceriodaphnia cornuta* and *Simucephalus ventulus* were also commonly seen Cladocera identified during the study. Rotifera recorder lower amount of individual density but was majorly dominated by *Proales decipens, Platyias leloupi*, and *Bryocamptus birsteini.* The results indicate a moderately rich zooplankton assemblage with representation from all major freshwater groups. The presence of diverse Copepoda, Cladocera and Rotifers is consistent with findings from similar freshwater ecosystems in tropical Africa (Akin-Oriola, 2003; Imoobe and Egborge 2010).

4.2.2 Zooplankton Distribution

The distribution of zooplankton encountered during this study is highlighted in Table 4.3. Copepoda recorded higher distribution in station 2 and 3 respectively whereas, station 1 had relatively stable distribution. All three stations showed relatively similar distribution patterns. Cladocera showed variation in distribution across all stations. Station one had the highest distribution whereas station 3 had the least cladoceran distribution. Rotifera had lower distribution compared to Copepoda and Cladocera. Station 1 had the least distribution with only 4 representatives while station 3 had the highest distribution with 7 species recorded. Ostracoda was represented generally by one specie only while Siluriformes was reported to be represented by an unnamed Bagridae juvenile.

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Table 4.3: Distribution of Zooplankton Community Fauna in Obazuwa Lake

Taxonomic Group	STATION 1	STATION 2	STATION 3
COPEPODA			
Cryptocyclops bicolor	+	+	-
Microcyclops rubellus	+	+	+
Microcyclops varicans	+	+	-
Mesocyclops leuckarti	+	+	+
Metacyclops minutus	+	+	+
Thermocyclops crassus	+	-	+
Thermocyclops neglectus	+	+	+
Eucyclops serratulus	+	+	+
Tropocyclops prasinus	+	+	+
Ectocyclops phaleratus	-	-	+
Eucyclops agiloides	-	-	+
Halicyclops troglodytes	+	+	+
Ergasilus sp.	-	+	+
Senecella calanoides	+	+	+
Eudiaptomus gracilis	+	+	+
Tropodiaptomus incognitus	+	+	+
Tropodiaptomus processifer	+	+	+
Thermodiaptomus galebi	+	+	+
Thermodiaptomus yabensis	+	+	+
Tropocyclops extensus	-	+	-
Bryocamptus birsteini	-	+	-
CLADOCERA			
Moinodaphnia macleayi	+	+	+
Moina recticulata	+	+	+
Ceriodaphnia cornuta	+	+	+
Daphnia longispina	+	+	+

Scapholeberis kingi	+	-	+
Simucephalus ventulus	+	+	+
Chydorus pubescens	+	+	+
Chydorus eurynotus	-	-	+
Kurzia longirostris	+	-	-
Pseudosida bidentata	+	+	+
Diaphanosoma excisum	+	+	+
Diaphanosoma sarsi	+	-	+
Moina Micrura	+	+	+
Daphnia pulex	+	-	-
ROTIFERA			
Ascomorpha ecaudis	-	+	-
Asplanchnopus multiceps	+	+	+
Platylas leloupi	-	+	+
Proales decipens	-	+	+
Branchionus calyciflorus amphiceros	-	-	+
Branchionus calyciflorus dorcas	-	-	+
Asplanchna brightwellii	+	-	+
Filinia opoliensis	+	+	-
Filinia longiseta	+	-	-
Epiphanes clavulata	-	-	-
Keratella tropica	-	-	+
OSTRACODA			
Sclerochilus littoralis	+	+	+
SILURIFORMES			
Unidentified Juveniles > 3mm	+	+	+

4.3. Spatial and Temporal Variation in Zooplankton Composition and Abundance

A total of 3771 zooplankton individuals were identified during the study comprising of 8 orders, 17 families and 48 species. 3478 individuals of Copepoda was recorded during the study contributing 92.23% of the total individuals recorded. 207 individuals (5.49%) of Cladocera 32 individuals of Rotifera (0.85%), 18 individuals (0.48%) of Ostracoda and 36 individuals (0.95%) of Siluriformes were recorded throughout the study. The spatial and temporal variation in abundance of in zooplankton taxa is represented in Figures 4.33 – Figure 4.37

4.3.1 Spatial Variation in Zooplankton Composition

Zooplankton encountered during the study varied amongst different stations. The variation in zooplankton composition and abundance is highlighted in Tables 4.4 – Table 4.8. Generally, Station 2 and 3 had relatively higher amount of copepods (17 species) compared to station 1 (16 species). A similar pattern was observed in rotifera where station 2 and station 3 had slightly higher zooplankton composition. However, station 1 and 3 differed from station 2 in terms of cladocera composition and had higher composition (12 and 13 species) respectively compared to 10 species recorded in station 2. Ostracoda and Siluriformes were represented by a single taxon. Across all stations station 3 had the highest zooplankton abundance (1596 individuals), followed by station 1 (1127 individuals) and station 2 (1048 individuals). The order of abundance ranged as follows: station 3 > station 1 > station 2.

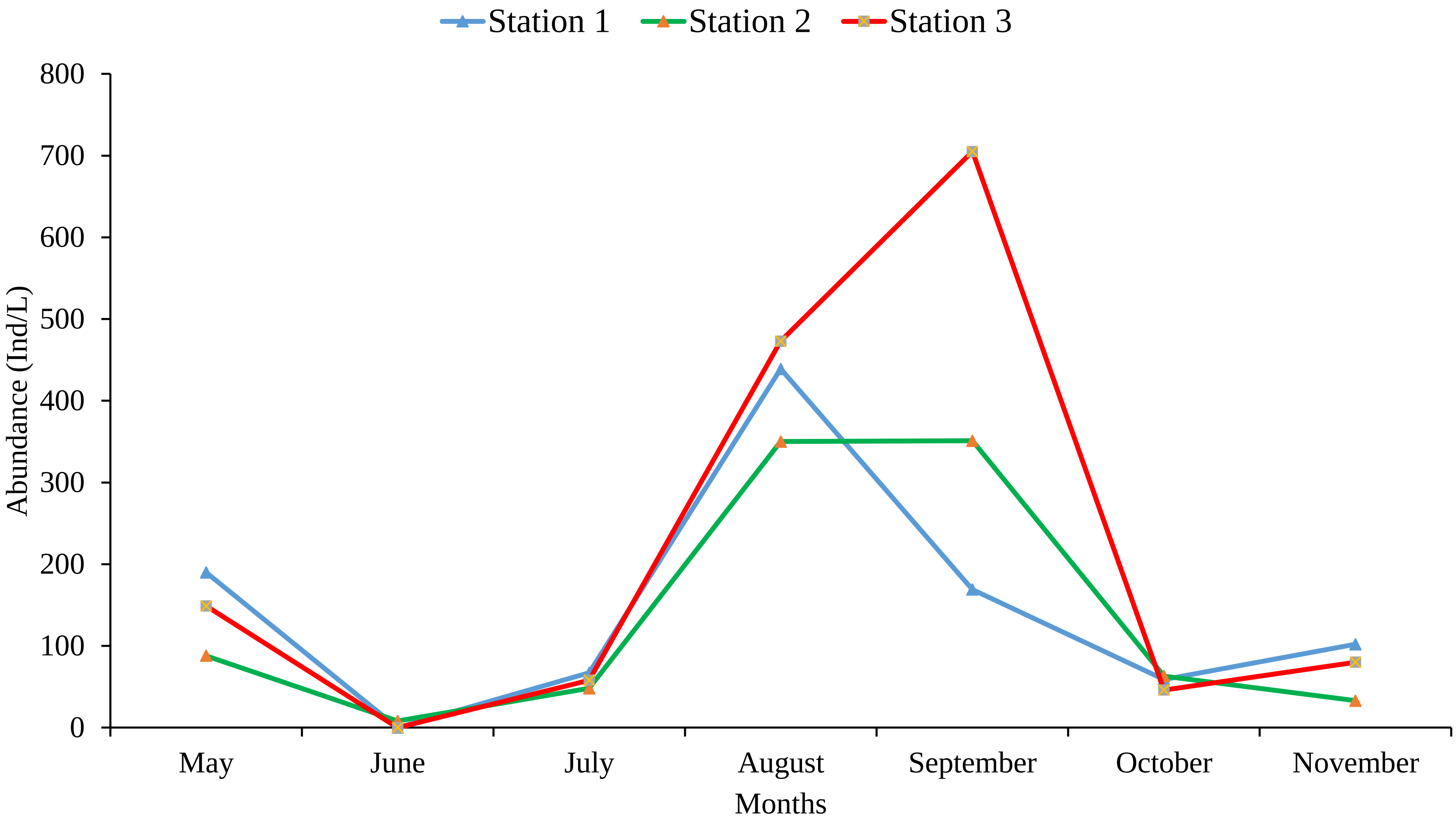

Figure 4.33: Spatial and Temporal variation of Copepoda in Obazuwa lake between May and November 2024

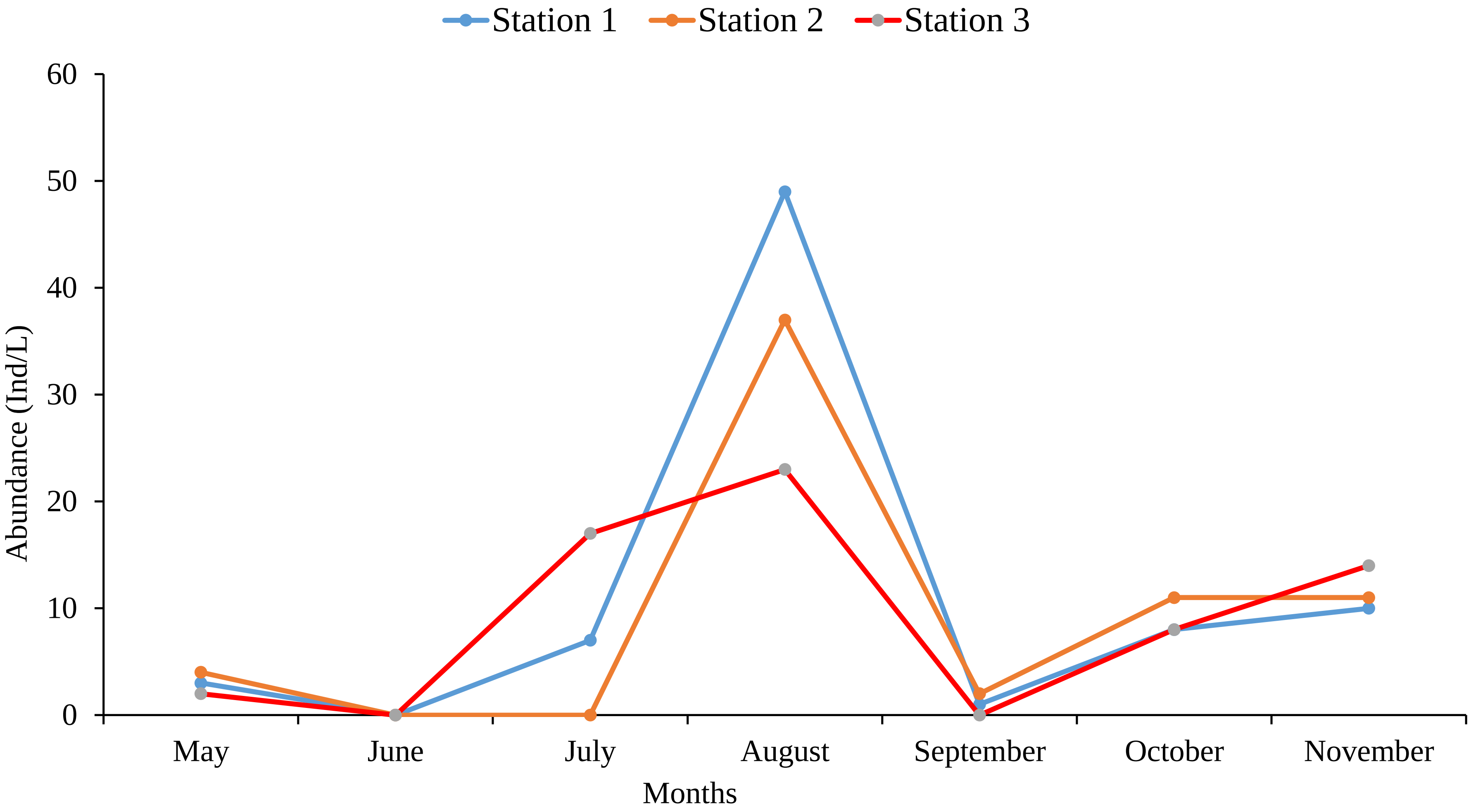

Figure 4.34: Spatial and Temporal variation of Cladocera in Obazuwa lake between May and November 2024

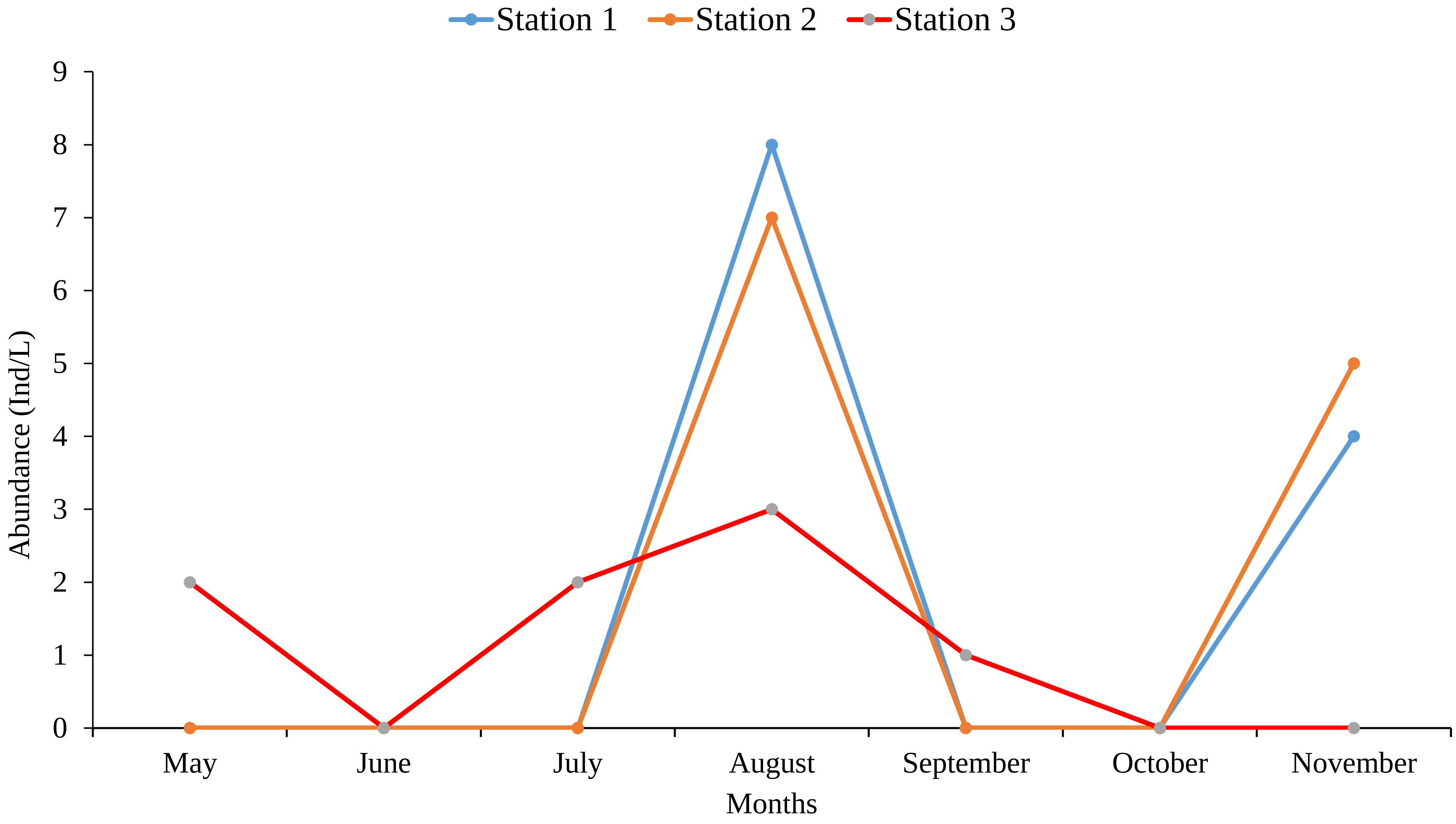

Figure 4.35: Spatial and Temporal variation of Rotifera in Obazuwa lake between May and November 2024

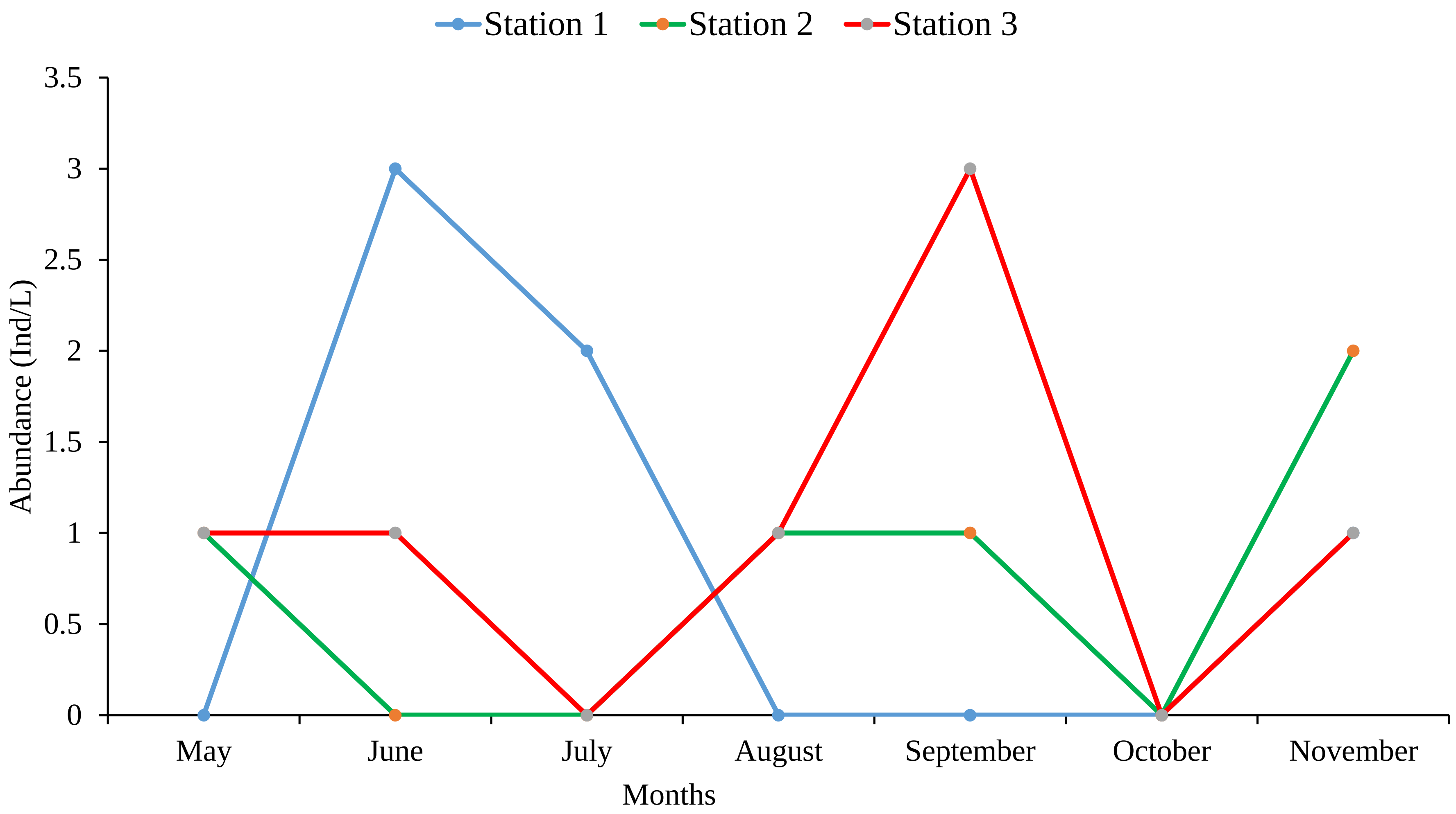

Figure 4.36: Spatial and Temporal variation of Ostracoda in Obazuwa lake between May and November 2024

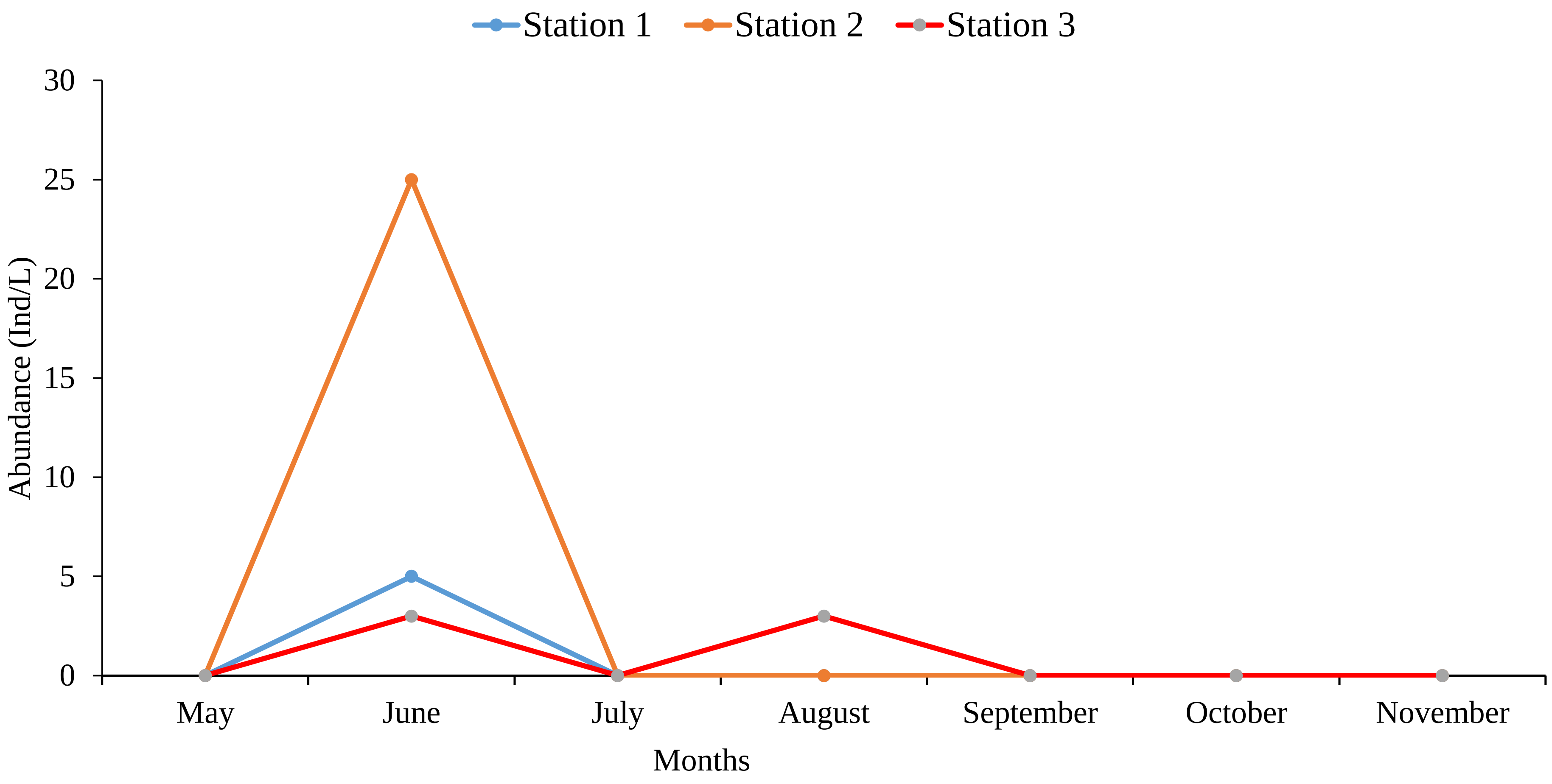

Figure 4.37: Spatial and Temporal variation of Juvenile Fish in Obazuwa lake between May and November 2024

Table 4.4: Spatial Variation of Copepoda Fauna between stations in Obazuwa Lake

COPEPODA SPECIES	STATION 1	STATION 2	STATION 3	TOTAL
Cryptocyclops bicolor	4	2	0	6
Microcyclops rubellus	13	24	7	44
Microcyclops varicans	1	4	0	5
Mesocyclops leuckarti	10	6	8	24
Metacyclops minutus	3	7	17	27
Thermocyclops crassus	3	0	5	8
Thermocyclops neglectus	8	10	14	32
Eucyclops serratulus	15	7	22	44
Tropocyclops prasinus	16	2	21	39
Tropocyclops extensus	0	1	0	1
Ectocyclops phaleratus	0	0	1	1
Eucyclops agiloides	0	0	1	1
Halicyclops troglodytes	1	5	2	8
Ergasilus sp.	0	1	1	2
Senecella calanoides	4	6	17	27
Eudiaptomus gracilis	357	302	578	1237
Tropodiaptomus incognitus	284	291	358	933
Tropodiaptomus processifer	49	37	29	115
Thermodiaptomus galebi	240	209	422	871
Thermodiaptomus yabensis	18	27	8	53
TOTAL	**1026**	**941**	**1511**	**3478**
Total Number of species	**16**	**17**	**17**	**20**

Table 4.5: Spatial Variation of Cladocera Fauna between stations in Obazuwa Lake

CLADOCERA SPECIES	STATION 1	STATION 2	STATION 3	TOTAL
Moinodaphnia macleayi	34	16	24	74
Moina recticulata	8	8	4	20
Moina Micrura	3	6	7	16
Ceriodaphnia cornuta	2	1	3	6
Daphnia longispina	3	16	5	24
Daphnia pulex	2	0	0	2
Scapholeberis kingi	1	0	1	2
Simucephalus ventulus	9	5	6	20
Chydorus pubescens	2	2	1	5
Chydorus eurynotus	0	0	2	2
Kurzia longirostris	1	0	0	1
Pseudosida bidentata	9	9	9	27
Diaphanosoma excisum	4	2	1	7
Diaphanosoma sarsi	0	0	1	1
TOTAL	**78**	**65**	**64**	**207**
Total Number of species	**12**	**10**	**13**	**14**

Table 4.6: Spatial Variation of Ostracoda and Siluriformes of Obazuwa Lake

TAXONOMIC GROUP	STATION 1	STATION 2	STATION 3	TOTAL
OSTRACODA				
Sclerochilus littoralis	6	5	7	18
SILURIFORMES				
Unidentified Bagrid juveniles > 3mm	5	25	6	36

Table 4.7: Spatial Variation of Rotifera Fauna between stations in Obazuwa Lake

ROTIFERA SPECIES	STATION 1	STATION 2	STATION 3	TOTAL
Ascomorpha ecaudis	0	3	0	3
Asplanchnopus multiceps	0	1	1	2
Platylas leloupi	4	1	0	5
Proales decipens	0	4	1	5
Branchionus calyciflorus amphiceros	0	0	2	2
Branchionus calyciflorus dorcas	0	0	2	2
Asplanchna brightwellii	0	0	1	1
Bryocamptus birsteini	4	1	0	5
Filinia opoliensis	0	2	0	2
Filinia longiseta	3	0	0	3
Epiphanes clavulata	1	0	0	1
Keratella tropica	0	0	1	1
TOTAL	**12**	**12**	**8**	**32**
Total Number of species	**4**	**6**	**6**	**12**

Table 4.8: Spatial Variation of Total Zooplankton Fauna in Obazuwa Lake

TAXONOMIC GROUP	STATION 1	STATION 2	STATION 3	TOTAL
Copepoda	1026	941	1511	3478
Cladocera	78	65	64	207
Rotifera	12	12	8	32
Ostracoda	6	5	7	18
Siluriformes	5	25	6	36
Total Number of Individuals	**1127**	**1048**	**1596**	**3771**

between stations 1,2 and 3 (6,5 and 7 individuals respectively). Unidentified juveniles from the Order Siluriformes and family Bagridae dominated station 2 (25 individuals) followed by stations 3 and 1 (6 and 5 individuals respectively).

Twenty (20) species of copepods were reported across all stations viz-a-viz: *Cryptocyclops bicolor, Microcyclops rubellus, Microcyclops varicans, Mesocyclops leuckarti, Metacyclops minutus, Thermocyclops crassus, Thermocyclops neglectus, Eucyclops serratulus, Tropocyclops prasinus, Tropocyclops extensus, Ectocyclops phaleratus, Eucyclops agiloides, Halicyclops troglodytes, Ergasilus sp., Senecella calanoides, Tropodiaptomus incognitus,*

Tropodiaptomus processifer, Thermodiaptomus galebi, Thermodiaptomus yabensis. Cryptocyclops bicolor and *Microcyclops varicans* were absent in station 3 throughout the sampling period. *Thermocyclops crassus* was absent in station 2. *Ectocyclops phaleratus* and *Eucyclops agiloides* was present only in station 3 and absent station 1 and 2. On the other hand, *Tropocyclops extensus* was only present in station 2 but absent in station 1 and 3. *Ergasilus sp.* was present in station 2 and 3 and absent in station 1. All other copepoda species were present across all stations.

Fourteen (14) species of cladocera was identified throughout the three stations sampled. These included: *Moinodaphnia macleayi, Moina recticulata, Moina Micrura, Ceriodaphnia cornuta, Daphnia longispina, Daphnia pulex, Scapholeberis kingi, Simucephalus ventulus, Chydorus pubescens, Chydorus eurynotus, Kurzia longirostris, Pseudosida bidentata, Diaphanosoma excisum* and *Diaphanosoma sarsi.* Cladocera exhibited fairly stable spatial distribution. *Daphnia pulex* and *Kurzia longirostris* were only seen in station 1 and was absent in stations 2 and 3. *Scapholeberis kingi* was absent in station 2 while *Diaphanosoma sarsi* was only present in station 3.

Twelve (12) species of rotifers were encountered during this study. They included: *Ascomorpha ecaudis, Asplanchnopus multiceps, Platylas leloupi, Proales decipens, Branchionus calyciflorus amphiceros, Branchionus calyciflorus dorcas, Asplanchna brightwellii, Bryocamptus birsteini, Filinia opoliensis, Filinia longiseta, Epiphanes clavulata* and *Keratella tropica. Ascomorpha ecaudis* and *Filinia opoliensis* was only recorded in station 2 and absent in station 1 and 3. *Asplanchnopus multiceps* and *Proales decipens* was absent in station 1.

Platylas leloupi and *Bryocamptus birsteini* were present in station 1 and 2 but absent in station 3. *Branchionus calyciflorus amphiceros, Branchionus calyciflorus dorcas, Keratella tropica* and *Asplanchna brightwellii* were recorded only in station 3. *Filinia longiseta* and *Epiphanes clavulata* was present only in station 1. Only 1 species each were recorded for Ostracoda and Siluriformes respectively. All species in these group were present across all stations

4.4. Temporal Variation in Zooplankton Fauna of Obazuwa Lake

This study identified key temporal variations in zooplankton dynamics (composition and abundance) during the seven (7) month duration of study. Zooplankton recorded maximum abundance in the wet season month of August and September. These two months accounted for 68.89% of the total zooplankton recorded in the study. Maximum zooplankton was recorded in august while minimum zooplankton abundance was recorded in June. The temporal variation in abundance, composition and distribution of cladocera is represented in Table 4.9 – Table 15 respectively.

May recorded 439 individuals comprising of 427 copepods, 8 cladocera, 2 rotifers, 2 ostracod and no juvenile fish species recorded. June recorded the least abundance of zooplankton (45 individuals), an abundance of 33 juvenile fish species recorded, 8 copepods and 4 ostracods. No cladocera or rotifer was recorded in the month of June. A total of 201 individuals were recorded in July. Rotifera and Ostracoda was represented each by 2 individuals. July also recorded the disappearance of juvenile fish species while copepod and cladocera were represented by 173 and 24 indiviuals respectively.

An increase was recorded in August as zooplankton reached its highest density of 1364 indiviuals. 1232 copepods, 109 cladocera, 18 rotifers, 2 Ostracods and 3 juvenile fish species were encountered during the month of August. Similarly, high zooplankton (1234 individuals) was also recorded in September with 1225 copepods, 4 cladocera, 4 ostracods and 1 rotifer recorded. No juvenile fish specie was found in the month of September.

The end of October recorded decline (195 individuals) in zooplankton abundance with only 2 taxonomic group (168 copepods and 27 cladocera) recorded respectively. No rotifer, ostracod or juvenile fish was recorded in the month of October. Zooplankton abundance increased slightly (266 individuals) in the ending month of November with 215 copepods, 35 cladocera, rotifers and 4 ostracods recorded. No juvenile fish was recorded during this month.

4.4.1 Temporal Variation in Zooplankton composition

Zooplankton abundance and composition also displayed temporal variations in the distribution of important taxonomic groups. Zooplankton were represented among all groups (Cladocera, Copepoda, Rotifera, Ostracoda, and Juvenile fish *sp.*) in the month of august. On the other hand, the least distribution of zooplankton groups was recorded in October where only copepods and cladocerans were represented, while other groups (rotifera, ostracoda and juvenile fish) were absent and not recorded. May recorded the presence of 4 taxonomic groups (copepods, cladocera, rotifers and ostracods) with juvenile fish being absent while June recoded the absent of cladocera and rotifer (only copepod, ostracod and juvenile fish) present. July, September and November both recorded the absent of juvenile fish *sp.* Respectively.

Table 4.9: Temporal Variation in Copepoda Fauna of Obazuwa Lake

COPEPODA SPECIES	May	Jun	Jul	Aug	Sep	Oct	Nov
Cryptocyclops bicolor	0	0	1	4	1	0	0
Microcyclops rubellus	0	0	36	0	0	1	7
Microcyclops varicans	0	0	3	2	0	0	0
Mesocyclops leuckarti	0	0	13	3	0	0	8
Metacyclops minutus	0	0	19	2	0	4	2
Thermocyclops crassus	0	0	1	1	0	4	2
Thermocyclops neglectus	2	0	17	0	5	3	5
Eucyclops serratulus	0	0	21	11	3	0	9
Tropocyclops prasinus	0	0	10	9	9	4	7
Ectocyclops phaleratus	0	0	1	0	0	0	0
Eucyclops agiloides	0	0	1	0	0	0	0
Halicyclops troglodytes	0	0	5	0	1	0	2
Ergasilus sp.	0	0	0	0	1	0	1
Senecella calanoides	0	0	1	21	5	0	0
Eudiaptomus gracilis	208	2	23	322	591	46	45
Tropodiaptomus incognitus	56	0	6	506	290	30	47
Tropodiaptomus processifer	23	4	0	47	1	26	14
Thermodiaptomus galebi	137	2	12	316	318	41	45
Thermodiaptomus yabensis	1	0	3	20	0	9	20
Tropocyclops extensus	0	0	0	0	0	0	1
TOTAL	**427**	**8**	**173**	**1232**	**1225**	**168**	**215**

Table 4.10: Temporal Variation in Cladocera Fauna of Obazuwa Lake

CLADOCERA SPECIES	May	Jun	Jul	Aug	Sep	Oct	Nov
Moinodaphnia macleayi	3	0	10	40	2	9	10
Moina recticulata	1	0	2	10	0	5	2
Ceriodaphnia cornuta	0	0	1	2	0	0	3
Daphnia longispina	0	0	0	17	0	0	7
Scapholeberis kingi	0	0	0	0	0	1	1
Simucephalus ventulus	0	0	2	11	0	3	4
Chydorus pubescens	1	0	1	3	1	0	0
Chydorus eurynotus	0	0	2	0	0	0	0
Kurzia longirostris	0	0	1	0	0	0	0
Pseudosida bidentata	2	0	2	11	1	4	7
Diaphanosoma excisum	0	0	1	4	0	1	1
Diaphanosoma sarsi	0	0	0	1	0	0	0
Moina Micrura	0	0	2	10	0	4	0
Daphnia pulex	2	0	0	0	0	0	0
TOTAL	**8**	**0**	**24**	**109**	**4**	**27**	**35**

Table 4.11: Temporal Variation in Ostracoda and Juvenile Fish Fauna in Obazuwa Lake

TAXONOMIC GROUP	May	Jun	Jul	Aug	Sep	Oct	Nov
OSTRACODA SPECIES							
Sclerochilus littoralis	2	4	2	2	4	0	4
Unidentified Juveniles > 3mm	0	33	0	3	0	0	0

Table 4.12: Temporal Variation in Rotifera Fauna of Obazuwa Lake

ROTIFERA SPECIES	May	Jun	Jul	Aug	Sep	Oct	Nov
Ascomorpha ecaudis	0	0	0	3	0	0	0
Asplanchnopus multiceps	0	0	0	1	0	0	1
Platylas leloupi	0	0	0	4	0	0	1
Proales decipens	0	0	1	0	0	0	4
Branchionus calyciflorus amphiceros	0	0	1	1	0	0	0
Branchionus calyciflorus dorcas	1	0	0	0	1	0	0
Asplanchna brightwellii	0	0	0	1	0	0	0
Bryocamptus birsteini	0	0	0	4	0	0	1
Filinia opoliensis	0	0	0	2	0	0	0
Filinia longiseta	0	0	0	1	0	0	2
Epiphanes Clavulata	0	0	0	1	0	0	0
Keratella tropica	1	0	0	0	0	0	0
TOTAL	**2**	**0**	**2**	**18**	**1**	**0**	**9**

Table 4.13: Total Zooplankton Fauna in Obazuwa Lake

TAXONOMIC GROUP	May	Jun	Jul	Aug	Sep	Oct	Nov
Copepoda	427	8	173	1232	1225	168	215
Cladocera	8	0	24	109	4	27	35
Rotifera	2	0	2	18	1	0	9
Ostracoda	2	4	2	2	4	0	4
Unidentified Juveniles > 3mm	0	33	0	3	0	0	0
Total	**439**	**45**	**201**	**1364**	**1234**	**195**	**266**

4.4.2 Temporal Variation in Species composition

Thermodiaptomus galebi and *Eudiaptomus gracilis* were the most widespread species across all months studied. *Tropodiaptomus processifer* and *Tropodiaptomus incognitus* were absent in July and June respectively. *Tropocyclops extensus* was only recorded in November, *Thermodiaptomus yabensis* was absent in June and September. *Senecella calanoides* was only present in July, August and September but was absent in May, June, October and November. *Ergasilus sp.* was rarely seen and only present in September and November in low quantities. Similarly, *Eucyclops agiloides* and *Ectocyclops phaleratus* was reported only in July. *Tropocyclops prasinus* and *Eucyclops serratulus* was absent in the initial months of May and June but was recorded in the remaining months with the exception of *Eucyclops serratulus* which was absent in October. *Cryptocyclops bicolor, Microcyclops rubellus, Microcyclops varicans, Mesocyclops leuckarti, Metacyclops minutus* and *Thermocyclops crassus* were all absent at the initial start of the study between May and June. *Cryptocyclops bicolor* was present in July, August and September but was absent in October and November. *Microcyclops rubellus* was absent in August and September but present in October and November. *Microcyclops varicans* and *Mesocyclops leuckarti* were present in July and August but absent in September, October and November with the exception of *Mesocyclops leuckarti* which was present in November. *Metacyclops minutus* and *Thermocyclops crassus* was present in July, August, October and November, however, was absent in September. *Halicyclops troglodytes* was present only in July, September and November. *Thermocyclops neglectus* was absent in July and August

4.4.3 Temporal Variation in Species Distribution

Only 6 species were represented in the month of May. The species included *Eudiaptomus gracilis, Tropodiaptomus incognitus, Tropodiaptomus processifer, Thermodiaptomus galebi*

Thermodiaptomus yabensis and *Thermocyclops negletus* with 208, 56, 23,137,1 and 2 individuals recorded respectively. June recorded the presence of *Eudiaptomus gracilis, Tropodiaptomus processifer* and *Thermodiaptomus galebi* while other species was absent. In July only *Tropocyclops extensus, Tropodiaptomus processifer* and *Ergasilus sp.* were absent. *Microcyclops rubellus, Thermocyclops negletus, Ectocyclops phaleratus Eucyclops agiloides, Halicyclops troglodytes, Ergasilus sp.* and *Tropocyclops extensus* were all absent in August while in September, *Microcyclops rubellus, Microcyclops varicans, Mesocyclops leuckarti, Metacyclops minutus, Thermocyclops crassus, Ectocyclops phaleratus Eucyclops agiloides, Thermodiaptomus yabensis, Tropocyclops extensus* were absent. In October, *Cryptocyclops bicolor, Microcyclops varicans, Mesocyclops leuckarti, Eucyclops serratulus, Ectocyclops phaleratus Eucyclops agiloides, Senecella calanoides, Ergasilus sp., Tropocyclops extensus* were absent while in November, *Cryptocyclops bicolor, Microcyclops varicans, Ectocyclops phaleratus Eucyclops agiloides, Senecella calanoides.*

Moinodaphnia macleayi and *Pseudosida bidentata* were the most widespread cladocera across sampling months being absent only in the month of June. *Moina recticulata* was absent in June and September while. *Ceriodaphnia cornuta***,** *Daphnia longispina, Simucephalus ventulus, Diaphanosoma excisum, Diaphanosoma sarsi and Moina Micrura* were all absent during the months of May and June. *Ceriodaphnia cornuta* was also absent in September and November, *Simucephalus ventulus* in September, *Diaphanosoma excisum* in October, while *Daphnia longispina* was absent in July, September and October. *Daphnia pulex* and *Diaphanosoma sarsi* were recorded only in May and August respectively. *Scapholeberis kingi* was only reported in the months of October and November, while *Chydorus eurynotus and Kurzia longirostris,* were found only in the month of July. *Chydorus pubescens* was present only in May, July, August, September but was absent in June, October and November. *Moina micrura* was recorded only in of July, August and October.

Rotifers showed minute abundance throughout the months of study. *Ascomorpha ecaudis, Asplanchna brightwellii, Epiphanes clavulata* and *Filinia opoliensis* were recorded only in the months of August. *Keratella tropica* was only recorded in the months of May. *Asplanchnopus multiceps, Filinia longiseta, Bryocamptus birsteini* and *Platylas leloupi* were recorded only in August and November. *Proales decipens* was recorded in July and November. *Branchionus calyciflorus amphiceros* was recorded in June and August while *Branchionus calyciflorus dorcas* was recorded in May and September. Generally, Rotifera species were more predominant in August and November. May, July and September all recorded lower abundance of Rotifers whereas June and October recorded no rotifer species.

Ostracoda also recorded lower density of individuals in the study. Only one species was recorded *Sclerochilus littoralis* and was quite widespread across all months with the exception of October which had no record of the species. Siluriformes was represented by a number of *Bagridae sp.* of juvenile fish. These juveniles dominated the month of June, was slightly recorded in the month of August. However, May, July, September, October and November recorded no occurrence of these juveniles.

4.5 Zooplankton Diversity Index

A number of ecological diversity indices were used to assess zooplankton community structure across stations. The results revealed clear variations in evenness, species richness and diversity among the stations (Table 4.14).

4.5.1 Species Richness and Abundance

Species richness, as indicated by Taxa (S) and Margalef index, varied slightly across the stations. Station 3 recorded the highest taxa number (34 species) and a Margalef value of 4.881, with greater species richness compared to Station 2 (Margalef = 4.745) and Station 3 (Margalef = 4.696).

Table 4.14: Diversity Indices of Zooplankton Composition of Obazuwa Lake

INDICES	STATION 1	STATION 2	STATION 3
Taxa (S)	34	34	37
Individuals	1127	1048	1596
Dominance (D)	0.2132	0.2039	0.2528
Simpson_1-D	0.7868	0.7961	0.7472
Shannon (H)	2.003	2.065	1.788
Evenness (e^H/S)	0.2181	0.2319	0.1616
Brillouin	1.95	2.008	1.749
Menhinick	1.013	1.05	0.9262
Margalef	4.696	4.745	4.881
Equitability_J	0.5681	0.5856	0.4952
Fisher_alpha	6.609	6.726	6.767
Berger-Parker	0.3168	0.2882	0.3622
Chao-1	36.5	36.5	48

The Menhinick index on the other hand revealed that station 2 had more specie richness followed by station 1 and 3. Although low, the values of Menhinick index indicated rich communities across sites. The total number of individuals also differed, with Station 3 having the largest count (1596 individuals), Station 1 slightly lower (1127 individuals), and Station 2 the least (1048 individuals).

The Fisher's alpha and Chao-1 estimators confirmed relatively stable richness across the stations, with Fisher's alpha values ranging from 6.609–6.767 and Chao-1 estimates ranging from 36.5–48 revealed the potential presence of a few undetected species in the samples.

4.5.2 Diversity and Dominance Patterns

The Simpson's Diversity Index (1 – D) ranged from 0.7472 to 0.7961, with the highest value recorded at Station 2 (0.7961), denoting lower dominance and higher diversity. Station 3 (0.7472) exhibited the lowest Simpson's index, and recorded relatively higher dominance by few taxa. The Shannon–Wiener index (H′) showed a similar pattern, ranging from 1.788 in Station 3 to 2.065 at Station 2. These results indicated that Station 2 supported the most diverse and evenly distributed zooplankton community, while Station 3 showed a comparatively less diverse assemblage.

The Brillouin index ranged from 1.749 in station 3 to 2.008 in station 2, confirming that station 2 was the most diverse sampling site, while station 3 was the least diverse. The low range of Berger-Parker index also confirmed the low dominance of species in Obazuwa lake

4.5.3 Evenness and Equitability

The Pielou's Evenness (e^H/S) values ranged between 0.1616 and 0.2319, suggesting moderate species distribution uniformity within each station. The Equitability (J) index also showed low variation among stations (0.49–0.58), indicating that although some species were more abundant, the overall evenness remained moderately consistent across sites. This suggests that the zooplankton community was neither highly skewed nor entirely uniform in its composition.

4.6 Correlation of Physicochemical parameters with zooplankton abundance

Pearson's correlation was used to assess the relationship between physicochemical parameters and zooplankton taxonomic groups. Appendix 2 and 3 shows the correlation coefficients between physicochemical parameters and zooplankton taxa distribution in Obazuwa Lake reporting how environmental conditions influenced the occurrence and abundance of these taxa. The statistical significance levels were denoted by * ($p < 0.05$) and ** ($p < 0.01$). Copepoda displayed significant positive correlations with nitrate ($r = 0.580$, $p < 0.01$) but negative relationships with BOD ($r = –0.448$, $p < 0.05$) and COD ($r = –0.485$, $p < 0.05$). Cladocera correlated significantly with air temperature ($r = 0.491$, $p < 0.05$) and nitrate ($r = 0.496$, $p < 0.05$). This suggests that the ambient warm temperature range reported in this study favoured cladocera abundance. Nutrient however enhanced the abundance of both copepods and cladocera. Rotifera exhibited moderately positive correlations with total suspended solids ($r = 0.676$) and zinc ($r = 0.954$), indicating their tolerance of increased turbidity and trace metal presence, possibly due to adaptive feeding mechanisms.

Ostracoda showed mostly weak and insignificant relationships with most parameters due to limited sensitivity to short-term variations with water variables. Siluriformes displayed a significant negative correlation with total hardness (–0.571, $p < 0.01$). Temperature generally showed a holistic influence on all taxonomic groups. Air temperature positively influencing Cladocera while water temperature showed weak negative relationships with remaining taxa. Water temperature however, showed slight minor negative correlation with Rotifera ($r = –0.279$).

The lake was within the stable limits for zooplankton survival and hence showed weak correlation with pH. Siluriformes appeared mildly affected by pH variations. Conductivity correlated weakly with Rotifera and Cladocera. Increased ionic concentration might favour zooplankton productivity by enhancing nutrient solubility. Dissolved oxygen had a weak to moderate positive influence on Copepoda (r = 0.360) whereas Siluriformes showed almost no dependence on dissolved oxygen. Organic pollution indications like BOD and COD, inversely affected the relative abundance of Copepoda, however, Siluriformes showed a mild positive correlation with BOD. Nutrients particularly nitrate, exhibited the strongest positive correlations with zooplankton (Copepoda and Cladocera).

Phosphate, however, showed no significant correlation with any taxa. Salinity, total dissolved solids, and total solids generally showed weak relationships with most organisms, although Rotifera displayed a strong positive relationship with TDS (r = 0.964). Iron stimulates primary productivity which invariably can skew zooplankton abundance. Heavy metal correlations revealed that iron showed strong linear associations with Copepoda (r = 0.825) and Cladocera (0.717). Lead, on the other hand, showed weak negative correlations across all zooplankton taxa. Chromium exhibited negative relationships, particularly with Ostracoda (r = –0.336) and Siluriformes (r = –0.148). Zinc and copper showed generally positive but non-significant relationships, with zinc correlating strongly with Rotifera and Cladocera.

4.7 Multivariate Relationship between Zooplankton and Physicochemical Parameters

The Canonical Correspondence Analysis (CCA) was performed to understand the relationship between zooplankton community structure and physicochemical characteristics of Obazuwa Lake (Figure 4.38). The first two canonical axes accounted for approximately 86.7% of the total variance (Axis 1 = 54.43%; Axis 2 = 32.24%). Axis 1 was associated with organic pollution and temperature-related parameters, such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), sulphate, manganese, and water temperature. The strong relationships of these parameters indicated that Obazuwa lake exhibited periodic eutrophication and organic enrichment, especially from anthropogenic inputs like domestic effluents and agricultural runoff. In contrast, Axis 2 was associated with water hardness, magnesium, nitrate, and pH. These parameters contributed to the geochemical and ionic buffering capacity of the lake

The Redundancy Analysis (RDA) was performed to evaluate the linear relationships between zooplankton community structure and physicochemical parameters across the sampling stations (Figure 4.39). RDA model reported R^2 value of 3.145 and an adjusted R^2 of –5.128. F-ratio ($F = 0.3801$) and the permutation test ($p = 0.863$; $n = 999$) revealed that the relationship between biological and physicochemical qualities of water was not significant ($p > 0.05$). RDA biplot displayed long vectors for sodium, potassium, nitrate, and temperature and shorter vectors for calcium, alkalinity, and hardness on the opposite side of Axis 1.

The Principal Component Analysis (PCA) was carried out to identify patterns and relationships between physicochemical characteristics of water and zooplankton orders of Obazuwa lake. The first two principal components (PC1 and PC2) explain 51.265% of variability of both characteristics. In the first principal component, parameters such as Manganese, Nitrate, Total solids, TDS, Magnesium, EC, dissolved oxygen, Iron, Potassium, Sodium, Lead, Water temperature and Air temperature all showed positive loadings whereas Copper, Zinc, total hardness, salinity, pH, TSS, turbidity, calcium, phosphate, alkalinity, sulphate, chromium, BOD and COD displayed negative relationships. Sulphate, chromium, BOD, COD, lead, air temperature and water temperature displayed by the second principal component showed negative relationships while all others displayed positive association. Flosculariaceae, Plioma, Ctenopoda displayed positive and negative association in PC2 and PC1 respectively whereas

Harpacticoida and Anomopoda showed positive relationships in both Principal components. All groups were in closed proximity with copper and zinc indicative of the strong influence of these heavy metals on their abundance and distribution. They were however influenced moderately by other parameters along PC1 axis. Similarly, Cyclopoida, Podocopida and Calanoida showed positive association in both PC1 and PC2 and were influenced heavily by Nitrate, Total solids, TDS, Manganese and Magnesium but were moderately influenced by iron, EC, dissolved oxygen, potassium and sodium. On the other hand, Siluriformes juveniles showed negative association with physicochemical characteristics, occasionally influenced subtly by water parameters.

4.8 Water Quality Analysis

The Arithmetic Mean Water Quality Index (WQI) and the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was computed using selected physico-chemical parameters. This was then used to quantify the overall quality of water and suitability for domestic purposes of Obazuwa Lake,

4.8.1 Arithmetic Mean Water Quality Index (WQI)

The computed Arithmetic WQI values and corresponding classifications are presented in Table 4.17. The results indicated that all three sampling stations fall under Grade E of the WQI classification, representing poor water quality conditions that are unsuitable for domestic and drinking purposes. The very high WQI values (739.005 to 774.126) indicated that several parameters exceeded the acceptable limits for surface and potable water. This suggests that the water sources are heavily influenced by man-made routines such as domestic waste discharge, farmstead runoff, or other pollution sources within the catchment area.

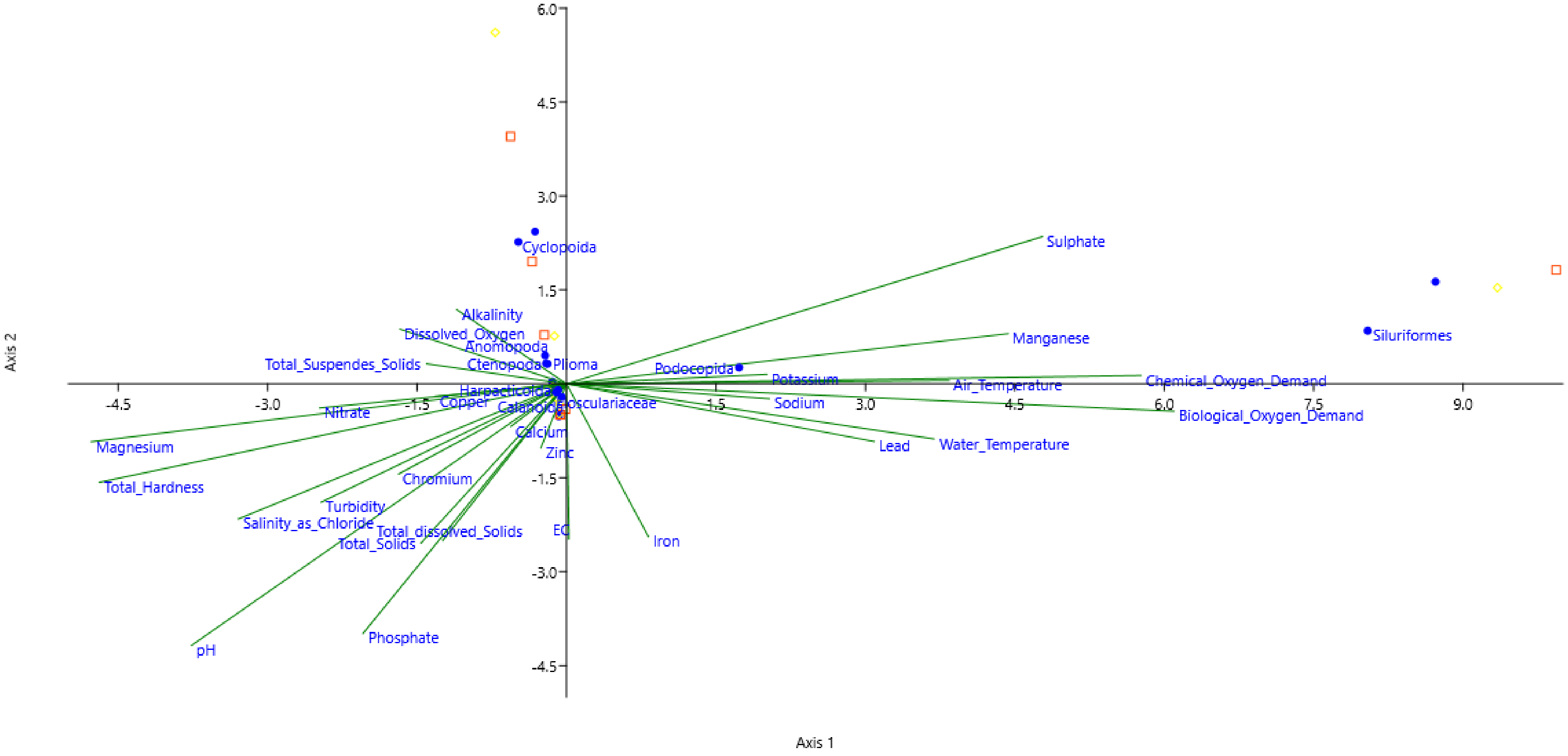

Figure 4.38: Canonical Correspondence Analysis (CCA) of Zooplankton Orders and Physicochemical Characteristics of Obazuwa Lake

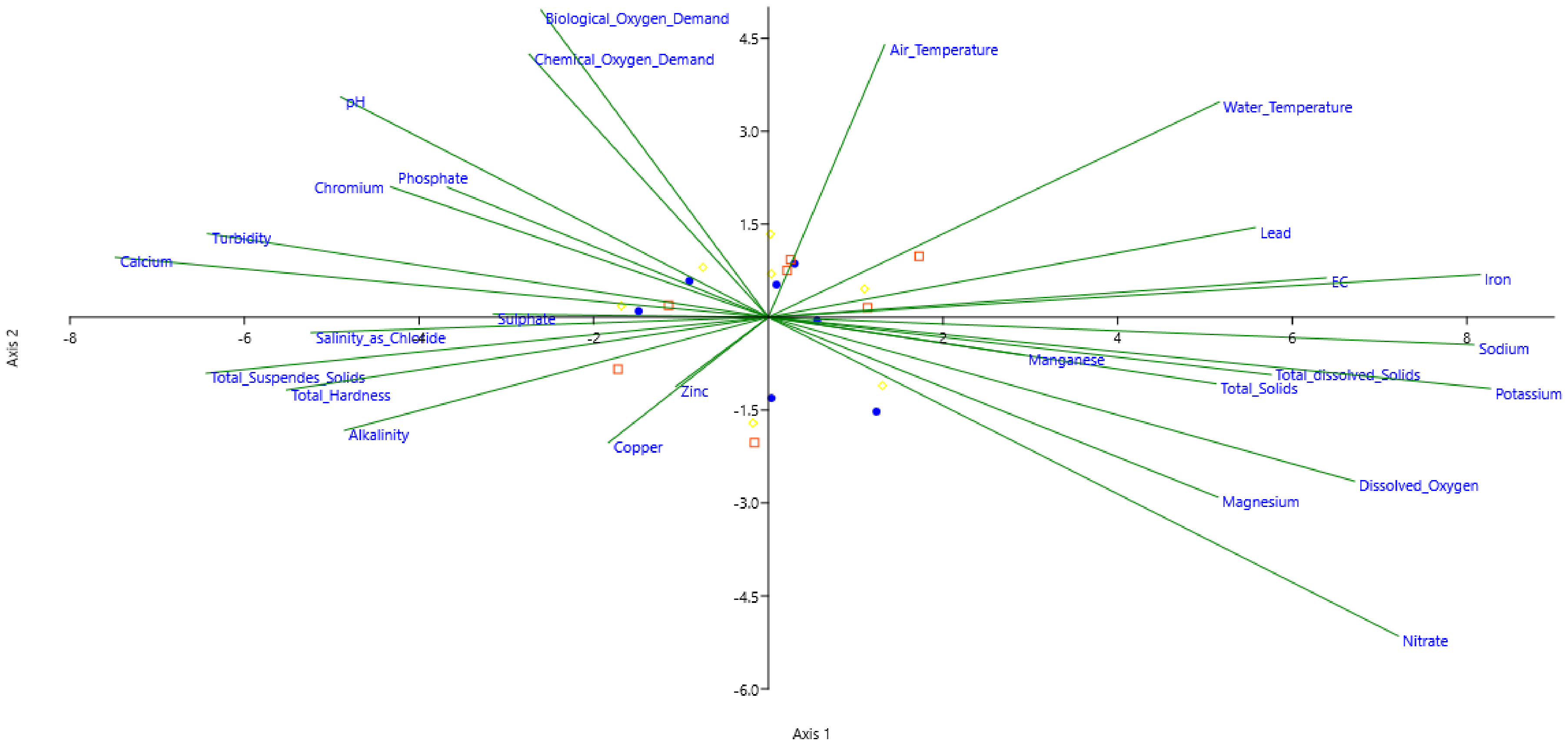

Figure 4.39: Redundancy Analysis (RDA) Showing Linear Relationship between Zooplankton Orders and Physicochemical Characteristics

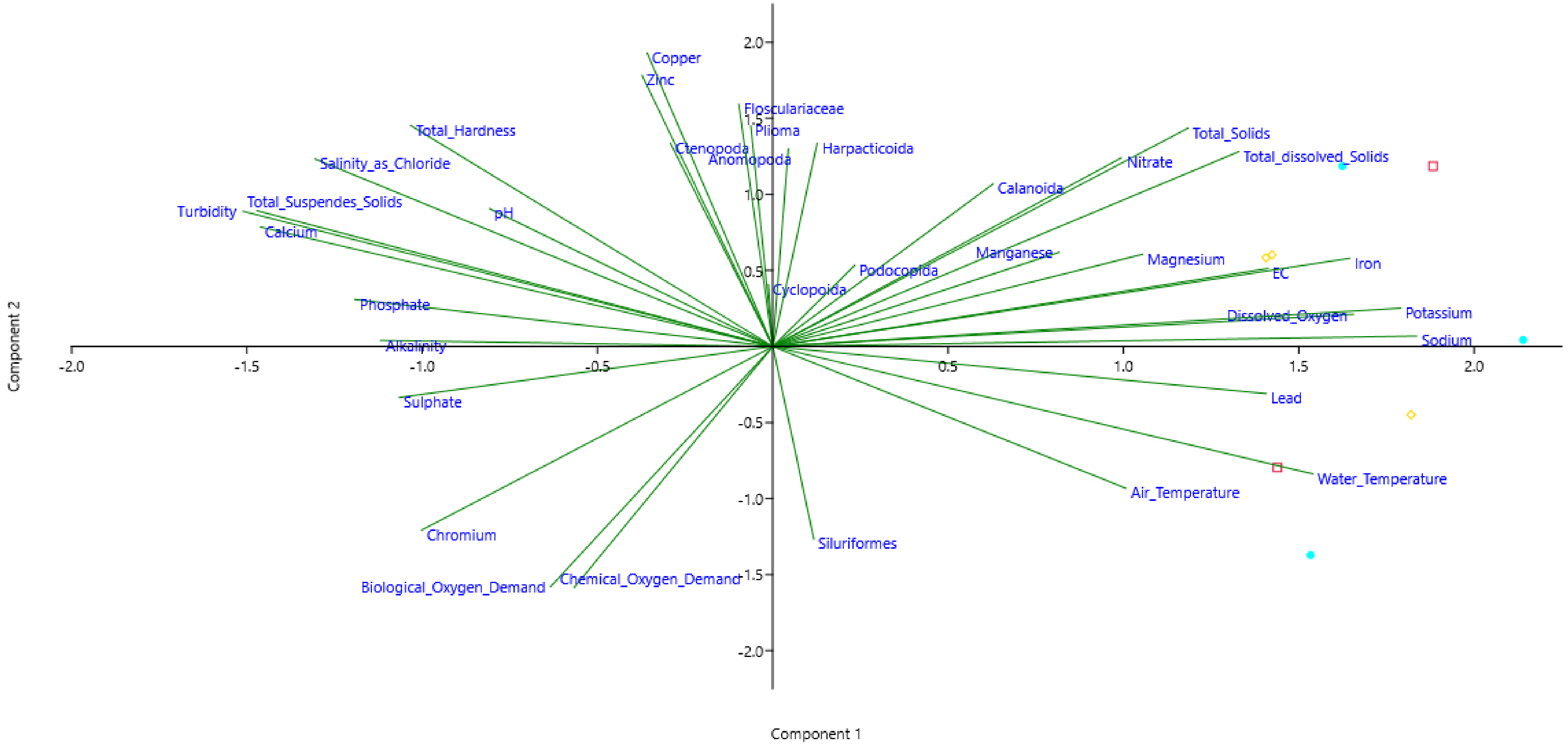

Figure 4.40: Principal Component Analysis (PCA) Showing Relationship between Zooplankton Orders and Physicochemical Characteristics

4.8.2 CCME Water Quality Index (WQI)

The CCME WQI was also used to provide a more comprehensive evaluation by considering the scope, frequency, and amplitude of water quality variable. The results and corresponding rankings are shown in Table 4.18. Results revealed that all stations recorded “Fair” water quality. This indicates that, while the water quality generally supports aquatic life, it was occasionally impaired by exceedances in some parameters. The index values (78.13 – 79.96) suggests moderate pollution levels but not as severe as indicated by the arithmetic WQI. Overall, both indices indicated that the water quality across all stations was compromised and not ideal for human consumption without precise water treatment.

Table 4.15: Arithmetic Mean Water Quality Index (WQI) Values, Grades and Water Quality Characteristics for the Sampling Stations of Obazuwa Lake (Brown *et al.* 1972).

	WQI	Grade	Water Quality Characteristics
Station 1	750.7401	Grade E	Unsuitable for drinking
Station 2	774.4126	Grade E	Unsuitable for drinking
Station 3	739.005	Grade E	Unsuitable for drinking

Table 4.16: Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) Rankings and Water Quality Characteristics for the Sampling Stations (CCME, 2001)

	CCME WQI	Ranking	Water Quality Characteristics
Station 1	79.96670605	Fair	The overall water quality is generally maintained, though it may occasionally face threats or degradation. In some, instances, water conditions deviate from the preferred standards.
Station 2	78.13749705	Fair	Water quality is sustained at acceptable levels but can sometimes experience minor impairment. Certain parameters may fall temporarily outside ideal conditions.
Station 3	79.78566217	Fair	The water quality remains adequate most of the time, yet it may occasionally show signs of stress or mild deterioration, with specific measures occasionally differing from optimal levels

CHAPTER FIVE

DISCUSSION

A total of 27 physicochemical parameters were assessed during this study. The results revealed no significant difference between the physicochemical characteristics measured across the study stations. This finding aligns with Adubor *et al.* (2025), Komolafe and Imoobe (2020), Ekperusi *et al.* (2022) and Ebisi *et al.* (2022) who also reported no significant difference in parameters recorded across stations.

5.1 Physical and Chemical Characteristics of Obazuwa Lake

Temperature influences almost all characteristics of water bodies and plays crucial role in the sustenance of a lake. The observed mean air temperature during the study ranged from 24.8°C to 29.1°C and was lower than those observed by Olomukoro *et al.* (2016) and Dirisu *et al.* (2019) at Asarama estuary. Similar temperature variations were recorded by Komolafe and Imoobe (2020). Iyagbaye and Iyagbaye (2023) also recorded relatively higher temperature of (25 – 35°C). Likewise, Mohammed *et al.* (2023) reported higher mean air temperature of 32.89°C. Air temperature did not exert a significant effect on the water temperature recorded in this study.

The mean water temperature in this study ranged from 26.90°C-27.30°C, which agrees with the findings of Anani and Olomukoro (2021), Adubor *et al.* (2025), Ekperusi *et al.* (2022), and those of Dangana lake by Ebisi *et al.* (2022) who reported comparable mean water temperature between 23.5 - 26.65°C at different stations. This results also corresponds with findings on Owan river by Iyagbaye and Iyagbaye (2023) who recorded water temperature range of 25.10°C – 33.70°C, though slightly higher than those obtained in this study. However, this study contrasts with Amoebi *et al.* (2023), who reported higher temperature values of 28.8°C – 29.0°C. In comparison, Jonah *et al.* (2020) recorded a similar range but noted that water temperature peaked in January, whereas in this study, water temperature reached it maximum temperature in May. Comparing results from this study with previous research shows that the findings did not agree with Anyanwu *et al.* (2023) for Anambra river whereas Anyanwu *et al.* (2021) and Isibor *et al.* (2020) recorded similar concentration ranges across stations. Asibor and Adeniyi (2021) and Anyanwu and Mbekee (2020) recorded similar mean temperature ranges of (24.61℃ – 29.20℃). and (21℃- 28℃) respectively. Rabiu *et al.* (2025) observed similar mean water temperature (27.03℃) whereas Mohammed *et al.* (2023) recorded slightly higher water temperature (28.12℃). Jonah *et al.* (2020) found lower water temperature compared to the study whereas Fan *et al.* (2023) recorded water temperature as low as 4.8 – 6 ℃. The temperature recorded in this study is typical of freshwater bodies and acted as a stabilizing factor for the sustenance of the vast diversity and composition of zooplankton recorded in this study.

Mean Dissolved Oxygen within the present investigation, fluctuated between 2.57 mg/l to 3.00 mg/l. this range falls below the acceptable range recommended by FMEnV (5-12mg/l). However, this values differed from those reported Ebisi *et al.* (2022), Anyanwu *et al.* (2023) and Amoebi *et al.* (2023) (3.3 – 5.0 mg/l) who recorded higher values DO concentration. The minimum and maximum DO concentration observed in the present work corresponded closely with the findings of Jonah *et al.* (2020) who reported spatial variation between 1.9 – 7.8 mg/l and Anyanwu *et al.* (2021) who recorded levels between 1.6 – 6.1 mg/l. In contrast, Isibor *et al.* (2020) reported higher results for DO and did with not agree with the study. Asibor and Adeniyi (2021) also recorded higher Dissolved oxygen of 3.23 – 5.64 mg/l while Iyagbaye and Iyagbaye (2023) recorded dissolved oxygen of 4.90 – 6.80 mg/l which do not aligns with the results of this study. Similarly, Anyanwu and Mbekee (2020) reported higher dissolved oxygen of (3.2 – 6.4 mg/l) compared to this study. Studies by Rabiu *et al.* (2025) and Mohammed *et al.* (2023) also documented slightly higher DO concentration compared to this study. Fan *et al.*

(2023) recorded high dissolved oxygen (9.9 – 12.1 mg/l) yet remained beneath the concentration recorded by Ihejirika *et al.* (2023). The low DO present through the study is attributed to organic loading of the lake by allochthonous input and occasional runoffs from anthropogenic activities (runoffs from industrial grinding mills, open defecation and refuge dumpsites). Similar unsatisfactory DO were also recorded by Egun and Oboh in Ikpoba Reservoir.

In this study, mean BOD ranged from 5.59 – 6.7 mg/l. Ebisi *et al.* (2022) and Amoebi *et al.* (2023) recorded lower amounts of mean BOD (3.00 – 3.12) and (1.5 – 3.5 mg/l). These recorded figures showed marginal reduced levels compared to those as recorded in the present investigation. Jonah *et al.* (2020) and Isibor *et al.* (2020) also recorded lower BOD, but did not follow the trend observed in BOD. Conversely, Anyanwu *et al.* (2023) documented that Anambra river exhibited rich biological oxygen demand. Anyanwu *et al.* (2021) did not agree with this study whereas Asibor and Adeniyi (2021) reported lower BOD (0.55 – 1.10). Iyagbaye and Iyagbaye (2023) reported lower BOD concentration (1.90 – 4.50 mg/l). Anyanwu and Mbekee (2020) and Mohammed *et al.* (2023) also reported lower BOD (1.5 – 4.2) alongside. Biological Oxygen demand was higher during the wet season in contrast to the dry season month of November. This observed low BOD recorded indicated moderate to excessive organic pollution of the lake.

The Hydrogen ion concentration in this study ranged from 6.53 to 6.68 across sampled stations, indicating slightly acidic to neutral conditions. These values comply with the FMEnv. (2011) recommended limit of 6.5 to 8.5 suitable for aquatic life and is typical of most freshwater bodies in Nigeria. Iyagbaye and Iyagbaye (2023) reported similar range of pH at Owan river (6.10 – 7.90) despite recording higher pH ranges in some months. The values recorded in this study was slightly lower than those observed by Ebisi *et al.* (2022), who reported range of (6.88 to

7.05) and Mohammed *et al*. (2023) who recorded mean pH of 7.03 across stations. This study also conforms to similar results by Isibor *et al.* (2020) who reported lower mean pH of 6.03 – 6.70. Jonah *et al.* (2020) also reported similar acidic to slightly alkaline range for pH. However, Asibor and Adeniyi (2021) and Anyanwu *et al.* (2023) reported slightly alkaline concentrations of 7.46 – 8.07 and 7.57 – 7.89. Mean pH reported by Rabiu *et al.* (2025) and Komolafe and Imoobe (2020) was also consistent with the findings of this study while Ihejirika *et.al.* (2023) recorded similar pH range (5.90 – 7.44) with this study. The range of pH recorded in this study were fairly stable, consistent with tropical freshwater bodies and poses no significant threat to aquatic life.

The mean electrical conductivity recorded in this study ranged from 63.14 – 70.43 µS/cm which falls within the permissible limits for portable water sources in Nigeria. Electrical conductivity mirrors freshwater body’s ability to convey electrical current and is primarily influenced by ionic contents of the lake. The moderate conductivity observed across all sampling stations suggest minimal influence from industrial activities near the study area. Related studies carried out by Ebisi *et al.* (2022) reported higher conductivity ranges (86.43 – 98.80 µS/cm) and did not agree with the findings of this study. Similarly, Amoebi *et al.* (2023) did not align with this study recording much higher conductivity levels above the permissible limits (1667 – 1675 µS/cm) while extremely high levels of electrical conductivity were also recorded by Mohammed *et al.* (2023). Jonah *et al.* (2020) and Anyanwu *et al.* (2021) recorded similar mean conductivity levels (62.3 – 70.9 µS/cm) and (45 – 168.4 µS/cm) respectively. Anyanwu *et al.* (2023) reported lower levels of conductivity (12.8 – 22.3 µS/cm) similar to those recorded by Ihejirika *et al.* (2023) while Asibor and Adeniyi (2021) (98 – 120 µS/cm) and Rabiu *et al*. (2025) (127.5 µS/cm). recorded higher conductivity in comparison to this study.

Turbidity is often measured in retrospect to the clearness, clarity or sediment characterization loading of aquatic systems. Turbidity values in this study ranged from 18.01 NTU - 21.94 NTU comparable to the ranged of (12.0 – 28.2 NTU) recorded by Jonah *et al.* (2020) for Uta Ewa Estuary. The findings of this study did not however, comply with those reported by Asibor and Adeniyi (2021). Anyanwu *et al.* (2023) and Iyagbaye and Iyagbaye (2023) recorded far lower mean turbidity concentration of (3.6 to 4.7 NTU) and (3.3 – 13.5 NTU) in contrast to findings observed in this study. Similar turbidity levels were reported by Rabiu *et al.* (2025) and Jonah *et al.* (2020) who recorded Low concentration level between (8.32 – 17.15 NTU). The relatively moderate to high turbidity recorded in this study reflects the overall passage of runoffs into the lake, confirming the relationship between water drains from surrounding domestic homes and farms into the lake.

Total dissolved solids (TDS), Total suspended solids (TSS) and Total solids (TS) are all indicators of the degree of suspension or dissolution of solids in aquatic bodies. Total dissolved solids (TDS) ranged from 31.00 to 35.00 mg/l, comfortably below the WHO allowed threshold of 1000 mg/l. The values obtained were substantially lower than those reported by Amoebi *et al.* (2023) (702 mg/l - 714 mg/l) but higher than those of Anyanwu *et al.* (2023). Adeniyi (2021) and Iyagbaye and Iyagbaye (2023) also reported higher TDS levels, while Rabiu *et al.* (2025) found markedly lower TDS values (6.00 mg/l) whereas Anyanwu and Mbekee (2020) reported high total dissolved solids (25.7 – 55.3 mg/l).

Mean Total Suspended Solids (TSS) in this study ranged from 7.98 – 11.27, which is significantly below the FMEnv (2011) permissible limit of 30mg/l, indicating water quality suitable for aquatic life. Anyanwu *et al.* (2023) reported lower TSS range (3.62- 4.91 mg/l) while Iyagbaye and Iyagbaye (2023) observed slightly higher level of suspended solids (mean total of 12.48). In contrast, Jonah *et al.* (2020) and Ihejirika *et al.* (2023) recorded relatively higher TSS concentration. Total solids recorded in this study ranged from 39.72 to 44.56 mg/l. These findings are consistent with those of Iyagbaye and Iyagbaye (2023) but higher than values reported by Anyanwu *et al.* (2023).

Total hardness across all sampling stations ranged from 31.56 – 34.30 mg/l. These values were lower than 44. – 52.2 mg/l reported by Anyanwu *et al.* (2023) in Anambra River but higher than those reported by Iyagbaye and Iyagbaye (2023). This finding were in contrast with Mohammed *et al.* (2023) who recorded extremely high hardness across stations whereas slightly higher concentration of hardness (53.10 – 58.34 mg/l) was recorded by Jonah *et al.* (2020). Higher hardness of water was also recorded by Dirisu *et al.* (2019) for Asarama estuary. The moderate Hardness recorded in this study implies that Obazuwa lake did not receive abundant minerals like calcium and magnesium which generally are the major constituents of hard water.

Total alkalinity in this study ranged from 19.16 – 21.80 mg/l and were in agreement with similar results reported by Anyanwu *et al.* (2023). This finding were however in contrast with Mohammed *et al.* (2023) who recorded extremely high alkalinity. Chemical Oxygen Demand (COD) values ranged from 106.00 – 117.29 mg/l, which was considerably higher than those reported by Anyanwu *et al.* (2023) (5.8 – 6.5 mg/l) and Iyagbaye and Iyagbaye (2023) (4.80 – 64.50 mg/l).

Chloride concentration in this study ranged from 13.53 – 17.43 mg/l which were higher than 4.14 – 5.62 reported by Anyanwu *et al* (2023) and those reported by Dirisu *et al.* (2019). Similarly, Asibor and Adeniyi (2021) recorded lower chloride values (8.03 – 12.11mg/l). Similar range of chloride concentration to this study was also recorded by Dirisu *et al.* (2018). Chloride recorded in this study was majorly sourced from geochemical weathering of underlying rocks beneath the lake (Dirisu *et al.* 2018) and was quite lower than those observed by Ekperusi *et al.* (2022) in Oghan River.

Mean Nitrate concentration ranged from 2.38 – 4.24 mg/l and was below the WHO recommended limits of 50mg/l. This finding congruent with the observation obtained by those of Anyanwu *et al.* (2023) and Anyanwu *et al.* (2021) who reported nitrate ranges of (1.9 - 2.8) and (1.1 – 5.6 mg/l) respectively. Anyanwu and Mbekee (2020) also recorded similar nitrate loading (0.9 – 3.4 mg/l) compared to this study. Ebisi *et al.* (2022) also observed lower concentrations 0.68 – 0.76 mg/l which was significantly below the range recorded in this study. Comparable increases in nitrate levels were noted by Jonah *et al.* (2020) while Isibor *et al.* (2020) and Asibor and Adeniyi (2021) reported comparatively lower nitrate than those found in this study. Relatively low nitrate level (0.00 – 0.4) was also encountered by Iyagbaye and Iyagbaye (2023), similar to those reported by Ihejirika *et al.* (2023) whereas slightly higher mean nitrate concentration (4.37 mg/l) was reported by Mohammed *et al.* (2023). The relatively high range of nitrate recorded in this study indicates that Obazuwa lake is occasionally perturbed by agricultural, human and animal activities.

Phosphate content in the water samples varied between 0.080 – 0.83 mg/l closely matching the results documented for Uta Ewa Estuary by Jonah *et al.* (2020) and Anyanwu *et al.* (2021). The results of this work was however slightly lower than those (0.85 – 1.04 mg/l) reported for phosphate by Ebisi *et al.* (2022). Lower phosphate levels were also documented by Anyanwu *et al.* (2023) and Isibor *et al.* (2020) while Iyagbaye and Iyagbaye (2023) observed slightly higher concentrations (0.1 – 1.20 mg/l) similar Asibor and Adeniyi (2021) who also reported higher levels of phosphate. Higher phosphate was also recorded by Anyanwu and Mbekee (2020). Rabiu *et al.* (2025) (0.19 mg/l), Jonah *et al.* (2020). and Mohammed *et al.* (2023). This observed low levels of phosphate corresponds closely with the findings of this study and confirms phosphate as a limiting element in lake ecology due to it being readily taken up by phytoplanktons. Fan *et al.* (2023) (0.1mg/l) and Ihejirika *et al.* (2023) also recorded low phosphate level aligning closely with results from this study.

Mean potassium concentration ranged from 2.93 mg/l to 3.31 mg/l which is higher than. 1.45 – 2.17 mg/l recorded by Anyanwu *et al.* (2023). Lower concentration of potassium was recorded by Ihejirika *et al.* (2023) and Iyagbaye and Iyagbaye (2023) who reported low concentrations between (0.10 – 1.10).

Mean sodium concentrations in this study ranged from 5.28 – 5.92 mg/l which were slightly higher than those reported by Anyanwu *et al.* (2023) (2.01 – 2.5mg/l). However, the results from Iyagbaye and Iyagbaye (2023) showed comparatively lower sodium concentrations (0.40 – 1.90 mg/l). Similarly, Ihejirika *et al.* (2023) recorded lower levels of sodium than those obtained in this study.

Calcium concentration ranged from 7.05 – 7.47 mg/l, aligning closely with the range reported by Anyanwu *et al.* (2023) (3.62 – 9.15 mg/l). This finding did not agree with calcium levels (1.10 – 7.40 mg/l) reported by Iyagbaye and Iyagbaye (2023) and those of Olomukoro *et al.* (2016) who also recorded lower concentration of calcium in Gbaagbaa River.

Sulphate concentration in this study ranged between 38.58 – 43.67 mg/l. These results agree with those reported by Isibor *et al* (2020) who observed a comparable range of 17.27 – 54.95mg/l. However, Asibor and Adeniyi (2021) recorded lower sulphate levels (4.22 – 5.99) that did not agree with the present findings. Similarly, Iyagbaye and Iyagbaye (2023) reported results that also differed from this study. Mean magnesium concentrations ranged from 3.36 – 3.74 mg/l. This finding was slightly higher than the 0.30 – 2.30 mg/l reported by Iyagbaye and Iyagbaye (2023).

Iron ranged between 0.043 – 2.859 mg/l and was within the ranges recorded by Isibor *et al.* (2020) and Keke *et al.* (2021). Similar low iron concentration was recorded by Ihejirika *et al.* (2023). Amoebi *et al.* (2023) however reported lower ranges of iron but were slightly higher than those observed in this study. Manganese concentration ranged from 0.061 mg/l to 0.090 mg/l substantially lower than the higher levels (3.8 – 4.0 mg/l) reported by Amoebi *et al.* (2023). The unusually high iron concentration was due to dumpsite leaching and local industrial activities like garri production (Anani *et al.,* 2020).

Lead concentrations ranged between 0.005 – 0.036 mg/l, lower than the 0.035 – 0.098 mg/l reported by Isibor *et al.* (2020) and comparable to the (0 – 0.01 mg/l recorded by Ihejirika *et al.* (2023) and higher than those reported by Keke *et al.* (2021). Cadmium concentration observed in this study was generally below detectable limits, with values less than 0.05mg/l across all sampling stations. Similar findings were reported by Isibor *et al.* (2020) (0.0001 – 0.085mg/l) while Ihejirika *et al.* (2023) recorded comparatively higher cadmium levels. Chromium concentration ranged from 0.016 – 0.40 mg/l, higher than that of 0.0001 – 0.020 mg/l reported by Isibor *et al.* (2020).

Zinc concentration ranged from 0.071 mg/l to 0.083 mg/l across all stations and was similar to results reported by Ihejirika *et al.* (2023) but contrasted with the findings of Keke *et al.* (2021) who recorded higher results. On the other hand, Mean Copper concentration ranged from 0.046 mg/l to 0.055 mg/l and was comparable to the findings of Ihejirika *et al.* (2023) and similar to those recorded by Keke *et al.* (2021) at River Siluko.

5.2 Zooplankton Composition, Abundance and Distribution of Obazuwa Lake

The study of the overall zooplankton taxa composition, abundance, distribution and their spatial and temporal variability in Obazuwa Lake revealed a total of 3771 organisms belonging to nine (9) orders, eighteen (18) families and forty-eight (48) species. The forty-eight species of zooplankton species observed in this study are commonly found in many tropical lakes and lotic waters. These included representatives from Cladocera, Copepoda, Rotifera, Ostracoda and Siluriformes have previously been reported by (Amoebi *et al.*, 2023; Edoreh *et al.* 2021; Iyagbaye and Iyagbaye, 2023; James and Ajah, 2021; Jabbi and Isah, 2022; Imoobe and Adeyinka, 2009).

The total zooplankton abundance of 3771 organisms recorded in this study was, however lower than the 5,646 organisms reported for Yardants Reservoir by Jabbi and Isah, (2022). In contrast, the number of zooplankton species observed in this study was higher than that reported by Amoebi *et al.* (2023) who identified twenty-four (24) species from Pindiga pond in Gombe State and the eleven species (11) reported by Edoreh *et al.* (2021) from Ugbevwe pond. Similarly, this study recorded a greater diversity of taxa compared to those reported by Iyagbaye and Iyagbaye (2023) in Owan river.

Obazuwa Lake, a lentic water body with relatively low flow velocity exhibited a consistently high abundance of zooplankton throughout the study period. Nevertheless, the species abundance reported here was lower than the fifty-nine (59) species recorded by James and Ajah (2021), who noted the dominance Rhizopoda in the great Kwa River, Calabar.

Representatives of Copepoda are known to be among the most abundant groups globally (Hemalatha *et al*, 2016). The dominance of Copepoda over Cladocera, Rotifer, Ostracoda and Juvenile Siluriformes observed in this study has similarly been reported by Amoebi *et al* (2023), Erhenhi and Omoigberale (2019**)** and Edoreh *et al.* (2021). The high dominance of copepoda recorded in this study is consistent with their ecological adaptability and widespread occurrence in freshwater ecosystems (Rashad *et al.*, 2020; Majeed *et al.*, 2021). Findings from this study agrees with those reported by Ikhuoriah *et al.*, *(*2015) and Robert *et al.*, (2010).

This study however did not agree with the findings of Abed *et al*., (2022) who reported Cladocera as the most abundant zooplankton in freshwater bodies. Six species of copepods (*T. prasinus, T. neglectus, C. bicolor, M. bodanicola, M. varicans, E. serrulatus)* recorded by Edoreh *et al.* (2021) were all present in the fauna of Obazuwa Lake.

Calanoid copepods dominated this study with 85.81% abundance and was primarily represented by family Diaptomidae with 3209 individuals recorded. This observation, however did not agree with findings of Edoreh *et al.* (2021) who reported the overall dominance of cyclopoids and family cyclopidae and an absence of calanoid copepods. Obazuwa Lake can therefore be described as relatively rich in copepod and crustacean zooplankton, making it a suitable habitat for ecological and aquaculture productivity.

In this study, cladocera constituted the second most abundant taxonomic group. This findings contrast with Amoebi *et al* (2023) who reported cladocera as one of the least abundant taxa in Pindiga pond. This relative high abundance observed in Obazuwa lake could be attributed to reduced herbivorous competition among taxonomic groups (Amoebi *et al*, 2023). The Physicochemical characteristics of the lake also played a vital role in sustaining this abundance of cladocera

Edoreh *et al.* (2021) reported the presence of families Sididae, Chydoridae and Macrothricidae, although the latter was absent in the present study. The occurrence of Large sized chydorids like *Chydorus* and *Kurzia sp.* during this study is likely due to the cool and stable temperature conditions observed around Obazuwa Lake. This ambient temperature resulted from shading effect of the surrounding forest grove. This study also contrasted with the findings of Iyagbaye and Iyagbaye (2023) who reported the absence of rotifers in Owan River and identified cladocera as the most dominant group.

Rotifera have been long recognized as biological indicators in pollution studies due to their sensitivity to variations in water quality. Rotifera closely followed cladocera in abundance but were relatively very few. Their presence may be attributed to their ability to exhibit upright movements which facilitates competitive avoidance and exploitation of diverse ecological niches (Amoebi *et al.* 2023).

The low abundance of rotifera compared to cladocera and copepoda reported in this study agrees with the findings of Ikhuoriah *et al.*, (2015) who recorded five different rotifers species. However, it was not in agreement with the findings of Tawari-Fufeyin *et al.* (2008) and Enerosisor *et al.* (2020) who recorded no rotifer species and one rotifers species respectively. Ibemenuga *et al.* (2020) reported the preponderance of Digononta rotifers as the most abundant zooplankton recorded in Mkpume stream and contrasts with the present findings. Although rotifera were slightly abundant, they did not dominate Obazuwa Lake possibly due to limited sexual and asexual reproductive activity.

The presence of juvenile siluriformes during the early rainy months of June indicated that Obazuwa lake provides favorable conditions for fish breeding and nesting. The abundance of juvenile fish species likely contributed to increased predation pressure in June and July leading to a notable decline in zooplankton abundance during those months.

Relative spatial abundance analysis among zooplankton taxa revealed that copepoda and ostracoda were most abundant in Station 3 followed by Station 1 and 2. On the other hand, Spatial abundance in Cladocera and Rotifera were in the order of Station 1 > Station 2 > Station 3 while that of Siluriformes was Station 2 > Station 3 > Station 1.

The occurrence of *Calanoida* species (mainly *T. incognitus, T. processifer* and *T. galebi* and *E. gracilis*) and Cyclopoida (*T. neglectus*) in this study does not agree with the works of Imoobe and Adeyinka (2010) and Isibor (2017) who inferred an oligotrophic status for Ovia River and

Osse River based on the presence of these species. In contrast to their observation, the coexistence of these copepods, cladocera and pollution tolerant rotifer such as *Keratella tropica* suggests moderate to high levels of pollution. This finding is also supported by evidences of low DO, high BOD and moderately abundant concentrations of total suspended solids, Phosphate and Nitrates recorded also in this study. This study classifies Obazuwa lake as a eutrophic lake. Obazuwa lake can therefore be regarded as a Eutrophic Lake as a result of the aforementioned reasons.

Station 3 exhibited the most abundant taxa richness, subsequently followed by station 2 and 1 which had relatively taxa composition. The Margalef index was highest in station 3 (4.881) and lowest in station 1 (4.696). Anthropogenic disturbances in the lake was identified as the primary source of nutrient enrichment.

According to Zheng *et al.* (2007), water quality can be classified using the Shannon-Wiener Diversity Index as follows: highly polluted (<1), heavily polluted (2-1), moderately polluted (3-2), slightly polluted (4.5-3), clean (>4.5), and Based on these standards, Obazuwa lake is considered moderately to heavily polluted. Stations 1 and 2 were moderately polluted. Obazuwa Lake is therefore moderately to heavily polluted. Station 1 and 2 was moderately polluted (Shannon-Wiener diversity indices of 2.003 and 2.065 respectively) whereas station 3 was heavily polluted (index 1.788).

In contrast, Maiti (2004) described Margalef and Shannon-Weiner indices value above three (3) as clean water, whereas lower values indicated pollution. Meng *et al.* (2020), also argued that the index of Margalef focuses more on taxonomic composition and richness rather than focusing on of community abundance. The values of Margalef species richness (4.696 – 4.881) were generally high in all sampling stations. This indicated that Obazuwa lake generally receives lesser periodic disturbances from human activities and natural pollution loading (Shah and Pandit, 2013).

Kaparapu and Geddada (2013) described the evenness index as a measure of how organisms are evenly distributed within a community. In this study, zooplankton distribution and abundance in Obazuwa Lake were generally spatially uneven as shown by the low evenness index values (0.1616 – 0.2311) recorded during the study. Simpson's diversity index (1-D) and Shannon-Weiner index (H) both revealed high diversity for Obazuwa Lake. Simpson's index values (0.7472 – 0.7961) confirmed that the lake was relatively species-rich.

However, this finding contrasts with Enerosisor *et al.* (2020) who reported lower diversity in Opobo River. The abundance of zooplankton peaked in the late rainy season months of August and September, likely due to increased rainfall during these months. The heavy downpours contributed to increase water depth, higher dissolved oxygen concentration and increased nutrient input from agricultural runoff and human activities. This study deviated notably from earlier findings by demonstrating spatial variation in zooplankton composition across the three stations. While Stations 1 and 2 had similar taxa composition (34 taxa each), station 3 recorded an 8.8% increase in species richness, indicating slightly higher biodiversity. The total number of individuals also varied considerably, with station 3 exhibiting a higher population density than stations 1 and 2. This difference likely reflects spatial heterogeneity in ecological conditions among the stations.,

Station 3 showed the greatest dominance index (0.2528) implying that a limited number of species dominated the community. This is attributed to a clear deviation in species distribution pattern. The Shannon-wiener diversity index also varied among stations: Station 2 (2.065) > Station 1 (2.003) and Station 3 (1.788), indicating that station 2 had the highest species diversity and Station 3 the lowest. The evenness values (0.2319, 0.2181 and 0.1616 for stations

2, 1 and 3 respectively) further confirmed uneven species distribution, particularly at Station 3. The Chao-1 index (estimated richness) suggested a potential preponderance of rare or hidden indicated that there was potential for preponderance of hidden or rare species in station 3. Obazuwa Lake can therefore be concluded as a “den” of rare zooplankton species, particularly rare tropical rotifers.

5.3 Multivariate Association of Zooplankton and Physicochemical Characteristics of Obazuwa Lake

CCA ordination revealed distinct patterns in zooplankton-environment relationships. Most zooplankton groups, including Cyclopoida, Cladocera, and Harpacticoida, clustered near the origin, suggesting that they are eurytopic (tolerant of a broad range of physicochemical conditions) and capable of adapting to moderate fluctuations in water quality. Siluriformes was separated along the positive side of Axis 1, in close association with high BOD, COD, and temperature values. As a result, Juvenile fishes recorded in this study were tolerant of the organically enriched, oxygen-deficient environments and must have been stressed between the months of August-November, hence their disappearance from the study results during those months Podocopida showed association with sodium, temperature, and manganese, with preference for mineralized and warmer waters. Anomopoda and Ctenopoda, displayed relationship with higher dissolved oxygen and lower organic loadings. These orders were found to be sensitive to pollution and thrived better in well-oxygenated and cleaner waters.

R^2 value of 3.145 and an adjusted R^2 of –5.128 from the Redundancy Analysis (RDA) indicated that only a small and statistical insignificant portion of zooplankton distribution was explained by physicochemical parameters. The measured physicochemical parameters however did not exert a statistically meaningful influence on the variation in zooplankton community composition. The first canonical axis (Axis 1) accounted for approximately 67.49% of the constrained variation and represented the primary water quality gradient influencing zooplankton abundance.

On the other hand, the second axis explained an additional 0.22% of the variance. Despite the dominance of the first axis, the lack of statistical significance revealed that axis-1 may not represent a strong ecological structuring force. The first axis was associated with sodium, potassium, nitrate, and water temperature, which loaded positively, while calcium, alkalinity, total hardness, and iron, were reported to be on the negative association. RDA analysis also revealed a potential ionic and thermal gradient separating more mineralized and warmer conditions from cooler, calcium- and hardness-dominated environments. The ordination of zooplankton taxa along physicochemical gradients indicated weak responses to the environmental variables.

Calanoida exhibited the highest positive relationship along the first axis. This suggested that Calanoida preferred to occur in environments with higher concentration of sodium, potassium, and temperature. Additionally, Cyclopoida, Ctenopoda, Anomopoda, and Harpacticoida clustered near the ordination center showing with a much broader ecological tolerance and limited response to environmental factors. Siluriformes, exhibited a mild inverse correlation with the main axis, preferring a less mineralized or cooler water conditions. The close clustering of most zooplankton orders around the origin could mean that the variation in community composition was not strongly related with these characteristics. Weak explanatory RDA strength implied that other unmeasured factors such as habitat heterogeneity, food availability, or predation pressure may play a more substantial role in shaping zooplankton distribution patterns in the study area.

5.4 Water Quality of Obazuwa Lake

The water quality assessment using both the Arithmetic Mean Water Quality Index (WQI) and the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) revealed that there was moderate pollution in the sampled stations of Obazuwa Lake. The Arithmetic WQI values (739.005 – 774.412) classified surface water of Obazuwa Lake under Grade E, indicating poor quality unsuitable for domestic or drinking purposes.

This results also agrees with finding of Anani and Olomukoro (2021) and Ikegu *et al.* (2024) who recorded poor water quality in Ossiomo River and Okpara creek, Delta State respectively. Similar poor water quality was also reported by Odigie (2019) in Obueniyomo River but contrasted studies by Uwaifo *et al.* (2018) of osse river who reported clear pristine nature of the water quality. Dibal and Olomukoro (2025) also characterised the heavy metal pollution index (HPI) of River Gongola in Gombe State as unsuitable for drinking, similar to the findings of the WQI and CCME WQI of this study. Olomukoro *et al.* (2022) also recorded similar higher WQI value for Orogodo River, attributing the unsuitable drinking condition of the river to the impoundment of heavy metals dominant in the river.

This deteriorating values of water quality could be associated with contamination from agricultural runoffs, domestic wastewater discharge and allochthonous inputs within the catchment. In addition, the CCME WQI values (78.13–79.96) classified the water as having “fair” quality, indicating moderate pollution capable of slightly to moderately supporting support aquatic life due to nutrient enrichment and less threshold of eutrophication. The results also indicated that although the water supports limited ecological use, it is not safe for human consumption without adequate treatment. Overall, both indices confirm that water quality across the study area is compromised as a result continuous pollution inputs from surrounding human activities.

5.5 SUMMARY

The following are the summary of the findings from this study:

1. The physicochemical characteristics of Obazuwa Lake showed spatial and temporal variations with no significant difference among sampling stations ($p > 0.05$).
2. A total of 3771 individuals, comprising, 48 species, 9 orders and 18 families were recorded, with the order of dominance being Copepoda (92.2%) > Cladocera (5.49%) > Rotifera (0.85%) > Ostracoda (0.48%) > Siluriformes (0.95%).
3. Diversity indices revealed moderate species richness and evenness, indicating a relatively stable zooplankton community.
4. Pearson's Correlation showed that BOD, COD, Nitrate and total hardness significantly influenced zooplankton taxa while Multivariate analysis (PCA, RDA and CCA) identified temperature, Nutrients (Nitrate and Phosphate), organic load indicators (BOD and COD) and conductivity as factors shaping taxa distribution.
5. Water Quality Index (WQI) values estimated from the lake showed elevated levels of contamination (WQI > 100), revealing that Obazuwa lake is unsuitable for direct domestic consumption.

5.6 CONTRIBUTION TO KNOWLEDGE

The study has contributed to knowledge in the following ways:

1. Provided baseline information on the zooplankton biodiversity and physicochemical characteristics of Obazuwa Lake, Edo State, Nigeria – an area previously understudied.
2. Documented the dominance of rare and pollution-tolerant zooplankton species, providing scientific evidence of organic enrichment and early eutrophication trends in the lake,

3. Established correlation and multivariate relationships between zooplankton taxa and key physicochemical parameters (temperature, COD, nitrate, phosphate and conductivity) as the main environmental drivers of community structure in the lake,
4. Results established from the study provided insight into the taxonomic richness of the lake and would be useful for aquaculture farmers intending to enrich their ponds biologically or harvest live zooplankton feeds,
5. Documented the impending threats of nutrient enrichment and moderate organic pollution which may give better insights on limnological monitoring and pollution control to policy and environmental managers.

5.7 CONCLUSION AND RECOMMENDATION

Zooplankton study remain one of the most reliable biological indicators of freshwater health. This study offered a simple, yet cost-effective method for the rapid assessment of zooplankton community structure, physicochemical characteristics and water quality of Obazuwa Lake. The presence and dominance of pollution tolerant species across various zooplankton taxa studied highlights the need for continuous monitoring of Obazuwa Lake in hopes of restoring it to its baseline water quality. This study hopes that more investigation into lentic water bodies be taken into account and researched in order to gain a holistic assessment of our lush zooplankton communities. It is however recommended that the use of live feeds for aquacultures practices be used in modern fisheries and that Obazuwa lake has the potential to become a hubspot for ponds enrichment in the nearest future. More works on the suitability of zooplanktonic fish and their preference for selected zooplankton reported in this study is being taken into consideration and may be researched into in the nearest future.

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APPENDIX

Appendix 1: One way Anova

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Air_Temperature	Between Groups	.420	2	.210	.116	.891
	Within Groups	32.520	18	1.807		
	Total	32.940	20			
Water_Temperature	Between Groups	.697	2	.349	.071	.931
	Within Groups	87.914	18	4.884		
	Total	88.611	20			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	.078	2	.039	.090	.915
	Within Groups	7.829	18	.435		
	Total	7.907	20			
EC	Between Groups	185.810	2	92.905	.691	.514
	Within Groups	2419.429	18	134.413		
	Total	2605.238	20			
Total_dissolved_Solids	Between Groups	48.381	2	24.190	.725	.498
	Within Groups	600.857	18	33.381		
	Total	649.238	20			
Total_Suspendes_Solids	Between Groups	44.544	2	22.272	.102	.904

	Within Groups	3937.917	18	218.773		
	Total	3982.462	20			
Total_Solids	Between Groups	85.416	2	42.708	.288	.753
	Within Groups	2668.531	18	148.252		
	Total	2753.947	20			
Chemical_Oxygen_Demand	Between Groups	576.872	2	288.436	.289	.753
	Within Groups	17991.166	18	999.509		
	Total	18568.038	20			
Turbidity	Between Groups	54.652	2	27.326	.152	.860
	Within Groups	3231.639	18	179.536		
	Total	3286.292	20			
Dissolved_Oxygen	Between Groups	.647	2	.323	.116	.891
	Within Groups	50.311	18	2.795		
	Total	50.958	20			
Biological_Oxygen_Demand	Between Groups	5.650	2	2.825	.169	.846
	Within Groups	301.363	18	16.742		
	Total	307.012	20			
Alkalinity	Between Groups	32.109	2	16.054	.153	.859
	Within Groups	1886.577	18	104.810		
	Total	1918.685	20			
Salinity_as_Chloride	Between Groups	55.693	2	27.846	.472	.631
	Within Groups	1060.911	18	58.939		
	Total	1116.603	20			
Calcium	Between Groups	.699	2	.349	.028	.972
	Within Groups	222.948	18	12.386		
	Total	223.646	20			

Magnesium	Between Groups	.630	2	.315	.173	.842
	Within Groups	32.673	18	1.815		
	Total	33.303	20			
Total_Hardness	Between Groups	27.879	2	13.939	.305	.741
	Within Groups	822.199	18	45.678		
	Total	850.078	20			
Nitrate	Between Groups	12.367	2	6.183	.401	.675
	Within Groups	277.317	18	15.407		
	Total	289.684	20			
Sulphate	Between Groups	97.804	2	48.902	.178	.838
	Within Groups	4946.604	18	274.811		
	Total	5044.408	20			
Phosphate	Between Groups	.003	2	.002	.013	.987
	Within Groups	2.399	18	.133		
	Total	2.402	20			
Sodium	Between Groups	1.566	2	.783	.098	.907
	Within Groups	143.528	18	7.974		
	Total	145.094	20			
Potassium	Between Groups	.598	2	.299	.127	.881
	Within Groups	42.315	18	2.351		
	Total	42.913	20			
Iron	Between Groups	.576	2	.288	.297	.746
	Within Groups	17.436	18	.969		
	Total	18.012	20			
Chromium	Between Groups	.000	2	.000	.000	1.000
	Within Groups	.352	18	.020		

	Total	.352	20			
Cadmium	Between Groups	.000	2	.000	.000	1.000
	Within Groups	.000	18	.000		
	Total	.000	20			
Copper	Between Groups	.000	2	.000	.262	.772
	Within Groups	.010	18	.001		
	Total	.010	20			
Lead	Between Groups	.000	2	.000	.535	.594
	Within Groups	.001	18	.000		
	Total	.001	20			
Zinc	Between Groups	.000	2	.000	.404	.674
	Within Groups	.010	18	.001		
	Total	.010	20			
Manganese	Between Groups	.003	2	.002	1.093	.356
	Within Groups	.025	18	.001		
	Total	.028	20			

Appendix 2: Pearson’s Correlation between Physicochemical Parameters and Zooplankton Orders

Parameters	**Copepoda**	**Cladocera**	**Rotifera**	**Ostracoda**	**Siluriformes**
Air Temperature	-.271	-.491*	-.402	.064	.320
Sig. (2-tailed)	.234	.024	.071	.784	.158
Water Temperature	-.004	-.288	-.279	.071	.276
	.985	.205	.221	.760	.225
pH	-.094	-.230	.022	.031	-.285
	.687	.315	.924	.894	.211
Conductivity	.298	.037	.098	.184	-.264
	.190	.872	.673	.424	.247
Turbidity	-.134	-.084	.138	.074	-.213
	.563	.717	.549	.751	.354
Alkalinity	-.192	.120	.058	-.203	-.029
	.404	.603	.802	.377	.900
Salinity	-.077	.077	.205	.010	-.334
	.740	.741	.372	.964	.139
TDS	.305	.037	.097	.177	-.285
	.178	.875	.676	.443	.210
TSS	-.332	.037	.144	-.092	-.193
	.141	.872	.535	.692	.402
Total Solids	-.251	.063	.220	-.025	-.370
	.272	.787	.338	.916	.098
BOD	-.448*	-.347	-.387	-.108	.408
	.042	.124	.083	.640	.066
COD	-.485*	-.221	-.190	-.125	.442*
	.026	.335	.410	.588	.045
Dissolved Oxygen	.360	.147	.110	.035	-.107
	.109	.526	.635	.879	.645
Total Hardness	-.133	.104	.349	.148	-.571**

	.566	.652	.121	.521	.007
Nitrate	.580**	.496*	.431	.113	-.178
	.006	.022	.051	.626	.441
Phosphate	-.002	.082	-.051	-.086	-.269
	.993	.724	.827	.709	.239
Sulphate	-.252	-.039	-.001	.201	.350
	.270	.867	.996	.383	.119
Sodium	.277	-.021	-.059	.147	.087
	.224	.930	.798	.524	.709
Calcium	-.366	-.060	.203	.126	-.193
	.103	.795	.377	.586	.401
Potassium	.318	.020	.012	.150	.134
	.161	.930	.957	.518	.564
Magnesium	.427	.222	.119	.006	-.389
	.054	.334	.607	.980	.082
Manganese	-.049	-.070	.014	.423	-.108
	.833	.763	.954	.056	.641
Zinc	.098	.046	.332	.259	-.099
	.672	.843	.141	.256	.670
Copper	.051	.084	.401	.315	-.154
	.825	.717	.072	.165	.505
Iron	.427	-.012	.061	.227	.031
	.053	.960	.793	.323	.893
Lead	.079	-.196	-.238	.094	.090
	.734	.395	.299	.685	.697
Chromium	-.251	-.025	-.257	-.336	-.148
	.273	.915	.260	.136	.523

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Sig. (2-tailed) indicates the probability (p-value) that the correlation occurred by chance.

Appendix 3: Pearson's Correlation between Physicochemical Parameters and Zooplankton Taxonomic Groups

Parameters	**Cyclopoida**	**Calanoida**	**Harpacticoida**	**Anomopoda**	**Ctenopoda**	**Plioma**	**Flosculariaceae**
Air Temperature (r)	.301	-.269	-.245	-.466*	-.527*	-.332	-.289
Sig. (2-tailed)	.239	.284	.033	.014	.142	.203	.080
Water Temperature	.366	-.300	.020	-.260	-.389	-.232	-.156
	.186	.930	.256	.081	.313	.501	.237
pH	-.291	-.068	-.255	-.048	.031	-.143	-.005
	-.291	-.068	-.255	-.048	.031	-.143	-.005
Conductivity	-.064	.298	.042	.004	.031	.206	.202
	.782	.189	.856	.988	.894	.370	.379
Turbidity	-.101	-.124	-.109	.073	.120	-.048	.123
	.664	.593	.637	.753	.605	.837	.595
Alkalinity	.139	-.201	.123	.079	-.003	.073	.168
	.549	.382	.594	.732	.989	.754	.467
Salinity	-.074	.029	.325	.096	.153	.360	-.074
	.905	.749	.901	.151	.680	.507	.109
Total dissolved Solids	-.068	.306	.040	.010	.028	.201	.206
	.768	.177	.863	.965	.903	.382	.370
Total Suspended Solids	-.061	-.323	.016	.146	.145	-.041	.083
	.794	.154	.944	.528	.531	.861	.720
Total Solids	-.106	-.240	.039	.180	.188	.049	.200
	.647	.296	.866	.434	.414	.834	.384
Biological Oxygen Demand	-.447*	-.406	-.347	-.276	-.421	-.195	-.159
	.042	.068	.123	.226	.057	.397	.492
Chemical Oxygen Demand	-.383	-.447*	-.205	-.267	-.177	-.146	-.140
	.086	.042	.373	.242	.442	.527	.545
Dissolved Oxygen	.209	.338	.177	-.052	.150	.099	-.020
	.363	.134	.442	.823	.517	.669	.932
Total Hardness	.016	-.133	.082	.206	.349	.057	.210
	.946	.567	.723	.370	.121	.807	.360

Nitrate	.258	.550**	.501*	.369	.345	.406	.445*
	.260	.010	.021	.100	.126	.068	.043
Phosphate	-.262	.019	.055	.213	-.090	.024	.055
	.252	.935	.812	.353	.697	.917	.814
Sulphate	-.032	-.246	-.054	.054	-.060	.007	.125
	.891	.282	.816	.818	.798	.975	.589
Sodium	-.047	.277	.006	-.162	-.063	.086	-.027
	.840	.224	.980	.483	.785	.712	.906
Calcium	-.143	-.350	-.081	.068	.150	.028	.236
	.535	.120	.726	.769	.516	.904	.303
Potassium	.015	.312	.047	-.133	.006	.126	.021
	.950	.169	.838	.566	.979	.587	.928
Magnesium	.234	.402	.228	.141	.200	.035	-.102
	.307	.071	.320	.541	.386	.881	.659
Manganese	-.087	-.042	-.066	-.077	-.048	.117	.142
	.707	.858	.776	.741	.835	.614	.541
Zinc	-.023	.098	.033	.110	.243	.224	.392
	.922	.674	.888	.635	.288	.329	.079
Copper	.117	.041	.064	.178	.353	.181	.344
	.614	.861	.783	.439	.116	.433	.127
Iron	-.204	.437*	.004	-.096	.033	.102	.097
	.376	.047	.986	.678	.889	.660	.674
Lead	-.224	.096	-.163	-.338	-.279	-.034	-.054
	.329	.679	.480	.134	.221	.885	.816
Chromium	-.166	-.234	-.028	-.003	-.259	-.133	-.150
	.472	.308	.905	.990	.257	.566	.516

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Sig. (2-tailed) indicates the probability (p-value) that the correlation occurred by chance.