LIMNOLOGICAL STUDIES OF KARIDNA RESERVIOR, IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIAIN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ZOOLOGY

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OCTOBER, 2015.

DECLARATION

I declare that the work in this thesis entitled "LIMNOLOGICAL STUDIES OF KARIDNA RESERVIOR, IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA" has been carried out by me in the Department of Biological Sciences. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree at this or any other institution.

Mohammed Tariq ABDULAZEEZ_____ _____

Signature Date

CERTIFICATION

This thesis entitled "LIMNOLOGICAL STUDIES OF KARIDNA RESERVIOR, IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA" by Mohammed Tariq ABDULAZEEZ meets the regulations governing the award of the degree of Master of Science (M.Sc. Zoology) of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty Allah, who bestowed on me the wisdom, strength and courage throughout this program and to all my siblings.

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My sincere gratitude goes to Almighty Allah who in his infinite mercies for making this programme a successful one.

I equally acknowledge the contribution of my able supervisors Prof M.L. Balarabe and Prof. S.A. Abdullahi for their guidance and contribution to this success my appreciation also goes to Mallam Magaji Abdulkadir of hydrobiology laboratory,Mr. Tanimu Yahuza for their immense contribution to the thesis and to the HOD of Department of Biological Sciences Ahmadu Bello University, Zaria and to all the staff of the department, I say thank you all.

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Most sincerely to my late parents Mal. Murtala Abdulaziz and Hajia Fatima Abdulaziz for their parental, moral and attitudinal training. May Almighty Allah Grant them Eternal rest, forgive them all their sins and Aljannatul firdaus be their final abode **AMIN** .

ABSTRACT

Physico-chemical parameters and zooplankton species distribution in Karidna Reservoir were investigated for a period of one year between October 2013 and September 2014 with the aim of establishingthe physical, chemical and biological (Zooplankton) parameters of Karidna Reservoir. Five sampling stations were chosen; the physicochemical and biological parameters were determined using standard methods, procedures and instruments. The results obtained for the physico-chemical parameters indicated that pH (6.19-8.63),Temperature (25.94-31.54^{o}C), Electrical Conductivity (38.20-64.20µS/cm), Total Dissolved Solids (19.20-37.20 mg/l), Transparency (19.40-40.10 cm) Dissolved Oxygen (2.40-6.81mg/L), Hardness (3.48-174.4mg/L) Calcium (2.14-3.86mg/L),Biological Oxygen Demand (2.91-40.85mg/L), Chloride (2.28-3.58mg/L) Phosphate-phosphorus (0.04-0.24mg/L), Nitrate- Nitrogen (0.14-0.30mg/L), Sulphate (0.06-0.21mg/L) Alkalinity (2.51-5.04mg/l).Po_4-, NO_3-,SO_4-,EC,TDS,Transparency,D.O and B.O.D were highly significant at ($P \leq 0.01$) between the seasons while non-significant differences are observed in Cl, Hardness, Alkalinity, Temperature and pH. It was only Calcium that was significant at $P<0.05$. The Zooplankton were more prevalent during the rainy season than the dry season and there were variations in their composition and as well as in their abundance along the reservoir continuum..Only three groups of Zooplankton were found: Rotifera with five genera, Cladocera with seven genera and Copepods with four genera. Rotifera dominated numerically (36.99%), followed by Cladocera (35.53%) and Copepods (27.48%).The distribution of zooplankton between the stations shows that station1 have more prevalent of zooplankton than other stations due to its direct contact with humans and other

anthropogenic activities.The zooplankton community composition of the reservoir also showed the reservoir to be productive and could support a diverse species of fishes.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Water sustains life. The quality of water is of vital concern for mankind because it directly linked with human health. Life on Earth depends upon water. Water comprises 99% of our own bodies andcovers 71% of the earth's surface (WHO,2000). It serves differentfunctions ranging from itstransport function through serving as solvent for most chemicals to servinghabitat to many organisms. Many organisms also depend on water for certainstages of their life. For instance, some insects and amphibians use water as theirbreeding sites while it serves as an agent of dispersal for many plant seeds and fruits. The biological diversity of aquatic areas is neglected world- wide, even incoral reefs that rival tropical rain forests in their extraordinary diversity of life (Ajuzie,2012)

Limnology("lake" and*logos*, "knowledge"), also called freshwater science, is the study of inland waters. It is often regarded as a division of ecology or environmental science. It covers the physical, chemical, biological and other attributes of all inland waters (running and standing waters, fresh and saline, natural or man-made). This includes the study of lakes,ponds, rivers, springs, streams and wetlands.Limnology is also the science of inland water, concerned with all the factors that influence living populations within those water bodies. (Gupta *et al.*,2006).

Nigeria is richly blessed with a vast area of inland waters. The total surface area of water bodies in Nigeria is estimated to be about 550,000 hectares (13,000km^2) and this constitutes about 15.9% of the total area of Nigeria. (Ekiye and Zejiao,2010). These

include both natural and man-made lakes, reservoirs, floodplains and cattle ponds, rivers and streams; but exclude deltas, estuarine and miscellaneous wetlands suitable for rice cultivation. (Ekiye and Zejiao,2010). The species composition and density of aquatic organisms will be influenced not only by geographical locations but also by water quality of their aquatic habitats.(Atobatele and Ugumba, 2008). This can in turn be adversely affected by human activities.

Reservoirs are considered favorable environments to the development of plankton communities, which may establish diverse assemblages in relatively short periods of time after impoundment (Rocha *et al*., 1999). Several factors usually contribute to the establishment of plankton communities in a reservoir, among which are good water quality, presence of nutrients, physico-chemical factors of water, hydrological characteristics of the reservoirs and reservoir ageing.Phytoplankton are usually at the base of aquatic food web and are the most important factor for production of organic matter in aquatic eco system. Most reservoirs will require significant amount of plankton to have productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are structured by these factors. Thus any perturbations in these factors may affect their assemblage which could have a significant impact on water quality and fisheries of reservoirs (Mustapha,2011). The zooplankton assemblage often influences energy flow through classical food chain, nutrient cycling and community populationdynamics within a reservoir ecosystem. This ecological niche has made them key actors in top down grazing effect (trophic cascade) on the bottom up forces which plays pivotal roles in biomanipulation for lake restoration purposes. The importance of

plankton in tropical reservoir ecosystems include its use in estimating potential fish yield, productivity, water quality, energy flow, trophic status and management (Beyruth,2000). Mustapha (2011) observed that energy in pelagic ecosystems flows from phytoplankton, the primary producers to zooplankton, the consumersthrough the classical food chains and microbial food webs. Models that use phytoplankton primary production as the main controlling variable for predicting fish yield in lakes and reservoirs have resulted in more successful predictions than many other methods.

Zooplankton are minute drifting invertebrates either in marine or fresh water column. Theyare indispensable members of the aquatic food chain, connecting primary producers to higher trophic levelsincluding economically important population of fish. Thechange in abundance, species diversity and communitycomposition of zooplankton indicates environmentalchanges like pH, temperature, nitrates, phosphates totaldissolved salt, nutrient levels, alkalinity aresensitive indicators of pollution in comparison withphytoplankton (Umadevi,2007).

Freshwater zooplankton comprises predominantly the rotifers, cladoceras, copepods, andoccasionally the ostracods and insects (Sabkara,2002). Crustacean plankton has been described as preferred fish food items by several authors, they are preferred by fishes to their rotifera counterparts for several reasons. First, they are relatively bigger, and planktivorous fishes which practice size-selective predation often prefer them to the rotifers (Ayodele *et al.*,2006). Also, unlike the rotifers which are not easily spotted by predatory fishes as a result of their transparent lorica(the shell of a rotifer), crustaceans are easily spotted. Furthermore, crustaceans are more important than rotifers in the transfer of energy from autotrophic phytoplankton to fishes based on their ecological

niche in freshwater systems. Rotifers are mostly herbivorous which could limit the amount of energy being harnessed from them by organisms at higher trophic levels, except there are intermediaries like crustaceans which feed on the rotifers. There is good evidence that rotifer species are differentially influenced by crustaceans via predation and competition (Douglas *et al.,* 2001). Cyclopoid copepods have in particular been described as effective predators of rotifers and so are some calanoid species which may include rotifers in their diets too (Denton,2007).

Aside their importances in fisheries, crustacean plankton (some cyclopoids) are also ecologically important by suppressing mosquito larvae. They are also known as intermediate hosts in the transmission of many parasites, especially worms. Some pathogenic human bacteria are carried and nurtured by Copepoda.(Douglas *et al*., 2001). Reservoir communities of phytoplankton constitute the basis of the aquatic food chain. This is because they are primary producers, which sustain populations of primary consumers that include zooplankton, some macro invertebrates and fishes. The composition and abundance of plankton communities may provide a hint on the health status of a reservoir. Presently, our knowledge on the zooplankton communities of Karidna Reservoir is limitedbecause of unavailability of information on the present composition of these organisms in the reservoir.

The monitoring of physicochemical characteristics of a water body is vital for both long term and short analysis (Wood, 1995). Distribution and productivity levels of organisms in any waterbody are largely determined by physicochemical factors (Adakole*etal*., 2008). The direct effects of interactions of many frequently measured water quality

parameters with biotic components that affect productive potentials of fish species have been demonstrated.It highlights the factors influencing the distribution, the survival and abundance of diverse species of organisms in water.

1.2 Statement of the Research Problem

The anthropogenic inputs from neighboring communities such as run-offs from agricultural farms containing of manures and fertilizers are the major problem that Karidna reservoir is experiencing. These inputs can cause serious effect to the water quality and subsequently affect the biodiversity and students within the reservoir. The role of nutrients, spatial and temporal fluctuations in controlling the species composition, diversity, and seasonal succession of planktonic composition in the reservoir has not been documented.

1.3 Justification

It was observed that most reservoir ecosystems are threatened by anthropogenic activities (Ibrahim *et al.,* 2009). This study of the physico-chemical parameters and the zooplankton communityofKaridna reservoir was initiated in order to provide baseline information on the quality of the water and proposed best management practice that will enhance the productivity of the water. Planktons are very sensitive to the environmentthey live, any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat.The species composition, distribution, diversity and relative abundance of zooplankton of Karidna Reservoir could have significant impact on fisheries and public health of the reservoir and its users (Mustapha,2011).

Therefore, planktonpopulation observation may be used as a reliable tool for bio monitoring studies to assess the pollution status of aquatic bodies. Also the results of the study will be used to enlighten the neighboring community on the effect of their activities to the water body.

1.4 Aim of the Study

The aim of the research was to establish the Limnological characteristics of karidna reservoir and its zooplankton distribution.

1.5 Objectives of the Study

1. To determine the physico-chemical parameters of Karidna reservoir in wet and dry seasons
2. To assess the distribution of zooplankton in the sampling stations.
3. To determine the relationship between the zooplankton community and water quality of Karidnareservoir.

1.6 Hypotheses

1. The physico-chemical parameters of Karidna Reservoir do not differ significantly betweenwet and dry seasons.
2. There is no significant difference in the distribution of zooplankton between the sampling stations.
3. There is no significance difference between zooplankton community and water quality of Karidna reservoir.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water

Water is an elixir of life. It governs the evolution and function of the universe on the earth hence water 'mother of all living world'. Majority of water available on the earth is saline in nature; only small quantity is fresh water. Freshwater has become a scare commodity due to over exploitation and pollution (Singh and Mathur, 2005). Pollution is caused when a change in the physical, chemical orbiological condition in the environment harmfully affect quality of human life including other animals and plants' life (Oketola*et al*., 2006). Industrial, sewagemunicipal wastes are been continuously added to water bodies hence affect the physiochemical quality of water making them unfit for use of livestock and other organismWater resources are of critical importance to both natural ecosystem and human development.

It is essential for agriculture, industry and human existence. The healthy aquatic ecosystem is depended on the physico-chemical and biological characteristics (Venkatesharaju*et al*.,2010). The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physic- chemical parameters and biological characteristics to assess the monitoring of these parameters is essential to identify magnitude and source of any pollution load.(Venkatesharaju *et al.*,2010). These characteristics can identify certain condition for ecology of living organism and suggest appropriate conservation and management strategies. Many researches are being carried

out till present day:Seasonal Influence of Limnological variables on plankton dynamics of a small, shallow, tropical African reservoir(Mustapha,2011); Relationships between The Physico chemical water parameters and Zooplankton Fauna of Tiga lake, Kano Nigeria Akindele(2013); Some aspects of the limnology of Makwaye (Ahmadu Bello University farm) lake, Samaru, Zaria (Balarabe, 2001);Effects of Limnological characteristic on Zooplankton composition and distribution in Dumbi and Kwangila ponds, Zaria; Araoye (2008) physico-chemical factors and their influence on fish species composition in Asa lake, Ilorin.

2.2 Water Temperature

It is one of the most important and essential parameter of aquatic habitats because almost all the physical, chemical and biological properties are governed by it. Temperature influences the oxygen contents of water, quantity and quality of autotrophs, while affecting the rate of photosynthesis and also indirectly affecting the quantity and quality of heterotrophs. The temperature of water varies throughout the year with seasonal changes in air temperature, day length, and solar radiations. Animals are stressed when temperature changes rapidly, because there is no enough time for physiological adaptation (Muhammad,2007). The significance of bright sunlight and temperature helped in production of green algae.

Temperature is one of the most important factors in the aquatic environment(Muhammad,2007). The temperaturealso plays a crucial and biological behavior of aquatic system. Temperature have no have been observed to play a directeffect on aquatic life up to 39^{o}Cin the river, Majumber(2007)observed that

solubility of oxygen in the water increased when water temperature decreases. The water level correlates negatively with core depth, during the rainy season (Adakole*et al.,* 2008).

Temperatures were found generally to be higher than air temperatures in the afternoon hours except for few months (January to March), air and surface water temperatures were almost uniform in the month of October/ November but most peculiarly in the morning hours and monthly variations of water temperatures surface and bottom (Araoye, 2008). The water temperature varied from winter to monsoon (June-August), higher water temperatures were recorded in lentic part of Bhagirathi and Bhilangana respectively compare to lotic portion. Water temperature of the lacustrine portion was significantly different from that of lotic and changes in physico-chemical features and Plankton (Ayoade, 2009)**.** Ibrahim *et al.,* (2009) reported "that low water temperature of Kontagora reservoir during the dry season could be as a result of seasonal changes in air temperature associated with the cool dry North-East trade winds". The air and water temperature readings indicated an increase from January to March in Makwaye Reservoir (Balogun*et al.*,2005).

2.3 Water pH

The pH expresses the acidity or alkalinity of water which is determined by means of hydrogen ion (H^+) and the hydroxyl ion (OH^-) in water.(Mahar,2003) Higher concentration of H^+ ions gives lower score on the pH scale and lower concentration of H^+ ions gives higher scores on the pH scale. Water of around pH 7 is called neutral. During daylight, aquatic plants usually remove the $CO_2$from the water quickly and pH increases. At night, CO_2 accumulates and pH declines (Mahar, 2003).pH value is very important for

plant growth. According toUmavathi *et al*., (2007) pH ranged 5 to 8.5 is best for plankton growth. Drop in pH was probably due to the stirring effect of the incoming flood from the rivers and streams that converged towards the lake resulting in the mixing of the poorly alkaline or acidic bottom water with alkaline surface water to reducepH, also the decrease in pH of the surface water in November and December was due to decomposition of the inundated terrestrial vegetation of the littoral zone following increased water levels. Decomposition reduced the amount of oxygen, while increasing the amount of carbon dioxide in the affected environment; this accounted for the positive correlation between pH and DO (Araoye, 2009). He also observed that the hydrogen ion concentration (pH) was nearly neutral throughout both season, and it was within the range for inland water pH 6.5 - 8.5.

Ibrahim *et al*. (2009) recorded wider pH range and the highest mean value in Shiroro Lake which could be due to combined effects of the different tributaries emptying their water into this site. He also that the lower season mean values may probably be due to higher input of organic matter and higher temperature which enhance the decay process. (Atobatele *et al*., 2008) observed a sharp decrease in the pH of Aiba Reservoir (Iwo, Osun State, Nigeria) in September during late wet season. This can be attributed to the increased organic matter brought in by rain as a result of runoff during peak wet season that tends to reduce dissolved oxygen through utilization of organic dehydration giving rise to a fall in pH.

2.4 Electrical Conductivity of Water

Conductivity of natural water is a measure of its ability to convey an electric current. Specific conductivity can be utilized as a rapid measurement of dissolved solids and is useful in monitoring waste streams and conducting field water quality studies (Asaolu*et al.*, 2004). The level of conductivity in water gives a good indication of the amount of mixable substances dissolved in it, such as phosphate, nitrate and nitrites. Different ions vary in their ability to conduct the electricity. But generally conductivity of the natural water is directly proportional to the concentration of ions. Distilled water has a conductivity of about 1μmhos/cm, while natural water normally has conductivity of 20-1500 μmhs/cm the conductivity of solutions depends upon the quantity of dissolved salts present (Asaolu*et al*., 2004).

The source of EC may be as a result of the abundance of dissolved salts due to poor irrigation management, minerals from rain water runoff, or other discharges. At about 0.3 μS/cm is the point at which the health of some crops and fresh water aquatic organisms will to be affected by the salinity(Agbaire,2009).

Salinity refers to the presence of dissolved inorganic ions such as Mg^{++}, Ca^{++}, K^{+}, Na^{+}, Cl^{-}, SO_2^{4-}, HCO_3^{-} and CO_3^{2-} in the aqueous solution or soil matrix. The salinity is quantified as the total concentration of soluble salts and is expressed in terms of electrical conductivity. There exists no in-situ salinity probe (based on EC alone) that can distinguish between the different ions that may be present. When salts such as sodium chloride are in their solid form, they exist as crystals (Agbaire, 2009).

Within the salt crystal, the sodium and the chlorine atoms are joined together in what is called an ionic chemical bond. An ionic chemical bond holds the atoms tightly together because the sodium atom will give up an electron to the chlorine thus ionizing the atoms. If an atom like sodium gives up an electron, it is said to be a positively charged ion (also called a cation). If an atom such as chlorine receives an electron, it is said to be a negatively charged ion (also called an anion and is given the suffix ide, like chloride). The sodium and the chloride ions comfortably arrange themselves into a stacked like configuration called a crystal lattice. The sodium chloride crystal lattice has a zero net charge.

Water will dissolve the sodium chloride crystal lattice and physically separate the two ions. Once in solution, the sodium ion and the chloride ion will float around in the solution separately and randomly. This is generally true for all inorganic salts. Once in a solution, the ions will float apart and become two separate species dissolved in the water. Typical, charged ions exist separately in a solution. If the water dries up, the cations and the anions will find each other and fuse back into a crystal lattice with a zero net charge.

2.5 Total Dissolved Solids (TDS)

Total dissolved solids indicate organic and inorganic matter in a sample. It is aggregated amount of the entire floating suspended solids present in water sample. The solids may be organic or inorganic in nature depending upon volatility of the substances. A high concentration of dissolved solids increases the density of water affects osmo-regulation of fresh water organisms, reduces solubility of gases and utility of water for drinking, irrigational and industrial purposes.(Garcia *et al*.,2002) According to Rao *et al*. (2003)

TDS analysis has great implication in the control of biological and physical waste water treatment processes.

2.6 Water Transparency

Transparency is how easily light can pass through a substance. In lakes this means how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. The top section of the lake that sunlight penetrates is called the Euphotic zone. The area around the edge of the lake that is shallow enough for plants to receive light is called the littoral zone. The area of the lake that is too deep for plants to grow is called the limnetic zone (Ayoade *et al*.,2009).

Water transparency depends on the amount of particles in the water. These particles can be algae or sediment from erosion, the more particles – the less water transparency. In other words, when the water is murky or cloudy and contains a lot of particles, the light cannot penetrate as deeply into the water column. (Muhammad,2007).

A secchi-disk is a black and white disk that is lowered by hand into the water to the depth at which it vanishes from sight. The distance to vanishing is then recorded, the clearer the water, the greater the distance. Secchi-disks are simple to use and inexpensive. For reservoir monitoring they have limited use, however, because in most cases the reservoir bottom will be visible and the disk will not reach a vanishing point. Deeper, slower moving reservoirs are the most appropriate places for secchi-disk measurement although the current might require that the disk be extra-weighted so it does not sway and make measurement difficult. The line attached to the secchi-disk must be marked according to

units designated by the volunteer program. Meter intervals can be tagged with duct tape for ease of use. (Atobatale and Ugwumba,2008).

2.7Water hardness

Hard water contains high concentrations of alkaline earth metals while soft water has low concentrations of such metals. Hardness usually includes only Ca^{++} and Mg^{++} ions expressed in the terms of equivalent $CaCO_3$. Total hardness of 15ppm or above are satisfactory for the growth of fish and do not require liming but water having less than 11ppm require liming for higher production of fish. Water having hardness less than 5ppm $CaCO_3$ equivalent cause low growth, distress and eventually death of fish .Total hardness value, which is the sum of calcium and magnesium hardness concentrations, was found to be significantly higher in the wet season; this was the same for calcium and magnesium ions (Mustapha, 2009).

Water hardness was higher during the dry season than the rainy season. This could be as a result of low water levels and the concentration of ions, and the lower rainy season value could be due to dilution. High concentration of Ca^{2+} and Mg^{3+} ions is responsible for hardiness and they are usually associated with high levels of bicarbonates (Ibrahim *et al.*, 2009).

2.8 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) has primary importance in natural water as limiting factor because most organisms other than anaerobic microbes diminish rapidly when oxygen levels in water falls to zero, of all dissolved gases, oxygen plays the most important role in determining the potential biological quality of water.(Araoye,2008) It is essential for

respiration, helps the breakdown of organic detritus and enables completion of biochemical pathways (Indabawa, 2010).In general, the concentration of dissolved oxygen will be the result of biological activity. Photosynthesis of some aquatic plants will increase the D.O during day light hours and the DO levels will fall during the nighttime hours. In natural waters, man-made contamination, or natural organic material will be consumed by microorganisms (Indabawa,2010).

As this microbial activity increases, oxygen will be consumed out of the water by the organisms to facilitate their metabolic digestion process. The water that is near the sediment will be depleted of oxygen for this reason.

In waters contaminated with fertilizers, suspended material, or petroleum waste, microorganisms such as bacteria will break down the contaminants. The oxygen will be consumed and the water will become anaerobic. Typically DO levels less than 2 mg/l will kill fish. (N'Diaye *et al.*,2013).

Ibrahim *et al.,* (2009) reported "The cool harmattan wind which increases wave action, and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season. Decomposition reduced the amount of oxygen, while increasing the amount of carbon dioxide in the affected environment. This accounted for the positive correlation between pH and DO. Dissolved Oxygen distribution followed a similar annual cycle with the pH. The high oxygen concentration recorded during the dry season was due to an enhanced photosynthetic activity and reduced turbidity during the dry season.Indabwa (2004) also reported lower values of

dissolved oxygen in summer season due to higher rate of decomposition of organic matter and limited flow of water in low holding environment due to high temperature.

2.9 Biological Oxygen Demand(BOD)

Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, manure, sewage or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live.(Zeb et *al.*,,2012)**.**

Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high, so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline. Nitrates and Phosphate are plant nutrients and can cause plant life and algae to grow quickly (Ayoade*et al*.,2006).

When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level. When BOD levels are high, Dissolved Oxygen(DO) levels decrease because the oxygen that is available in water is being consumed by bacteria, since less dissolved oxygen is available in the water, fish and other aquatic organism may not survive (Bhatti and latif,2011).

2.10 Phosphate-Phosphorus (PO_4^-)

Phosphorus is one of the most important major nutrients that are required to living organism, although needed in small amount; it is one of more common phytoplankton growthelements (Kolo *et al.,* 2010**).** Phosphorus enters lakes as inorganic phosphate ions, inorganic polymer and organic phosphorus compounds in living micro-organisms and dead detritus. Some organic forms of phosphorus are relatively unreactive and would not be detected by analyses for phosphates. Organic phosphorus can dramatically affect the algal growth; therefore, it may be more appropriate to evaluate total phosphorus as opposed to the reactive phosphates. Some microorganisms will uptake only inorganic phosphates; in this case, measurement of reactive phosphates may be a better indicator of water quality than total phosphorus. Ideally, phosphates and total phosphorus should both be evaluated when assessing a water system (Kolo *et al.*, 2010)

The fate and transport of phosphorus and phosphorus containing compounds in the environment is driven by the phosphorus cycle. The phosphorus cycle is primary driven by the uptake of phosphorus by living organisms. Phosphorus and phosphorus containing compounds act as energy conveyers for living organisms.(Ude,2011) Once the organism dies, phosphorus will be reintroduced to the soil and water where it is up taken again by another organism. The residence time in any particular body of water will be a function of pH, temperature, and climate. The most common source of phosphate pollution is poor management of agricultural irrigation and run off (Ude,2011).

2.11 Nitrate-Nitrogen (NO_3-)

Nitrate-nitrogen is required in aquatic and terrestrial ecosystem in a moderate quantity.Nitrate ion (NO_3^-) is the common form of nitrogen in natural waters. Nitrite (NO_2^-) will oxidize into nitrate after entering an aerobic regime. The amount of nitrate in solution at a given time is determined by metabolic processes in water; that is production and decomposition of organic matter (Balarabe, 2001). Kigamba (2005) reported the increased level of nitrates leached into African lakes from the excessive use of nitrogen fertilizers. The most highly oxidized form of nitrogen compounds is commonly present in surface and ground water because it is the end product of aerobic decomposition organic nitrogenous matter.Unpolluted natural waters usually contain only minute amounts of nitrate (Ude,2011).

In the environment, nitrate will become toxic to fish at about 30 mg/L. Nitrate pollution will cause eutrophication of a stream where algae and aquatic plant growth will consume the oxygen and increase the TSS of the water. Eutrophication is usually the result of nitrate and phosphate contamination and is a significant reduction of water quality.

Nitrate can exist naturally in groundwater but can increase dramatically on irrigated lands if the irrigation operation is not managed properly. Groundwater contaminated with nitrate can contaminate sources of drinking water in wells, and will contaminate the surface water as the ground water recharges streams and lakes. As more land is converted into agricultural land and as urban areas expand, nitrate monitoring is an important tool in accessing locating and mitigating man made sources of nitrate (Ude,2011).

2.11 Alkalinity

Alkalinity refers to the capability of water to neutralize acids. This is really an expression of buffering capacity. A buffer is a solution to which an acid can be added without changing the concentration of available H^+ ions appreciably. It is essentially absorbs the excess H+ and protects the water body from fluctuations in pH**.**

Generally, the basic species responsible for alkalinity in water are bicarbonate ion,carbonate ion and hydroxyl ion(Edema *et al*.,2002).

The presence of calcium carbonate or other compounds such as magnesium carbonate contribute to the buffering system.minor contributors to alkalinity are ammonia and conjugate bases of phosphoric, silicic, boric and organic acids**.**

Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks (lime stone) which are mostly $CaCO_3$. Since hard water contains metals carbonate (mostly $CaCO_3$) it is high in alkalinity. Conversely, unless carbonate is associated with sodium or potassium which do not contribute to hardness. Soft water usually has low alkalinity and little buffering capacity. So generally, soft water is much more susceptible to fluctuations in pH from acid rains or acid contamination (Edema *etal.*,2002). It is important to distinguish between high basicity manifested by an elevated pH and high alkalinity and the capacity to accept H+. Whereas pH is an intensity factor, alkalinity is a capacity factor.

Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes.

Living organism especially aquatic life function best in a pH range of 6.0 to 9.0.

2.12 Chloride (Cl^-)

Chloride is generally present in all natural surface waters, from as low concentration as faction of mg/dm3 to thousand mg/dm^3. Chlorides are present in natural waters due to high solubility of salts of muratic acid(HCl). They are commonly found in the environment. The lowest concentrations of chlorides are in rain water, mountain streams and rivers, why the highest concentration of the salt is found in marine waters, however high concentrations may be also found in ground water because of naturally high levels of chloride in soils in some areas or contamination by road(Hujare,2005).

Generally, chlorides penetrate into natural water from soil, natural layer of salt municipal and industrial sewage and waste of animal origin. Chlorides are not removed in typical sewage treatment processes and they entirely pass into surface water deteriorating their quality. In case of determination of chloride content in water it is necessary to define their origin., if natural or pollution. In case of water pollution together with chloride high concentration of nitrogen compounds and increase in quantity of bacteria occurs(Gupta *et al*.,2004) there is no evidence that ingestion of chloride is harmful to humans. High chlorides concentration increase corrosive properties of water (Umavathi*et al.,* 2007).

2.13 Sulphates

Commonly occur in natural waters, contrary to sulphates which are rarely present in natural waters. They get into water due to erosion of rocks and soil, biochemical oxidation of sulphur and its compounds, atmospheric precipitation, biochemical decomposition of plant and animal proteins and from industrial sewage. Especially high content of sulphates can be present in sewage from chemical industry (Gupta *et al.*,2004)

Sulphates are one of the at least toxic anions and large quantities would have to be ingested for health disorders to occur(diarrhea type symptoms). The presence of sulphate indrinking water can result in noticeable bitter taste (Gupta *et al.*,2004).

2.14 Calcium (Ca^{2+})

Of the cations found in most freshwater systems, calcium generally has the highest concentration (Hujare,2005).Calcium is akey element in many geochemical processes, and minerals constitute the primary sources of calcium and magnesium carbonate minerals and CO_2 dissolved in water (Hujare,2005).

Water containing a high level of carbondioxide readily dissolves calcium from its carbonate minerals.

2.15 Studies on Zooplankton

Zooplankton (Greek: Zoo animal; planktos, wandering) are myriads of diversefloating and drifting animals with limited power of locomotion. Majority of them are microscopic, unicellular or multicellular forms with size ranging from a fewmicrons to a millimeter or more. In addition to size variations, there are differencesin morphological features and taxonomic position (Kutikova,2004).

The zooplankton plays an important role to study the faunal bio-diversity of aquaticecosystems. They include representatives of almost every taxon of the animalkingdom and occur in the pelagic environment either as adults (holoplankton) oreggs and larvae (meroplankton). By sheer abundance of both types and theirpresence at varying depths, the zooplanktons are utilized to assess energy transferat secondary

trophic level. They feed on phytoplankton and facilitate the conversionof plant material into animal tissue and in turn constitute the basic foodfor higher animals including fishes, particularly their larvae. The zooplanktonoccurrence and distribution influence pelagic fishery potentials. The fishes mostlybreed in areas where the planktonic organisms are plenty so that their youngones could get sufficient food for survival and growth (Fernado,2002). Certain planktonic organismsare capable of concentrating radioisotopes and can act as indicator of certainpollutants, the study of which is important to marine environmental science.Zooplankton communities of fresh water bodies constitute an extremely diverse assemblage of organisms represented by most of the invertebrate phyla, however, thedominant zooplankton includes rotifers, cladocerans, copepods and ostracods and theirdistribution and diversity are influenced by seasonal variations of physicochemicalproperties, biotic factors including feeding ecology and predation pressure.(Douglas *et al*., 2001)

Zooplankton as a biotic component of the aquatic ecosystems play a key role incycling of organic materials, helping in regulating algal and microbial productivitythrough grazing, as suspension feeders and predators in the transfer of primaryproductivity to fish and other consumers (Denton, 2007). They often exhibit dramaticchanges in response to the changes in the physico-chemical and biotic properties of theaquatic environment hence are good bioindicators for the assessment of trophic state ofwater.

The planktonic forms with calcareous or siliceous shells or tests contribute tothe bottom sediments. The zooplankton are more varied as compared to phytoplankton,their variability in any aquatic ecosystem is influenced mainly bypatchiness, diurnal vertical

migration and seasons. Evaluation of zooplanktonproduction in any particular area will largely depend on use of correct zooplanktonmethodology that involves collection of samples, fixation, preservation, analysis.(Mahar,2003).

Investigation of food chains in the aquatic ecosystems is very important in point of view of the feeding habitats of fishes. It is evident that live food aquaculture including production of fauna and flora is particularly significance in aquatic animal nutrition. In addition, natural food are considered as rich source of various chemical constituents such as protein, fat content, the necessary amino acids and enzymes which play a crucial role of fish growth (Salavatian*et al.*,2005). The importance of zooplankton in aquatic ecosystems is the supply of nutritional source for fish larve and a number of adult fish (Sabkara*et al.*, 2002). In addition to their socio-economic importance, reservoirs due to their high dissolved nutrient content and incoming organic load from the water shed areas, considered as productive systems that provide various aquatic animal populations with nutritional substances. The main elements of these ecosystems include non-living factors (physico-chemical factors) and living factors (producers, consumers and decomposers) that are bound together through a highly complex biological structure. As secondary products, the zooplankton constitutes another ring of the food chain in aquatic ecosystems, which are constantly and actively present in different water resources. They are in turn consumed by other members in the food chain, the nektons. Zooplanktons are major nutritional elements for a variety of aquatic animals ranging from larvae up to adult fish species (Mustapha,2010).

For certain reservoirs, such as the ones used for water supply, the understanding of zooplankton seasonality can be an important factor to be considered for quality management purposes (Garcia *et al*., 2002). Zooplankton identification, analysis and abundance play a significant role in the quality judgment, purification of sewage and industrial waste. It so important in water management and control aimed at fish farming or swimming purposes.

2.15.1 Rotifers

The rotifers (Rotifera), commonly called wheel animals) make up a phylum of microscopic and near-microscopic pseudocoelomateanimals. Some rotifers are free swimming and truly planktonic, others move by inchworming along a substrate, and some are sessile, living inside tubes or gelatinous holdfasts that are attached to a substrate. Rotifers are very common planktonic animals in fresh water lakes and streams. Although rare in the oceans, rotifers are unusual animals in many respects. First, rotifers are very small, usually less than 200mm, which, for a complex multicellular animal, brings it to about the size of a typical protozoan.(Sabkara *et al*.,2002).

Second, almost all rotifers are females. Males in some families have never been observed. Females lay fertile eggs without the need of a male or fertilization, using a process known as parthenogenesis.(Robert,2003).

Foodsources with many species also contributing to the decomposition of soil organic matter. Most species of the rotifers are cosmopolitan, but there are also some endemicspecies (Alekseev,2002) Recent barcoding evidence, however, suggests that

some 'cosmopolitan' species, such as *Brachionusplicatilis*, *B. calyciflorus*, *Lecane bulla*, among others, are actually species complexes (Garcia *et al*.,2002).

2.15.2 Copepods

The most abundant planktonic crustaceans belong to the Order Copepoda, and a typical copepod mayundergo ecdysis twelve times in its life. The three suborders of copepods are:

1. Calanoid copepods have a major movable articulation between the 5^{th} and 6^{th} thoracic segment, orposterior to their 5th thoracic legs. They tend to be more oval shaped and often have long or branchedantennae.
2. Cyclopoid copepods have a major movable articulation between the 4^{th} and 5^{th} thoracic segment, or between their 4^{th} and 5^{th} thoracic legs. They tend to be more rounds shaped and often haveshorter or less branched antennae than calanoids.
3. Harpacticoid copepods have a metasome that is aboutthe same width as their urosome. They often have very long setae extending from their caudal rami(Robert,2003).

Copepods are a group of small crustaceans found in the sea and nearly every freshwaterhabitat. Some species are planktonic (drifting in sea waters), some are benthic (living on the ocean floor), and some continental species may live in limno-terrestrial habitats and other wet terrestrial places, such as swamps, under leaf fall in wet forests, bogs, springs, ephemeral ponds and puddles, damp moss, or water-filled recesses (phytotelmata) of plants such as bromeliads and pitcher plants. Many live underground in

marine and freshwater caves, sinkholes, or stream beds. Copepods are sometimes used as bioindicators (Schwab,2012).

Most copepods have a single compound eye in the middle of their head, but copepods of the genus *Corycaeus*possess two large cuticular lenses paired to form a telescope (Schwab,2012).

Copepods vary considerably, but can typically be 1 to 2 millimetres (0.04 to 0.08 in) long, with a teardrop-shaped body and large antennae. Although like other crustaceans they have an armouredexoskeleton, they are so small that in most species this thin armour, and the entire body, is almost totally transparent. Some polar copepods reach 1 centimetre (0.39 in). Most copepods have a single median compound eye, usually bright red and in the centre of the transparent head; subterranean species may be eyeless. Like other crustaceans, copepods possess two pairs of antennae; the first pair are often long and conspicuous (David,2009).

Copepods typically have a short, cylindrical body, with a rounded or beaked head. The head is fused with the first one or two thoracic segments, while the remainder of the thorax has three to five segments, each with limbs. The first pair of thoracic appendages are modified to form maxillipeds, which assist in feeding. The abdomen is typically narrower than the thorax, and contains five segments without any appendages, except for some tail-like "rami" at the tip (David,2009).

Because of their small size, copepods have no need of any heart or circulatory system (the members of the order Calanoida have a heart but no blood vessels), and most also

lack gills. Instead they absorb oxygen directly into their bodies. Their excretory system consists of maxillary glands.

2.15.3 Cladocera

Cladocera is an order of small crustaceans commonly called water fleas. Around 620 species have been recognized so far, with many more undescribed. They are ubiquitous in inland aquatic habitats, but rare in the oceans. Most are 0.2–6.0 mm (0.0079–0.2362 in) long, with a down-turned head, and a carapace covering the apparently unsegmented thorax and abdomen. There is a single median compound eye. Most species show cyclical parthenogenesis, where asexual reproduction is occasionally supplemented by sexual reproduction, which produces resting eggs that allow the species to survive harsh conditions and disperse to distant habitats. (Douglas, 2001)head is angled downwards, and may be separated from the rest of the body by a "cervical sinus" or notch(Douglas,2001). It bears a single black compound eye, located on the animal's midline, in all but two genera, and there is often a single ocellus(Denton,2007). The head also bears two pairs of antennae – the first antennae are small, unsegmented appendages, while the second antennae are large, segmented and branched, with powerful muscles(Douglas,2001). The first antennae bear olfactory setae, while the second are used for swimming by most species. The pattern of setae on the second antennae is useful for identification. The part of the head which projects in front of the first antennae is known as the rostrum or beak.

The mouthparts are small, and consist of an unpaired labrum, a pair of mandibles, a pair of maxillae, and an unpaired labium.They are used to eat "organic detritus of all kinds" and bacteria.

The thorax bears five or six pairs of lobed, leaf-like appendages, each with numerous hairs or setae. Carbon dioxide is lost, and oxygen taken up, through the body surface (Douglas,2001)

Mustapha (2010) reported the zooplankton assemblage in Oyun Reservoir was attributed to several biotic and abiotic factors interacting together. These include temperature, transparency, nutrients, food availability and reservoir morphometry. The fourteen genera of the zooplankton found consisting of Rotifera (eight), Cladocera (three) and Copepoda (three) could not be described as highly diversed. The zooplankton genera found in the reservoir agrees with the observations of Rocha *et al.*,(1999) about zooplankton assemblages in reservoirs.

The dominance of Rotifera and genus *Brachionus*was not unexpected as both the latter and former has been reported by, Akin-Oriola (2003) and Mustapha &Omotosho (2006) as the most dominant zooplankton group in Nigerian aquatic ecosystems. The high population density of the rotifers could be attributed to their parthenogenetic reproductive patterns and short developmental rate under favourable conditions, their morphological variations called cyclomorphosis and adaptations (Wetzel, 2001) and their ability to feed on different food type.

The dominance of Rotifera and genus *Brachionus* was not unexpected as both the latter and former has been reported by Akin-Oriola (2003) and Mustapha & Omotosho (2006) as the most dominant zooplankton group in Nigerian aquatic ecosystems. The dominance of *Brachionus*is an indication that the reservoir is eutrophic and their abundance was due to the presence of high organic matter in the reservoir. The relatively low abundance of Cladocera and copepods was as a result of the hydrodynamics of the reservoir such as the low water volume, short residence time, relative old age of the reservoir and its morphometry. The highest population of the two groups occurred at Station 2 which was the transitional zone of the reservoir between the riverine and lacustrine ecosystems. The reason for this was due to the presence of food (phytoplankton) on which they graze and the high transparency of the zone. High clay content and silt turbidity resulting in low transparency was responsible for the low population of the crustacean zooplankton in station 3. The effect of this caused juvenile mortality of the zooplankton and suppressed their growth through food availability. This suppression could have encouraged rotifer population to dominate. Larson &Samora (2009) have noted this type of scenario in a tropical reservoir. The low genera abundance of cladocerans and copepods has also been documented in other water bodies like Lake Cubhu, South Africa.Ogun and Ona rivers (Akin-Oriola 2003).

The predominance of *Daphnia* among the cladocerans could have arisen due to its large bodied size which enables it to graze on large quantities and diverse forms of phytoplankton. High *Daphnia* population occurred due to their effective grazing on rotifers. The density and biomass of cladocerans were primarily determined by food supply. Though, genus *Cyclops* was the dominant genus among the copepods, its

relatively low abundance in the reservoir could be described as a good omen. This is because of the medical implications of large population of the genus in water bodies of Africa, where water is consumed directly from reservoirs without being treated. The low population of the genus could be due to their slow reproduction, growth and renewal rate. Absence of parthenogenetic forms of copepods might be responsible for their low population density.(Akin-Oriola,2003)

The high population density and biomass of zooplankton during the rains was traced to high population of phytoplankton food source which were highly abundant within the reservoir during the rains. According to Rocha *et al.*(2000), increase in primary production (phytoplankton), tends to be followed by increase in zooplankton number and biomass. Muylaert*et al.*(2003) also corroborated the finding that zooplankton biomass usually reaches their peak during the rains in reservoirs. Apart from food source, low predation by fish during the rains as a result of their breeding could also have encouraged high population of the zooplankton. High fish predation, less availability of food source, low temperature during "harmattan" period could be responsible for the decline in zooplankton during the dry season.

Achembach&Lampert (1997) have emphasized these factors as been responsible for zooplankton biomass reduction. Food resource, ability to adapt to food conditions and less predation (topdown forces) may be the reasons for the significant abundance of Rotifers, Cladocera and Copepoda in the rains. The absence of some genera such as *Lecane, Sida*and *Diaptomus*in some stations could have occurred as a result of patchiness

or dispersal. Dispersal has been noted to play a major role in structuring zooplankton population and communities (Shurin& Havel, 2002).

Adakole*et al.*(2005) observed that the complex of organisms which develops in a given aquatic habitat is indicative of environmental conditions that have occurred during the organism's development, thus invertebrates encountered and enumerated represent the summation of the prevailing water quality conditions of Kubannilake. Cladocera was the most abundant followed by Rotifera and Copepoda respectively. Cladocera was represented by *Daphnia* and *Diaphanosome* species. Rotifrea was represented by *Keratella* and *Branchionus* species with *Keratella* forming the most abundant species. Copepoda was represented by *Diaptomus* species, Cyclops species and *Nauphlus* larvae. *Nauhllii* species formed the most abundant. (Balogun*et al.*,2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Karidnareservoir is located in College of Agriculture and Animal science Mando, Igabi local governmentKaduna State.The study area occupies some 406.39m^2 within latitudes 10° 37'12" – 10° 37'36" N and longitude 7° 25' 12" – 7° 25' 36" E (Figure 3.1).

The reservoir catchment lies within the tropical wet and dry climatic zone, characterized by strong seasonality in rainfall and temperature distributions. It has two distinct seasons, the dry season (October to March) and wet season (April to September).The area has a single maximum rainfall regime with average annual totals ranging from 1050mm to 1250mm

3.2 Sampling Procedures

Five sampling stations were chosen within the water reservoir as follows:

Station 1: Area round the entrance where human activities like bathing, washing, irrigation farming and animal activities are taking place.

Station 2: At the lower point where there are less human activities.

Station 3: At the deepest part of the reservoir and

Station 4 and 5 at the longest part of the reservoir.

Samples were collected for a period of twelve months.Water samples were collected from six samplingstations between the hours of 8:00 am to 1:00 pm. In this method,water was sampled at surface level by dipping 1 litre plastic sampling bottle and slides over the

most uppersurface of water with their mouth against passage ofthe water into the bottle (APHA,2005).

Some parameters were determined *insitu* using Hanan Instrument of model (HI 98129) such as the Temperature, pH,Electrical conductivityand Total dissolved solids while some were transported to the laboratory for the analysis ofphysico-chemical parameters.

3.3Determination of Water Transparency

The transparency of the water wasmeasured using 20cm diameter Secchi disk, whichwas dipped into the water till the disk disappearedand the depth was recorded, it was then dippedfurther and then withdrawn carefully and the depth atwhich it became visible was also recorded. Actualmeasurement was obtained by taking the average ofthe two readings (APHA, 2005).

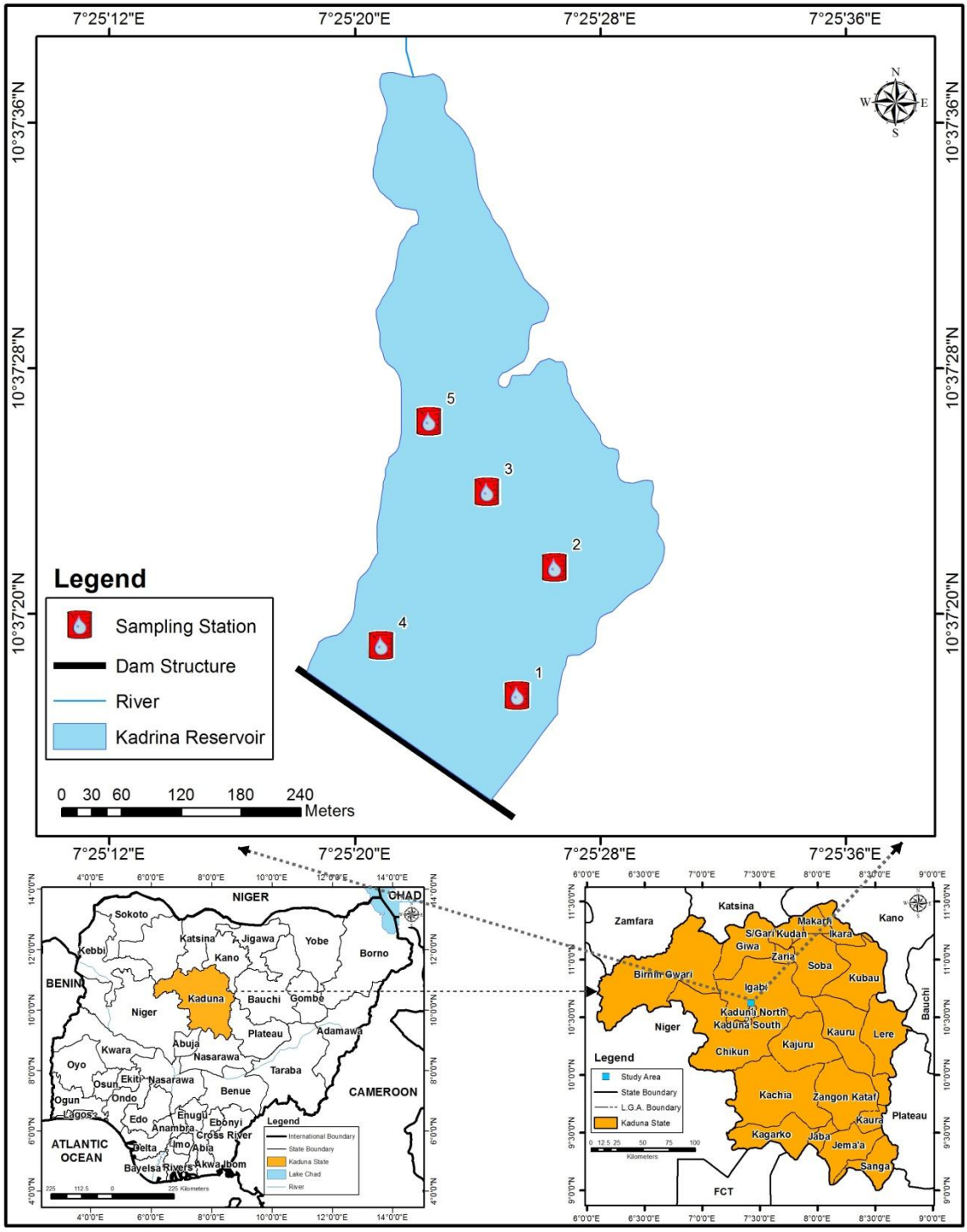


Figure 3.1: Map of Kadrina Reservoir showing Sampling Stations
Source: Fieldwork/Administrative Map of Igabi L.G.A., Kaduna State.

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3.4 Determination Of Physico- Chemical Parameters Of Karidna Reservoir

3.4.1 Determination of water hardness

a. Chemicals

Exactly 0.372g of ethylene diamine tetra-acetic acid disodium salt (EDTA) was dissolved in 100 ml of distilled water (0.1 N) and used as titrate.

Buffer solution was prepared by dissolving 16.9g of ammonium chloride in 143 ml in volumetric flask with1.179 g of magnesium carbonate, 12.6 H_2O in 50 ml distilled water. These two reagents were mixed to make 250 ml as a final volume of buffer solution, Erichrome black-T dye was use as indicator. (APHA,2005)

b. Procedure

Water sample (10 ml) was taken into conical flask with the help of pipette, 0.5 mg of buffer tablet (Erichrome black-T dye) and 1ml of conc. ammonium hydroxide (NH_4OH) was added as indicator and then titrated with 0.1N (EDTA) solution.

c. Calculation for determination of water hardness

$$\text{Hardness (mg/l)} = \frac{N \times M \times 50{,}000}{V}$$

Where:

N = Normality of titrate 0.1 N

M = Mean of three titre value readings

V = Volume of water sample

50,000 = standard value of equation APHA (2005).

3.4.2 Determination of dissolved oxygen

Two mililiters of $MnSO_4$ was added at the site of collection of water sample before taken to the laboratory. Water sample was then poured into a 300 ml bottle and two mililitres of alkali-iodide azide reagent was added then stoppered with care to exude air bubbles, it was then mixed gently by inverting the bottle a number of times until a clear supernatant was obtained. It was then allowed to settled for two minutes after which 2ml Concentrated $H2SO_4$ was added by allowing the acid run down the neck of the bottle. It was stoppered again and mixed by gentle inversion until dissolution was complete. 100ml of the prepared solution was transferred into a conical flask and then titrated with 0.0125N of $Na_2S_2O_3.5H_2O$ solution to a pale straw yellow color.

Two milliliters of freshly prepared starch solution was added and color becomes blue. Titration was continued by adding the thio-sulphate drop wise until the blue color disappeared.

3.4.3Determination of biological oxygen demand

For biochemical oxygen demand the sample tested for Dissolved oxygen was incubated for five days in a cupboard and Dissolved oxygen was also tested, the difference between the initial value of Dissolved oxygen and the value after incubation was used as value of biochemical oxygen demand in the water sample (Mahar, 2003).

3.4.4 Determination of phosphate-phosphorus

This was determined using the Dennigesmethod and APHA (2005). One millilitre (1ml) of Denniges reagent and 1 drop of stannous chloride was added to 100ml water sample. Absorbance at 690nm was measured with spectrophotometer, model S101 using distilled

water as the blank. The phosphate concentration of water sample was read from the calibration curve.

3.4.5 Determination of total nitrate-nitrogen

One hundred (100) ml of water sample was poured into a crucible and evaporated to dryness and cooled. Two (2) ml of phenoldisulphonic acid was added and smeared around the crucible, after 10 minutes, 10ml of distilled water was added followed by 5ml strong ammonia solution. Setting the spectrophotometer at the wave length 430nm, absorbance of the sample treated was obtained, using water as blank. The concentration of nitrate- nitrogen was obtained from the calibration curve in mg/L.(APHA,1998)

3.4.6 Determination of alkalinity

One Hundred (100) ml of water sample was transferred into a conical flask and Two (2) drops of bromo-cresol green and two (2) drops of methylred were added respectively. The mixture was swirled and titrated with solution of H_2SO_4 until color change.

The formula used is Total alkalinity in CacO3 mg/l= Titer value X 10 (APHA,1998)

3.4.7 Determination of chloride

One hundred (100) ml of water sample was transferred into a conical flask and 2-3 drops of potassium chromate was added, and content was swirled for few minutes then titrated against silver nitrate solution until dirty reddish precipitate was obtained.

Cl mg/l = volume of $AgNO_{3\times}10$. (APHA,1998)

3.4.8 Determination of sulphate

One hundred (100) ml of water sample was poured in a conical flask and 1g of Barium chloride (Bacl) was added and shaked and was allowed to stand for 3minutes and finally the readings was taken at 430nm wavelength.(APHA,2005)

3.4.9 Determination of calcium

Fifty (50) ml of the water sample was measured and into a conical flask then 1ml of Sodium Hydroxide (NaOH) was added to produce pH of 13-14 and was stirred and 0.2g of murexide indicator was added and stirred and color changes to pink. Titration was done against EDTA and the color changes from pink to purple. (APHA,2005)

3.5 Zooplankton Sampling and Analysis

Zooplankton samples were collected with silk plankton net of 25cm diameter of 70cm meshes attached with a bottle of 50ml capacity at the base. The net was sunk just below the surface and then towed through a distance of 10m horizontally. The content of the collected vial was then poured into plastic bottle of 50ml capacity and preserved in 4% formalin. Counting was done by shaking the preserved sample and pipetting 1ml of and then mounted on a compound microscope.

Identification was done based on standard identification guides of zooplankton. Alekseev(2002), Fernado(2002),and Kutikova (2002); Smith (2001) Identification and classification of Freshwater invertebrates; Geiling(2000) identifying the Immature Life Stages of Copepods. Lynne (2004): Comparative Freshwater Ecology unit 2nd Edition.. The relative abundance of the various taxa was then calculated using the formular:

$$No/m^3 = \frac{C \times V'}{V'' \times V'''}$$

Where:

C= number of organism counted

V'= Volume of the concentrated sample, (ml)

V''= Volume of water counted, (ml)

V'''= Volume of the grab sample, (m^3)

To obtain organisms per liter, it is divided by 1000 (APHA,2005)

3.5 Data Analysis

The results obtained were subjected to analysis of variance to test significance at level of 0.05; between the physico-chemical factors and number of seasonal variations. The distribution and abundance of the zooplankton communities in the reservoir was also assessed .Correlation analysis was used to test relationship between physico-chemical parameters and zooplankton.

CHAPTER FOUR

4.0 RESULTS

4.1 Physico-Chemical Parameters

The Physico-Chemical Parameters of the reservoir showed monthly mean variation (Table 4.1). The water temperature variation indicated mean ± SE value of (27.99 ± 0.16^{o}C); the pH values ranged between (7.41 -7.57) with mean ± SE value of 7.49 ± 0.08; Transparency of the reservoir fluctuated with mean ± SE value of 28.22 ± 1.07 cm. The Dissolved Oxygen values in the reservoir ranged from 2.40mgL^{-1}to 6.81mgL^{-1}; with the mean ± SE of 4.74 ± 0.15mgL^{-1}. The biochemical oxygen demand in Karidna reservoir revealed monthly variation with mean ± SE value of 2.88 ± 0.07mgL-1. The electrical conductivity ranged from 38.20µS/cm to64.20µS/cm with mean ± SE of 54.75 ± 1.17µS/cm. The hardness in the reservoir shown mean ± SE of 3.27 ± 0.11mg^{L-1}(CaCO3); Nitrate-nitrogen indicated mean ± SE values of 3.27 ± 0.01mg^{L-1}during the period of study. Total dissolved solids in the reservoir have the mean ± SE value of 28.25$\pm$0.72mg^{L-1}.Phosphate-phosphorus was 0.14 ± 0.01mg^{L-1}. The mean ± SE value of Calcium was 2.64$\pm$ 0.11 mg^{L-1}. Alkalinity has the mean value of 3.80$\pm$ 0.16 mg^{L-1}; Sulphate of the reservoir have the mean$\pm$ SE values of 0.09$\pm$0.01mg/$^{L-1}$ and Chloride with the mean $\pm$ SE 3.22$\pm$0.12 mg^{L-1}. The Physico-chemical parameters studied were all non-significant except across the stations except transparency that was significant (Table4.2). Based on seasons all the physic-chemical parameters were highly significant except chloride that was non-significant (Table 4.3a and b)

Table 4.1 Seasonal Variation of the Physico-chemical Parameters of Karidna Reservoir

Parameter	Season		Total	P value
	Dry	Wet		
pH	7.41±0.04	7.57±0.15	7.49±0.08	0.329ns
Temp (^oC)	27.78±0.40	28.19±0.44	27.99±0.29	0.497ns
EC (µS/cm)	58.97±1.35	50.53±1.59	54.75±1.17	0.000**
TDS (ppm)	31.53±0.89	24.97±0.76	28.25±0.72	0.000**
Transparency (cm)	31.78±0.89	24.65±0.76	28.22±1.07	0.001**
Cl (mg/L)	3.23±0.15	3.21±0.19	3.22±0.12	0.912ns
PO_4-(mg/L)	0.18±0.01	0.11±0.01	0.14±0.01	0.000**
NO_3 (mg/L)	0.27±0.01	0.20±0.01	0.24±0.01	0.000**
SO_4 (mg/L)	0.07±0.002	0.12±0.02	0.09±0.01	0.004**
Hardness (mg/L)	135.2±4.8	126.4±7.6	130.8±4.4	0.311ns
Ca (mg/L)	2.43±0.10	2.85±0.18	2.64±0.10	0.042*
Alkalinity (mg/L)	3.89±0.27	3.71±0.18	3.80±0.16	0.565ns
DO (mg/L)	5.49±1.88	4.00±0.20	4.74±0.15	0.000**
BOD (mg/L)	2.48±0.09	3.28±0.09	2.88±0.07	0.000**

** - highly significant at P≤0.01, Non-significant at P>0.01

Table 4.2: Physico-chemical Parameters of Karidna Reservoir Based on Stations

Physico-chemical Parameters	Stations					Total	P value
	I	II	III	IV	V		
pH	7.73±0.25^{a}	7.54±0.19^{ab}	7.28±0.16^{b}	7.48±0.15^{ab}	7.41±0.12^{ab}	7.49±0.08	0.485ns
Temp (^{o}C)	28.71±0.53^{a}	28.09±0.58^{ab}	27.95±0.72^{b}	27.80±0.70^{b}	27.38±0.78^{b}	27.99±0.29	0.716ns
EC (µcm)	58.67±2.09^{a}	54.67±2.61^{ab}	53.00±2.98^{b}	53.33±2.66^{b}	54.08±2.79^{ab}	54.75±1.17	0.565ns
TDS (ppm)	31.08±1.62^{a}	28.50±1.68^{ab}	27.17±1.58^{b}	27.25±1.49^{b}	27.25±1.67^{b}	28.25±0.72	0.371ns
Transparency (cm)	27.71±2.11^{b}	26.29±1.68^{b}	27.04±1.64^{b}	24.96±1.74^{b}	35.08±3.49^{a}	28.22±1.07	0.021*
Cl (mg/L)	3.10±0.29^{ab}	3.35±0.23^{ab}	2.91±0.20^{b}	2.89±0.29^{b}	3.85±0.26^{a}	3.22±0.12	0.058ns
PO_4-(mg/L)	0.17±0.23^{a}	0.16±0.02^{ab}	0.14±0.02^{ab}	0.11±0.01^{b}	0.13±0.01^{ab}	0.14±0.01	0.136ns
NO_3 (mg/L)	0.25±0.02^{a}	0.24±0.02^{ab}	0.23±0.02^{b}	0.24±0.02^{ab}	0.24±0.01^{ab}	0.24±0.01	0.965ns
SO_4 (mg/L)	0.12±0.04^{a}	0.08±0.01^{ab}	0.08±0.01^{ab}	0.08±0.01^{ab}	0.11±0.03^{b}	0.09±0.01	0.682ns
Hardness (mg/L)	127.6±10.8^{b}	124.4±9.6^{b}	137.2±8.4^{ab}	138.8±11.6^{a}	126.4±10.4^{b}	130.8±4.4	0.794ns
Ca (mg/L)	2.72±0.10^{b}	2.53±0.18^{b}	2.42±0.25^{b}	3.03±0.31^{a}	2.53±0.26^{b}	2.64±0.10	0.381ns
Alkalinity (mg/L)	3.44±0.34^{ab}	3.20±0.28^{b}	3.99±0.42^{ab}	4.36±0.40^{a}	4.01±0.27^{ab}	3.80±0.16	0.132ns
DO (mg/L)	4.62±0.30^{b}	4.55±0.38^{b}	4.71±0.36^{b}	4.94±0.31^{a}	4.91±0.39^{ab}	4.74±0.15	0.909ns
BOD (mg/L)	2.95±0.13^{b}	2.90±0.12^{b}	3.00±0.12^{a}	2.94±0.18^{b}	2.58±0.23^{b}	2.88±0.07	0.355ns

Table 4.3a: Physico-chemical Parameters of Karidna Reservoir Based on Season

Parameters	Dry Season					
	October	**November**	**December**	**January**	**February**	**March**
pH	7.30 ± 0.10^{bc}	7.60 ± 0.07^{bc}	7.47 ± 0.07^{bc}	7.44 ± 0.05^{bc}	7.41 ± 0.12^{bc}	7.24 ± 0.07^{c}
Temp (^{o}C)	26.46 ± 0.74^{c}	26.90 ± 0.60^{c}	26.20 ± 0.72^{c}	26.90 ± 0.53^{c}	28.76 ± 0.19^{b}	31.48 ± 0.19^{a}
EC (µS/cm)	61.60 ± 0.51^{a}	64.20 ± 1.53^{a}	63.20 ± 0.97^{a}	60.60 ± 0.68^{ab}	52.20 ± 3.50^{bc}	52.00 ± 5.10^{bc}
TDS (ppm)	31.00 ± 0.55^{b}	31.60 ± 1.33^{b}	37.20 ± 0.86^{a}	36.00 ± 1.41^{a}	25.60 ± 1.94^{bc}	27.80 ± 0.86^{bc}
Transparency (cm)	40.10 ± 0.39^{a}	28.10 ± 1.54^{bcd}	30.20 ± 1.85^{bc}	30.40 ± 1.81^{bc}	34.30 ± 5.09^{ab}	27.60 ± 5.75^{bcd}
Cl (mg/L)	3.58 ± 0.37^{ab}	3.18 ± 0.34^{abc}	3.00 ± 0.36^{abc}	3.06 ± 0.23^{abc}	3.46 ± 0.51^{abc}	3.12 ± 0.39^{abc}
PO_4-(mg/L)	0.15 ± 0.01^{bcd}	0.20 ± 0.03^{ab}	0.24 ± 0.02^{a}	0.17 ± 0.03^{bc}	0.15 ± 0.03^{bc}	0.14 ± 0.01^{bcd}
NO_3 (mg/L)	0.30 ± 0.01^{a}	0.30 ± 0.01^{a}	0.28 ± 0.03^{ab}	0.27 ± 0.19^{abc}	0.27 ± 0.02^{abc}	0.20 ± 0.02^{def}
SO_4 (mg/L)	0.07 ± 0.01^{bc}	0.07 ± 0.01^{bc}	0.07 ± 0.01^{bc}	0.07 ± 0.01^{bc}	0.07 ± 0.01^{bc}	0.06 ± 0.01^{bc}
Hardness (mg/L)	145.6 ± 9.6^{abc}	142.4 ± 12^{abc}	143.2 ± 10^{abc}	3.48 ± 0.25^{bc}	144 ± 10.8^{abc}	97.6 ± 6^{de}
Ca (mg/L)	2.48 ± 0.19^{b}	2.74 ± 0.24^{b}	2.41 ± 0.22^{b}	2.16 ± 0.28^{b}	2.28 ± 0.22^{b}	2.52 ± 0.27^{b}
Alkalinity (mg/L)	4.92 ± 0.64^{a}	2.51 ± 0.14^{d}	4.38 ± 0.80^{ab}	3.34 ± 0.39^{bcd}	5.04 ± 0.64^{a}	3.16 ± 0.32^{bcd}
DO (mg/L)	6.71 ± 0.26^{a}	6.08 ± 0.25^{ab}	5.33 ± 0.11^{bc}	5.08 ± 0.14^{c}	6.81 ± 0.27^{a}	2.95 ± 0.14^{e}
BOD (mg/L)	32.33 ± 0.13^{cd}	28.75 ± 0.10^{d}	29.83 ± 0.17^{cd}	27.17 ± 0.13^{d}	40.83 ± 0.33^{e}	23.08 ± 0.14^{d}

Table 4.3b: Physico-chemical Parameters of Karidna Reservoir Based on Season

Parameters	Wet Season						Total	P value
	April	May	June	July	August	September		
pH	6.19±0.21^{d}	7.51±0.13^{bc}	7.65±0.17^{bc}	7.62±0.10^{bc}	8.63±0.31^{a}	7.79±0.26^{b}	**7.49±0.08**	0.000**
Temp (^{o}C)	31.20±0.36^{a}	31.54±0.18^{a}	25.94±0.07^{c}	26.30±0.07^{c}	27.04±0.13^{c}	27.10±0.49^{c}	**27.99±0.29**	0.000**
EC (µS/cm)	52.00±1.10^{bc}	55.80±1..36^{abc}	50.20±2.06^{c}	55.80±1.77^{abc}	38.20±1.80^{d}	51.20±6.63^{c}	**54.75±1.17**	0.000**
TDS (ppm)	25.60±0.60^{c}	27.40±0.40^{bc}	25.20±1.32^{c}	26.40±0.81^{c}	19.20±0.74^{d}	26.00±3.30^{c}	**28.25±0.72**	0.000**
Transparency (cm)	28.10±3.23^{bcd}	27.10±2.05^{bcd}	23.10±1.78^{cd}	20.80±1.21^{cd}	19.40±1.22^{d}	29.40±3.61^{bcd}	**28.22±1.07**	0.002**
Cl (mg/L)	2.50±0.09^{bc}	3.24±0.60^{abc}	2.28±0.30^{c}	3.14±0.19^{abc}	4.12±0.19^{a}	3.96±0.42^{a}	**3.22±0.12**	0.067ns
PO_4^-(mg/L)	0.12±0.01^{cd}	0.15±0.03^{bc}	0.09±0.01^{de}	0.04±0.02^{e}	0.13±0.01^{cd}	0.14±0.01^{cd}	**0.14±0.01**	0.000**
NO_3^- (mg/L)	0.24±0.02^{bcd}	0.17±0.02^{ef}	0.15±0.02^{f}	0.22±0.004^{cde}	0.18±0.01^{ef}	0.26±0.03^{abc}	**0.24±0.01**	0.000**
SO_4^- (mg/L)	0.14±0.01^{ab}	0.06±0.003^{bc}	0.21±0.05^{a}	0.04±0.01^{c}	0.19±0.07^{a}	0.09±0.01^{bc}	**0.09±0.01**	0.000**
Hardness (mg/L)	124±16^{cd}	87.2±8.4^{e}	80±6.8^{e}	133.6±5.2^{bc}	174.4±14^{a}	158.4±5.6^{ab}	**3.27±0.11**	0.000**
Ca^+ (mg/L)	2.44±0.36^{b}	2.14±0.24^{b}	2.64±0.70^{b}	2.98±0.20^{ab}	3.86±0.26^{a}	3.06±0.40^{ab}	**2.64±0.10**	0.035**
Alkalinity (mg/L)	3.38±0.45^{bcd}	2.62±0.18^{cd}	3.28±0.26^{bcd}	4.04±0.21^{abc}	4.54±0.36^{ab}	4.38±0.45^{ab}	**3.80±0.16**	0.001**
DO (mg/L)	3.86±0.24^{d}	2.40±0.28^{e}	3.89±0.34^{d}	5.22±0.22^{c}	2.80±0.12^{e}	5.81±0.57^{bc}	**4.74±0.15**	0.000**
BOD (mg/L)	23.83±0.13^{bc}	24.25±0.13^{b}	22.75±0.17^{bc}	29.33±0.18^{a}	3.03±0.19^{c}	2.91±0.15^{cd}	**2.88±0.07**	0.000**

4.1.1. Temperature

The highest value for temperature was observed in wet season (28.19 mg/l) which was non-significance between the seasons ($P \geq 0.05$) (Table 4.1). The mean monthly variation oftemperature was higher in May (31.54^{o}C) (Table 4.3). Station I has the highest value (28.7 ^{o}C) among the stations. (Table 4.3, Fig 4.1).

4.1.2 Water pH

The highest value for pH was observed in the wet season (7.57 mg/l) which was non-significant between the seasons ($P \geq 0.05$) (Table 4.1) the mean monthly variation of pH among the months shows that the month of August (8.63 mg/l) to be highest (Table 4.3) while station I has the highest value (7.73 mg/l) across the sites (Table 4.3, Fig 4.2).

4.1.3 ElectricalConductivity

The highest value for EC was observed in dry season (58.9 µS/cm) which was highly significant from the wet season (50.53 µS/cm) (Table 4.1) ($P \leq 0.01$). Among the months the highest EC value was November (64.20 mg/l) (Table 4.3) and station I had the highest value (58.67 mg/l) which was non-significant from other stations. (Table, 4.2, Fig. 4.3).

4.1.4 Total dissolved solids

The highest value for TDS was recorded in dry season (31.53 mg/l) which was highly significant from the wet season (24.97 mg/l) (Table 4.1) ($P \leq 0.01$) the monthly variation of TDS value was recorded highest in the month of December (37.20 mg/l) (Table 4.3)

and station I has the highest value (31.08 mg/l) which was non-significant from thestations. (Table.4.3 Fig, 4.4).

4.1.5 Water transparency

Transparency: the highest value for transparency was recorded to be high in dry season (31.78cm) which was highly significant from the wet season (24.65cm) (Table 4.1) ($P \leq 0.01$). Among the months the highest value for transparency was observed in the month of October (40.10cm) (Table 4.3) and station V was observed to be highest among all other stations (Table 4.2 , Fig.4.5).

4.1.6 Water hardness

Hardness has the highest value in dry season (3.36 mg/l) which was non-significant between the seasons. ($P \geq 0.05$) (Table 4.1). Among the months the highest value for hardness was observed in the month of August (4.36 mg/l) (Table 4.3) while station IV was observed in the month of August (4.36 mg/l) (Table 4.3) while station IV was higher (3.47 mg/l) which was non-significance ($p>0.05$) (Table 4.2, figure 4.10).

4.1.7 Dissolvedoxygen

The concentration of dissolved Oxygen was highest in dry season (5.48 mg/l) it exhibited a highly significant variation from wet season (4.00 mg/l) (Table 4.1) ($P \leq 0.01$). Among the months the highest value for D.O was observed in February (6.81 mg/l) (Table 4.3) and station IV was recorded to had the highest value for D.O across the stations.(Table 4.2, Fig 4.13).

4.1.8 Biological oxygen demand

Biological Oxygen Demand (BOD): the highest value was recorded in wet season (3.28 mg/l) which was highly significant from dry season (2.48 mg/l) (Table, 4.1) ($P \leq 0.01$). the month of June was observed to had the highest value for BOD (Table 4.3). Site I was recorded to have the highest value across the sites (Table 4.2, Fig 4.14).

4.1.9 Phosphate – phosphorus (PO_4^-)

Result shows that Phosphate was observed to be higher in dry season (0.18 mg/l) which was highly significant from wet season (0.11) ($P \leq 0.01$) (Table, 4.1). Among the months, the highest value for phosphate was observed in the month of December (0.24 mg/l) (Table 4.3) while station I had the highest value (0.17mg/l) which was non-significant from otherstations (Table 4.2, Fig 4.7).

4.1.10 Nitrate- Nitrogen (NO_3^-)

There was high concentration of Nitrate- nitrogen in dry season (0.27 mg/l) which was highly significant ($P \leq 0.01$) from the wet season (0.20 mg/l) (Table. 4.1).

Variation of Nitrate- nitrogen among the months revealed that October and November had the highest concentration (0.30 mg/l) each.(Table 4.3) while station I maintain the nitrate level(0.25 mg/l) which was non-significant ($P \geq 0.05$) (Table 4.3, Fig 4.8).

4.1.11 Alkalinity

Analysis of Variance revealed the value of alkalinity to be high in dry season (3.89 mg/l) which was non-significant between the season ($P \geq 0.05$) (Table 4.1). Among the months October was observed to be highest (4.92mg/l) (Table 4.3). While station IV was higher(4.36 mg/l) which was non-significant across the stations (Table 4.2, Fig 4.12).

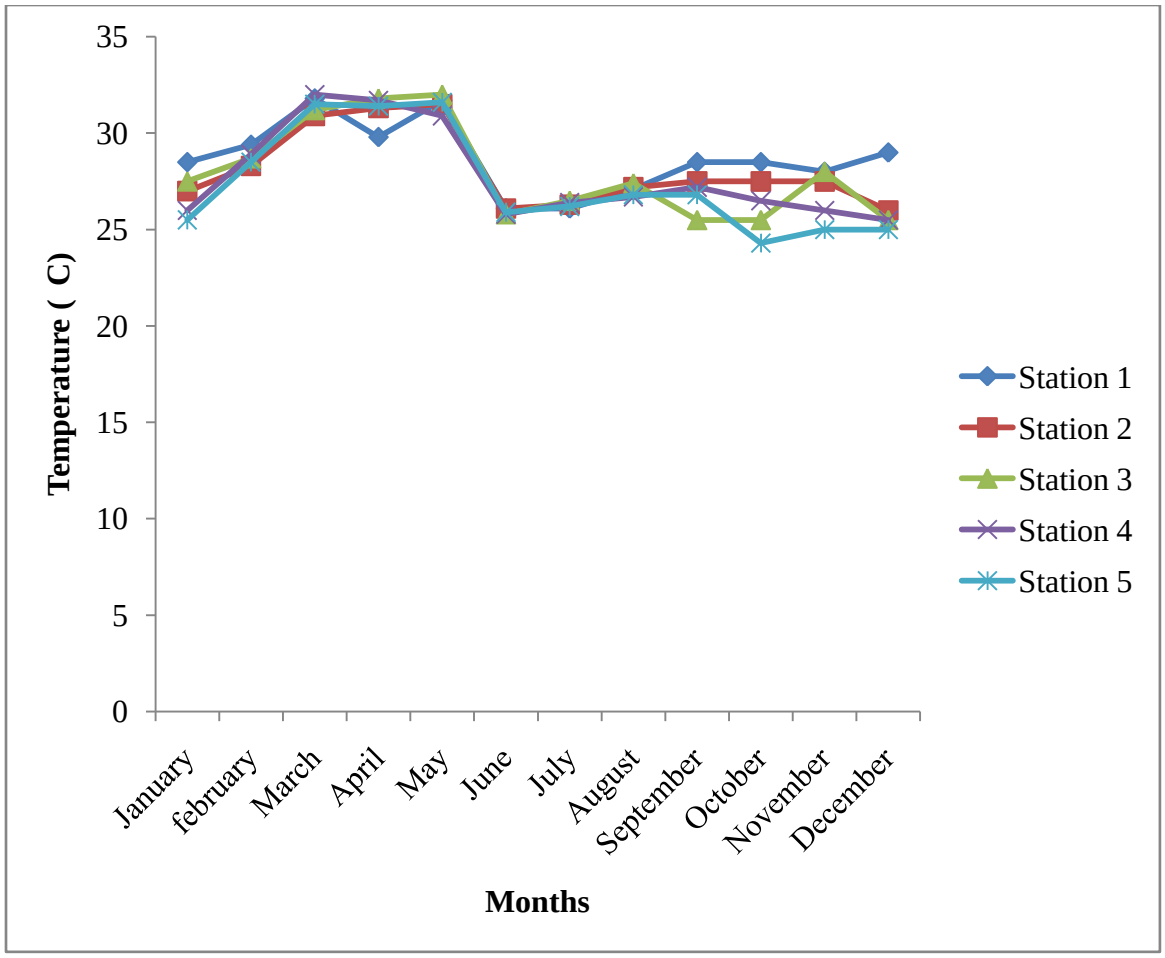


Figure 4.1: Mean Monthly Variation of Temperature (°C) at Various Stations

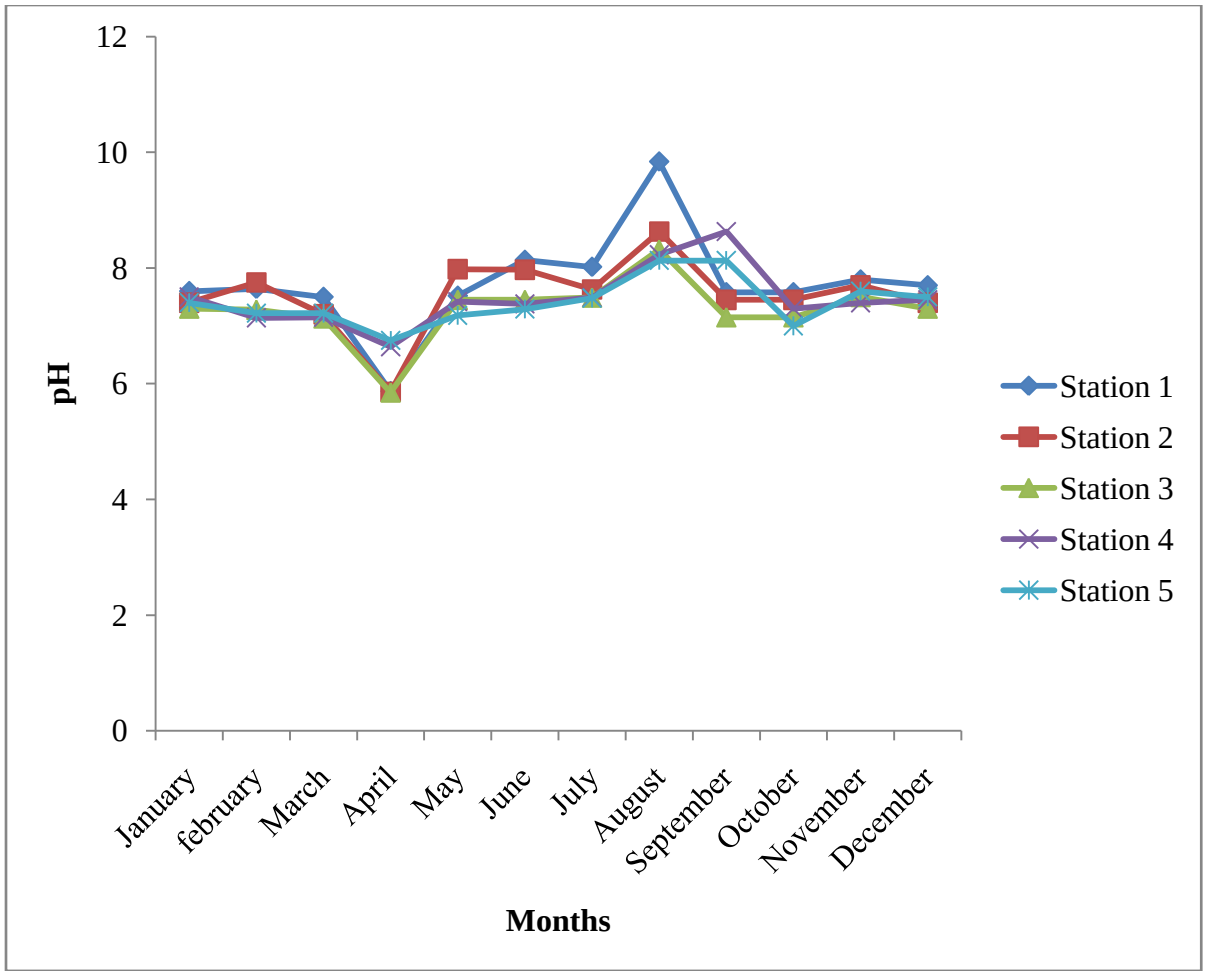


Figure 4.2: Mean Monthly Variation of pH at Various Stations

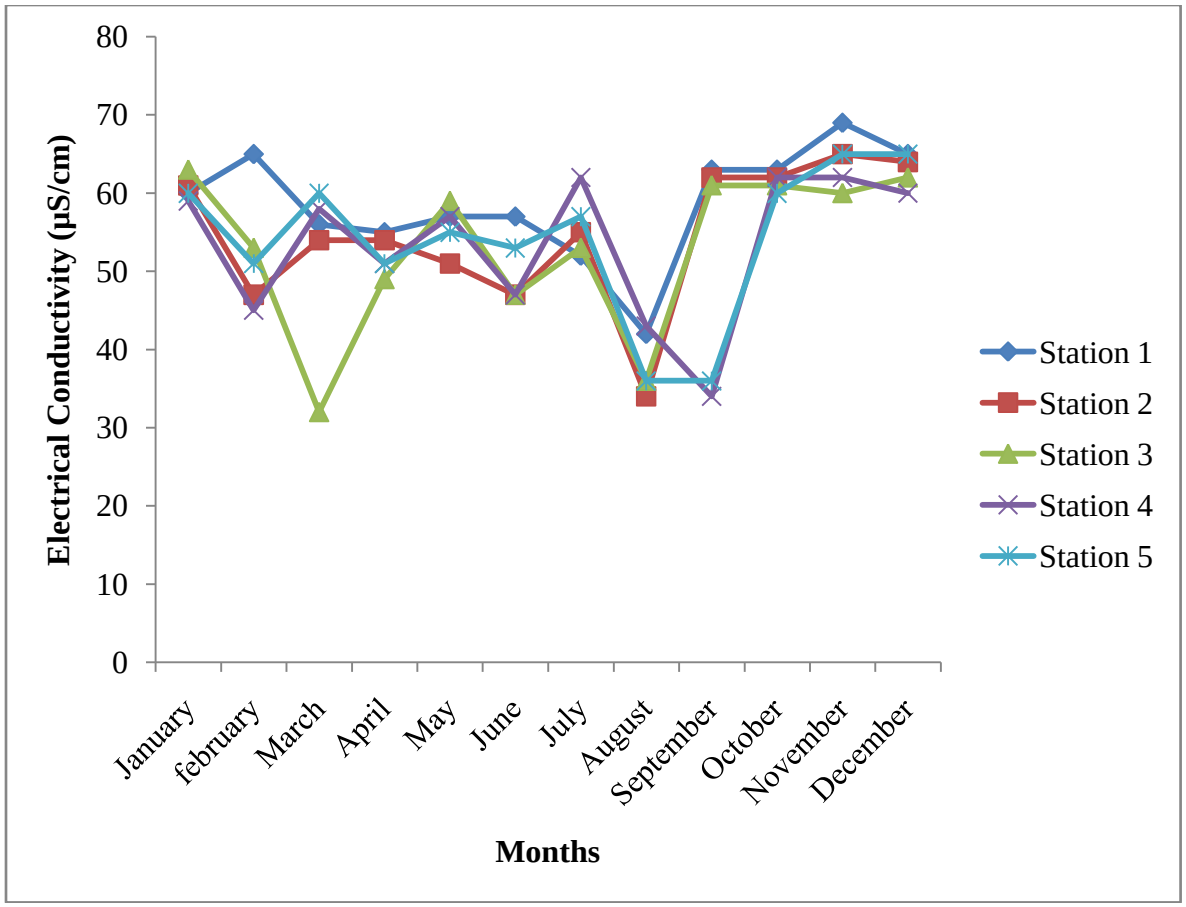


Figure 4.3: Mean Monthly Variation of Electrical Conductivity (µS/cm)

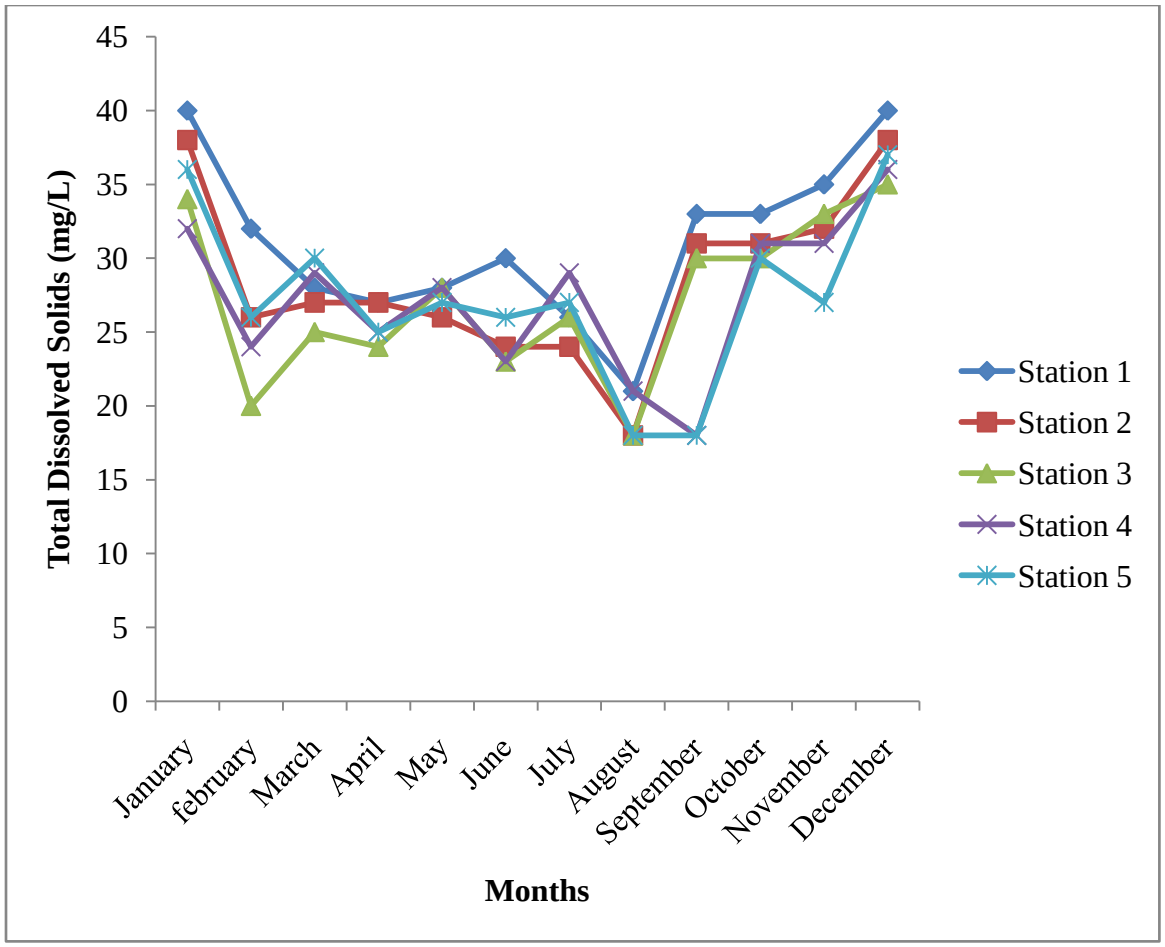


Figure 4.4: Mean Monthly Variation of Total Dissolved Solids (mg/L)

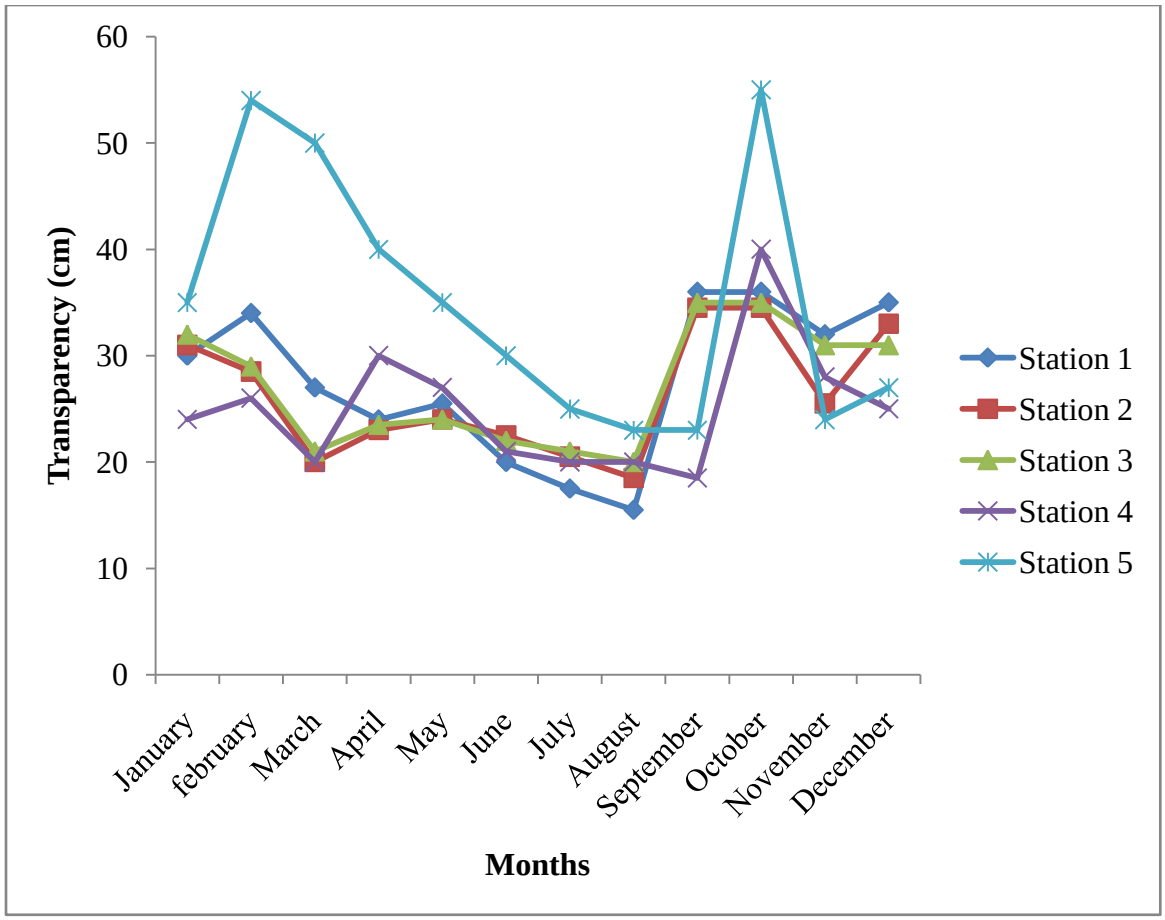


Figure 4.5: Mean Monthly Variation of Water Transparency (cm)

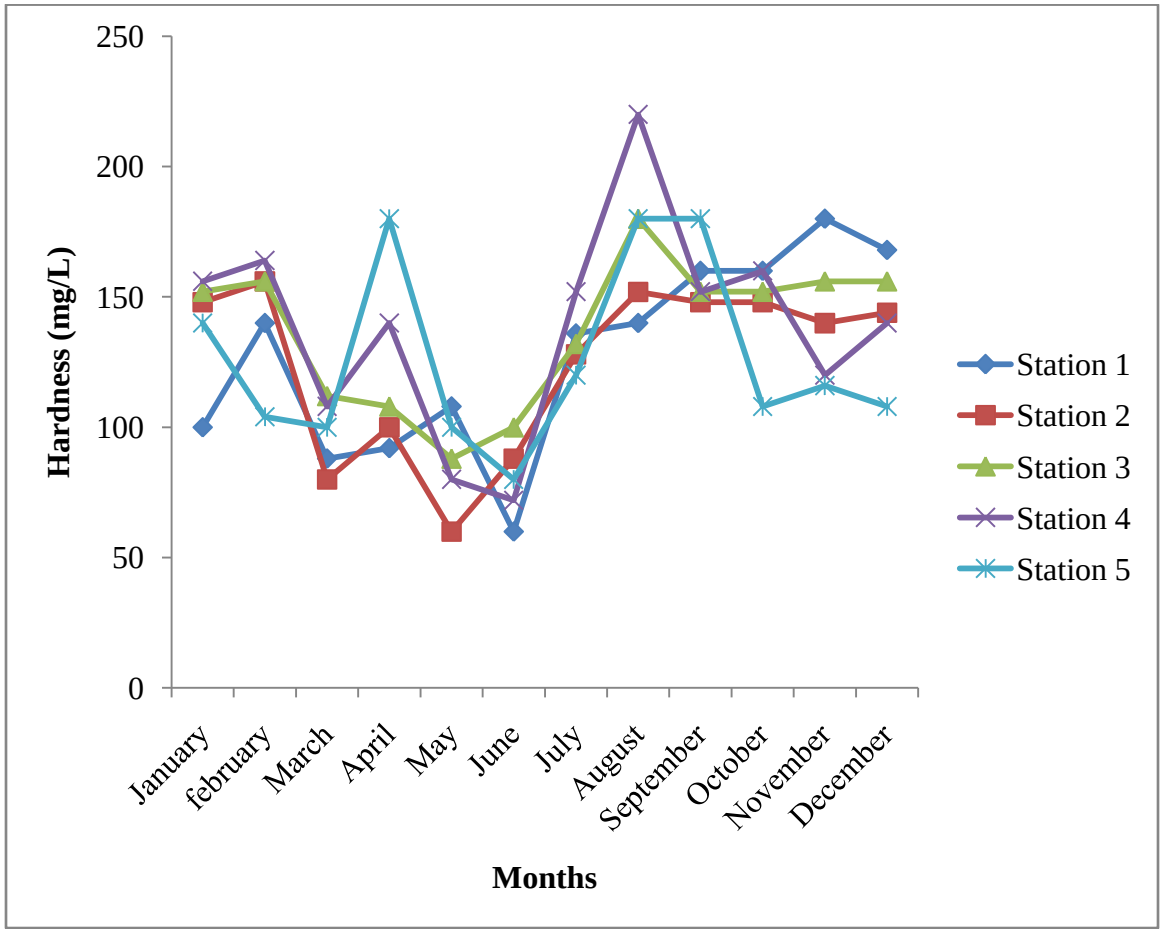


Figure 4.6: Mean Monthly Variation of Water Hardness (mg/L.$CaCO_3$) at Various Stations

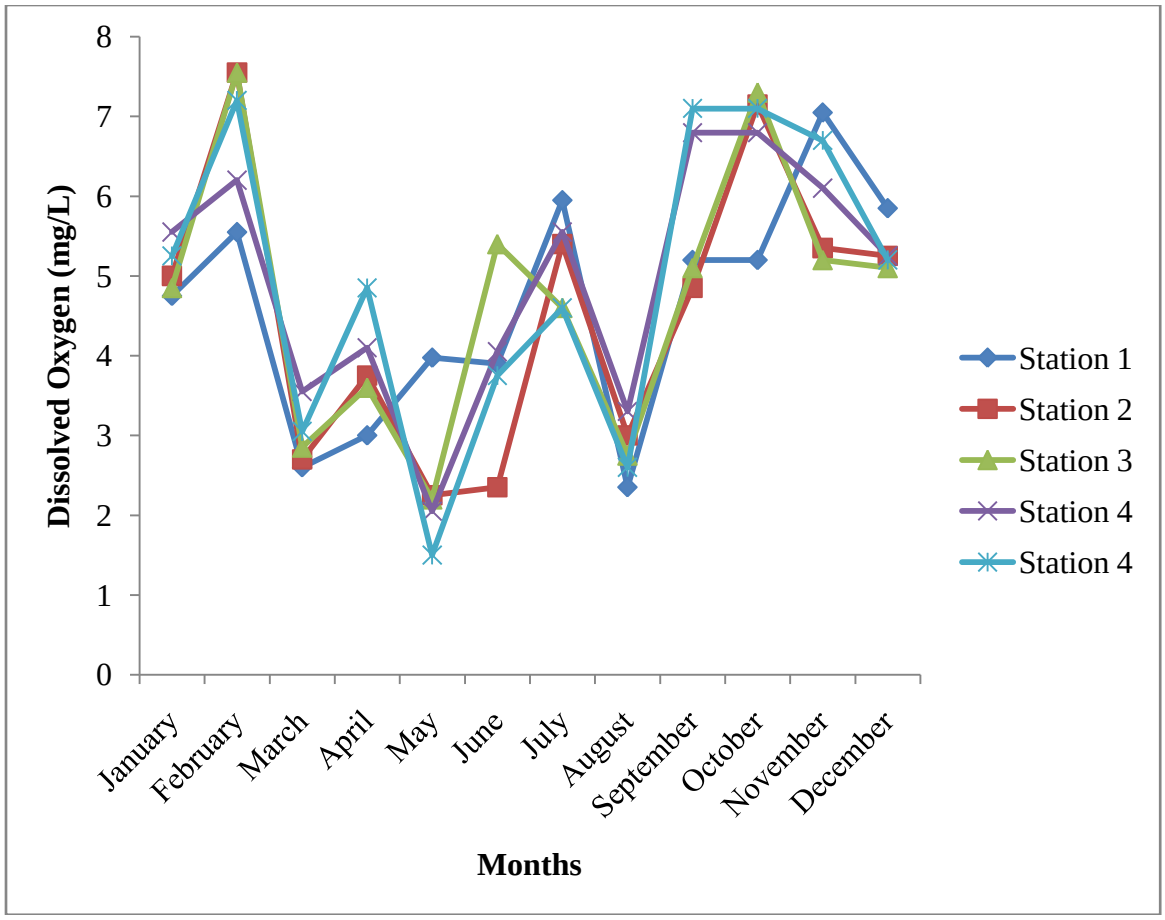


Figure 4.7: Mean Monthly Variation of Dissolved Oxygen (mg/L).

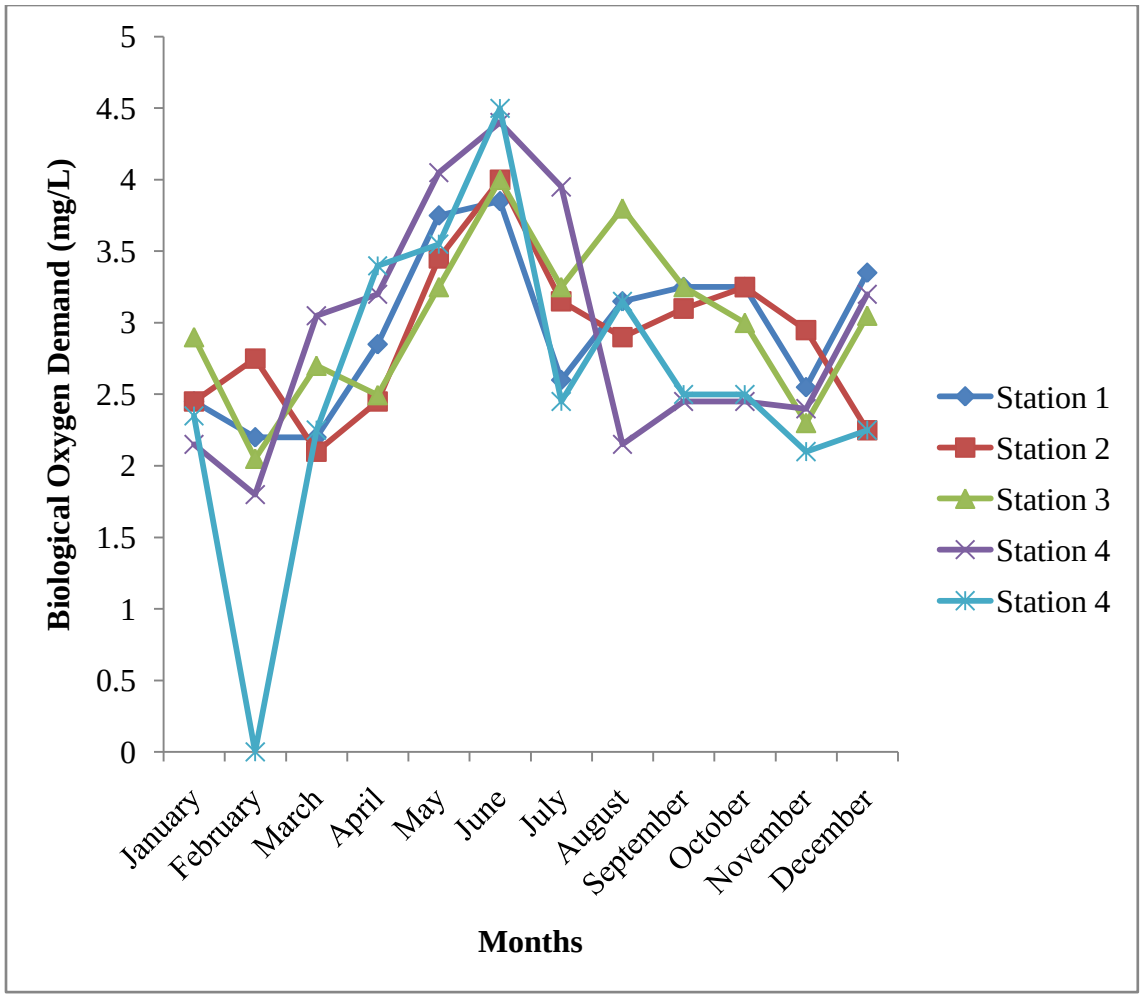


Figure 4.8: Mean Monthly Variation of Biological Oxygen Demand (mg/L).

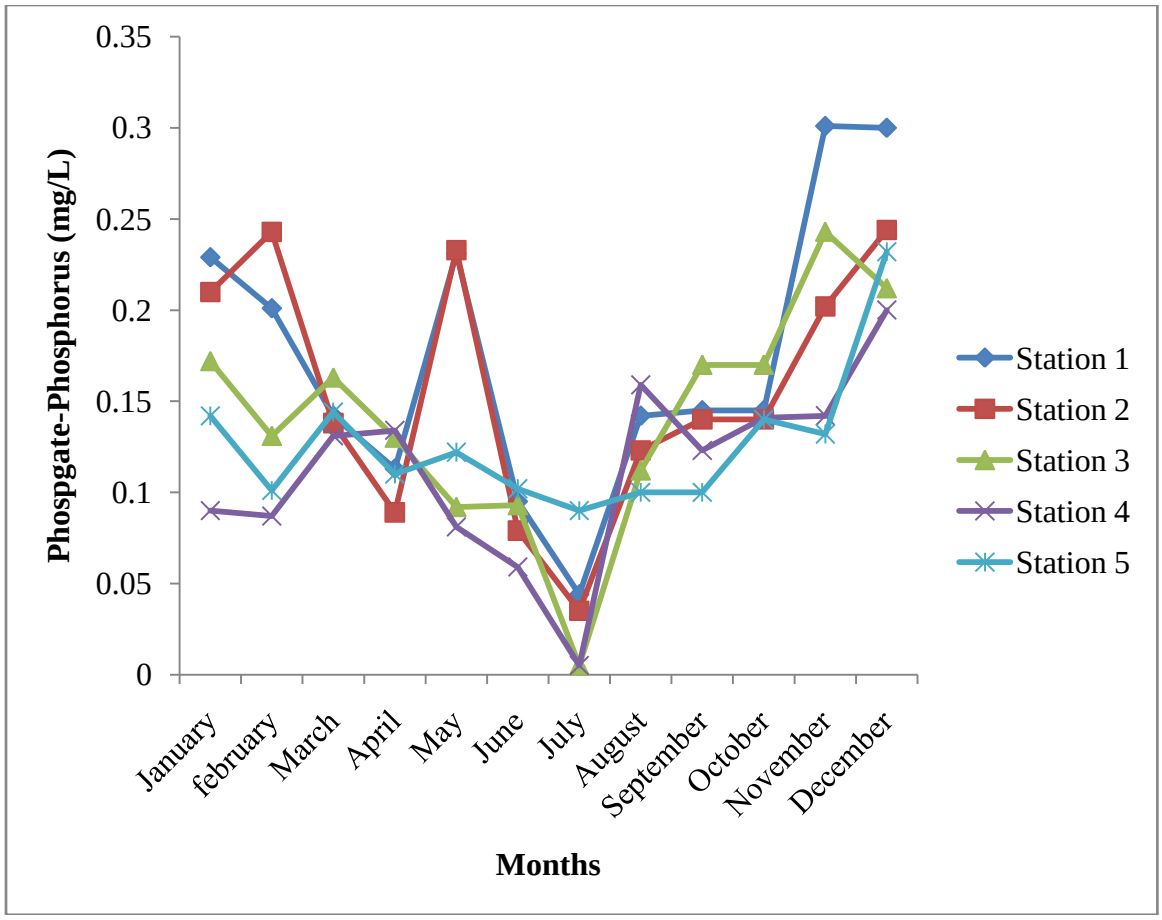


Figure 4.9: Mean Monthly Variation of Phosphate-Phosphorus (mg/L) at VariousStations

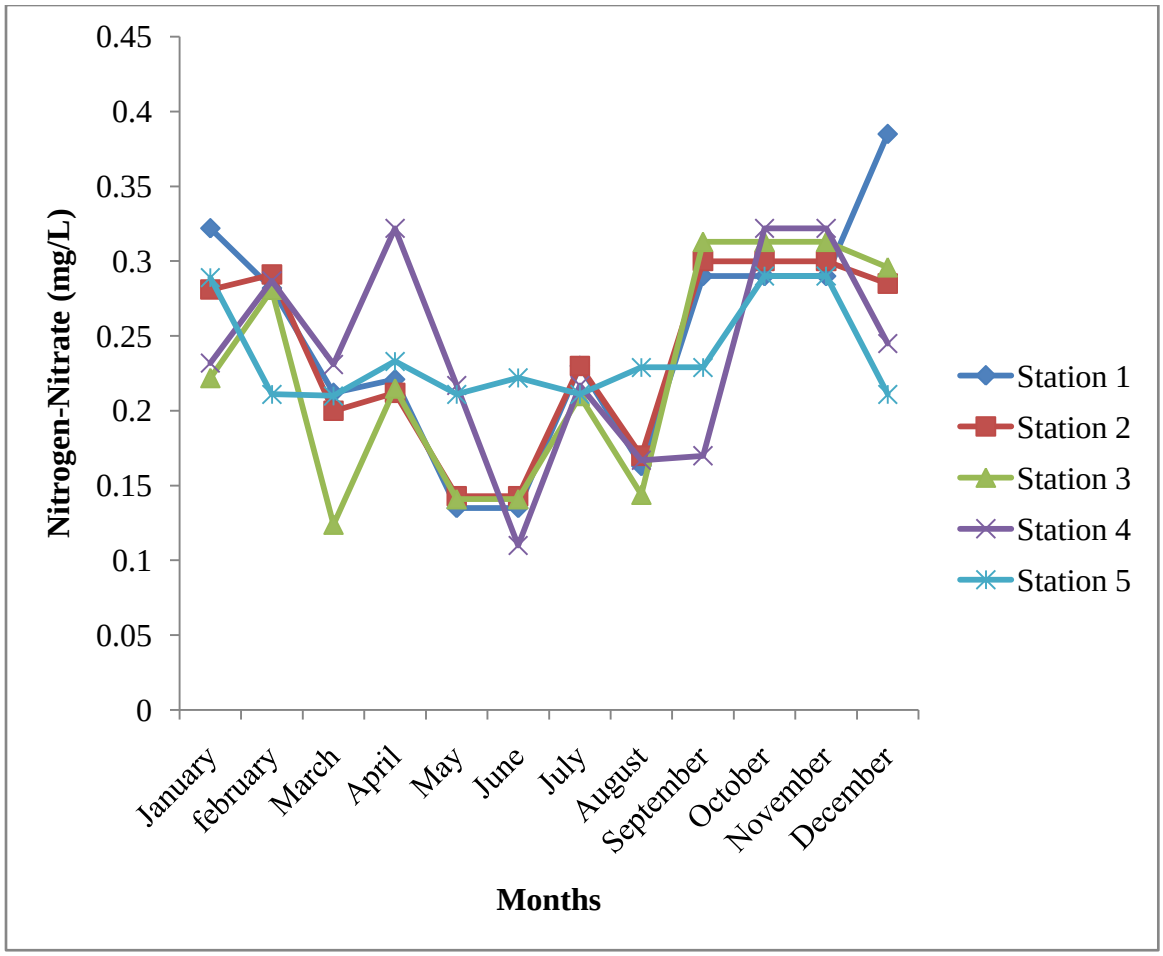


Figure 4.10: Mean Monthly Variation of Nitrate-Nitrogen (mg/L) at Various Stations

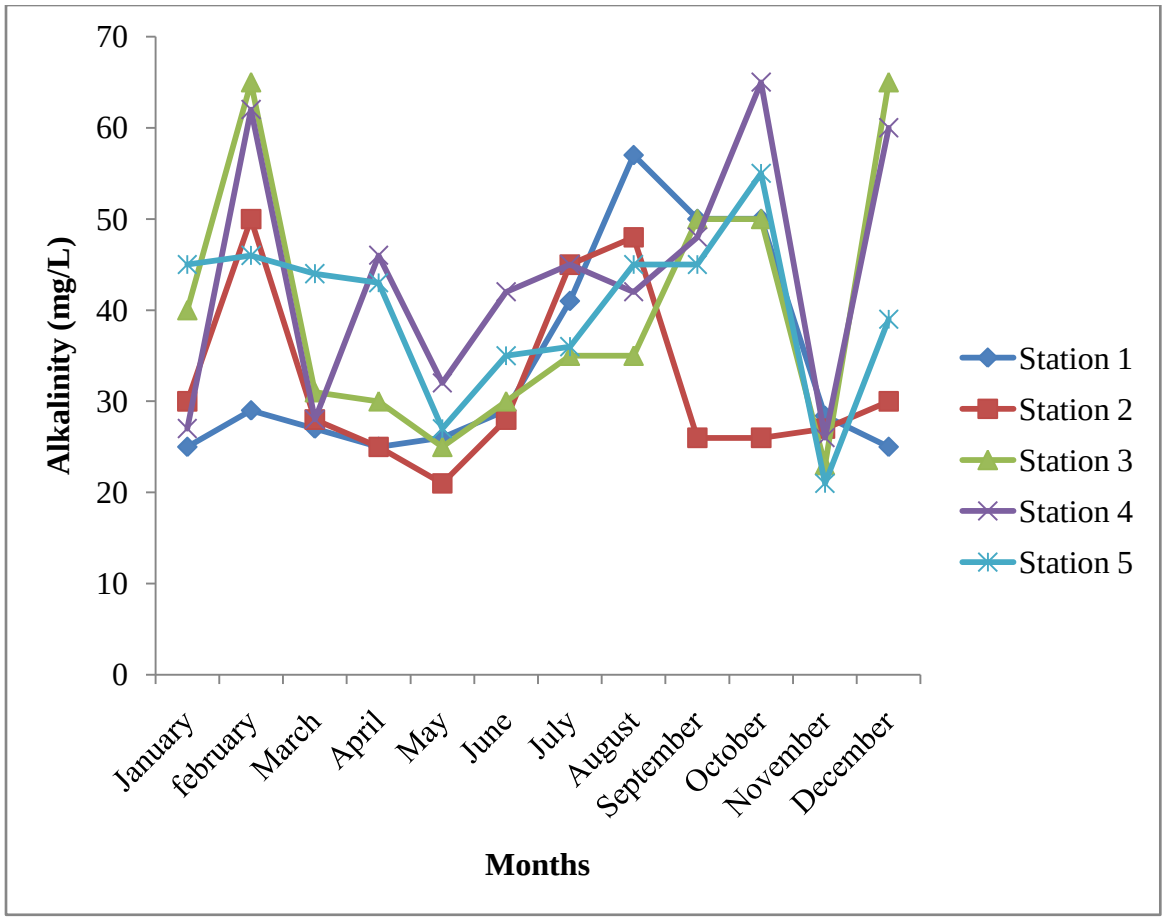


Figure 4.11: Mean Monthly Variation of Alkalinity (mg/L) at Various Stations

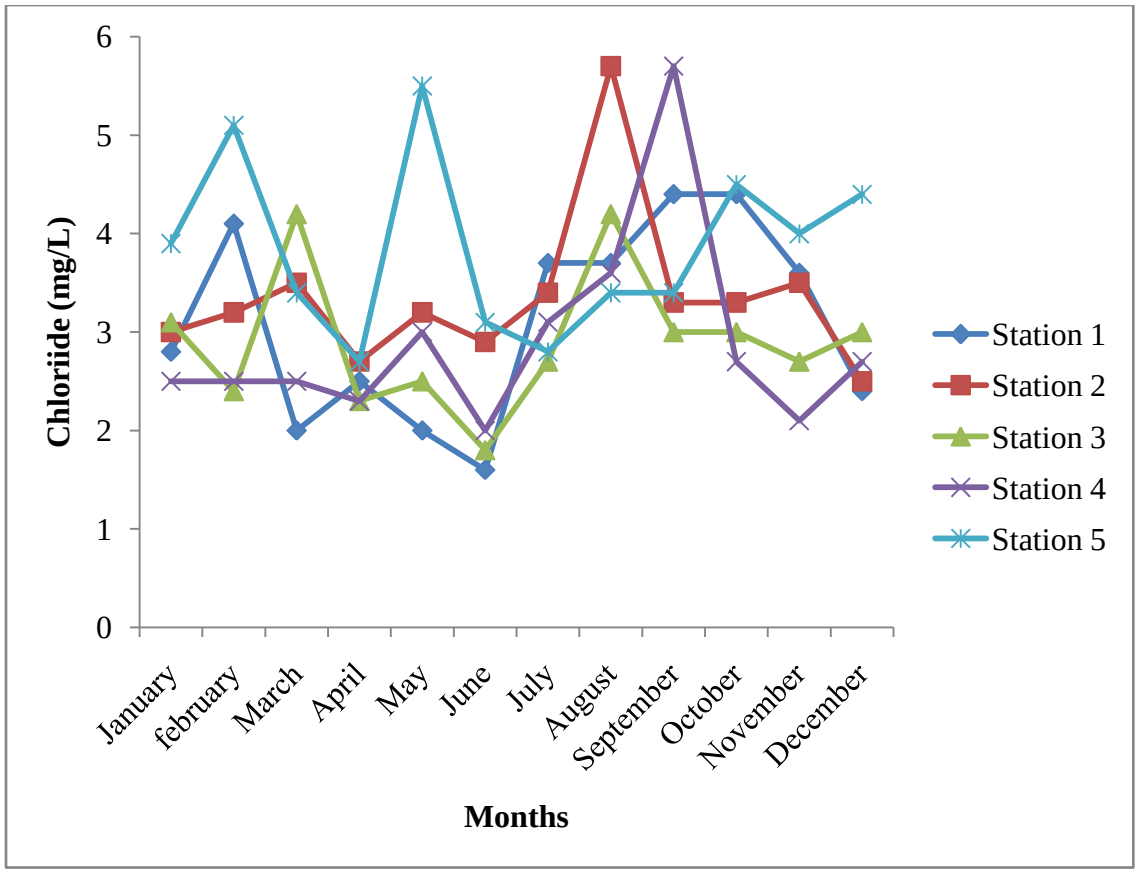


Figure 4.12: Mean Monthly Variation of Chloride (mg/L) at Various Stations

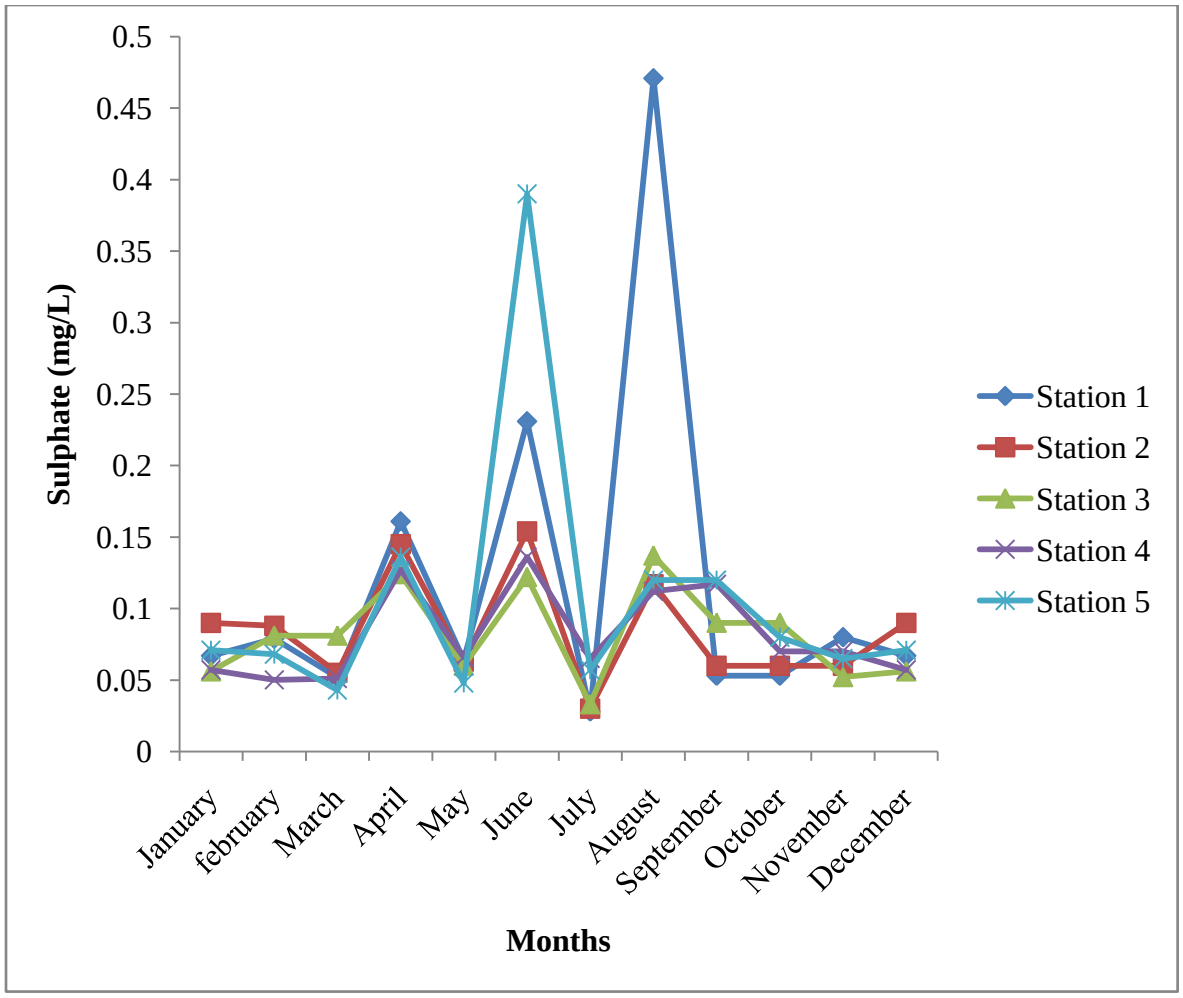


Figure 4.13: Mean Monthly Variation of Sulphate (mg/L) at Various Stations

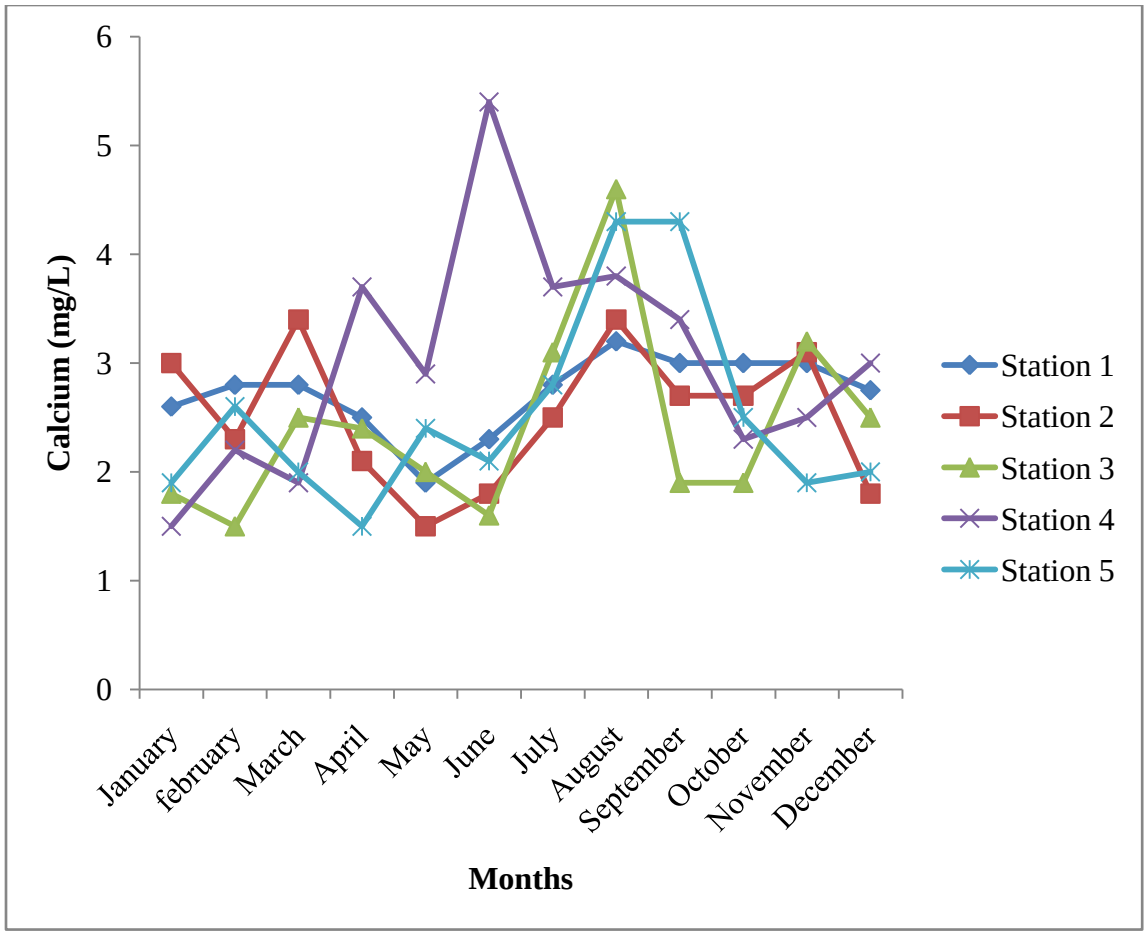


Figure 4.14: Mean Monthly Variation of Calcium (mg/L) at Various Stations

4.1.12 Chloride

Analysis of variance shows that chloride was observed to be highest in dry season (3.23 mg/l) which was non-significant between the seasons ($P \leq 0.05$) (Table. 4.1) among the months the highest value was observed in the month of August(4.12 mg/l) (Table.4.3) while station I had the highest value (3.85mg/l) of which was non-significant from other stations (Table 4.2, Fig 4.6).

4.1.13 Sulphate (SO_4^-)

Analysis of variance revealed that the highest value for Sulphate was observed in the dry season (0.12 mg/l) which was non-significant between the seasons ($P \geq 0.05$) (Table 4.1). Variation of sulphate among the months showed that June had the highest value (0.12 mg/l) which was non-significant across the station. (Table4.2, Fig 4.9).

4.1.14 Calcium

There was high rate of calcium in wet season (2.85 mg/l) which was non-significant between the seasons. ($P>0.05$). The mean monthly variation of calcium shows the month of August (3.86 mg/l) to be highest (Table 4.3) while site IV has the highest value across the sites (Table 4.2, Fig 4.11).

4.2 Zooplankton Abundance Based On Stations

The total number of zooplankton observed in this study was 3555 organisms with the family rotifera having the highest abundance (1315 organisms, 36.99%) while the least abundant was the family copepoda (977 organisms, 27.48%).

Comparison of the various families of organism observed among the families, shows that rotifera have the highest abundance of zooplankton in station I (462 organisms, 35.1%), Station II (321 organisms, 24.41%) and station III (260 organisms, 24.41%). In station IV and station V, the Family Cladocera had the highest abundance of 169 organisms (13.38%) and 161 organisms (12.75%) respectively (Table 4.4).

Based on Stations among the species, *Brachionous* (149 organisms, 38.50%) in station I, *Diaphaesoma* (128 organisms, 36.68%) in station II, *Bosmina* (94 organisms, 21.74%) in station III, Cyclops (53 organisms, 14.02%) in station IV and *Bosmina* (51 organisms, 11.81%) in station V had the highest abundance in the stations while *Polyphemus* (3 organisms, 11.11%) in station I and II, *Macrothrix* (8 organisms, 21.62%) in site III, *Lecane* (5 organisms, 7.94%) and *Polyphemus* 0 (0.00) in site V had the lowest species occurrence.(Table4.4)

Table 4.4: Zooplankton Family and Species Abundance Based On Stations

Family	Species	Stations				
		I (%)	**II (%)**	**III (%)**	**IV (%)**	**V (%)**
Cladocera	*Bosmina spp*	140 (32.41)	101 (23.38)	94 (21.76)	46 (10.65)	51 (11.81)
	Daphniaspp	100 (35.71)	59 (21.07)	32 (11.43)	42 (15.00)	47 (16.79)
	Diaphaesoma	110 (31.52)	128 (36.68)	38 (10.89)	41 (11.75)	32 (9.17)
	Macrothrix spp.	11 (29.73)	7 (18.92)	8 (21.62)	5 (13.51)	6 (16.22)
	Simocephalus spp	8 (11.27)	13 (18.31)	14 (19.72)	19 (26.76)	17 (23.94)
	Polyphemus spp	3 (11.11)	3 (11.11)	14 (51.85)	7 (25.93)	0 (0.00)
	Eurycercus spp	28 (41.79)	9 (13.43)	13 (19.40)	9 (13.43)	8 (11.94)
		400 (31.67)	**320 (25.34)**	**213 (16.86)**	**169 (13.38)**	**161 (12.75)**
Copepods	*Cyclops spp.*	134 (35.45)	80 (21.16)	76 (20.11)	53 (14.02)	35 (9.26)
	Diatomas spp.	98 (36.84)	51 (19.17)	58 (21.80)	31 (11.65)	28 (10.53)
	Nauphilii spp	58 (27.49)	36 (17.06)	49 (23.22)	34 (16.11)	34 (16.11)
	Eubranchipus spp	49 (40.16)	23 (18.85)	21 (17.21)	18 (14.75)	11 (9.02)
		339 (34.70)	**190 (19.45)**	**204 (20.88)**	**136 (13.92)**	**108 (11.05)**
Rotifers	*Branchionus spp*	149 (38.50)	91 (23.51)	60 (15.50)	47 (12.14)	40 (10.34)
	Kellicottia spp	111 (32.46)	109 (31.87)	64 (18.71)	33 (9.65)	25 (7.31)
	Keratella spp.	93 (37.05)	60 (23.90)	46 (18.33)	27 (10.76)	25 (9.96)
	Lecane spp.	20 (31.75)	15 (23.81)	14 (22.22)	5 (7.94)	9 (14.29)
	Trichocera spp.	89 (32.72)	46 (16.91)	76 (27.94)	30 (11.03)	31 (11.40)
		462 (35.13)	**321 (24.41)**	**260 (19.77)**	**142 (10.80)**	**130 (9.89)**
Site Total		**1201 (33.78)**	**831 (23.38)**	**677 (19.04)**	**447 (12.57)**	**399 (11.22)**

4.3 Seasonal Abundance of Zooplankton Based on Families and Species

Based on season, all the species were observed to be more abundant in the wet season than in the dry season (Table 4.5). The number of cladocera, copepoda and rotifera were low in dry season with 578 organisms (45.76%), 421 organisms (43.09%) and 505 (38.40%) respectively while in wet season were 685 organisms (54.24%), 556 organisms (56.91%) and 810 organisms (61.60%).

Although *macrothrix*, *simocephalus*, *polyphemus* of the family cladocera were not found at all during the wet season of this study. Meanwhile, all the other species found were observed to be higher in the wet season except *daphnia* which was higher in dry season.

The family Copepoda with Cyclops (226 organisms, 59.79%), Nauphillii larvae (109 organisms, 51.66%) and *Eubranchipus* (88 organisms, 72.13%) were highest in wet season while diatoms was the same for both seasons (dry and wet) (table 4.5).

The family Rotifera with species *Branchionus* (228 organisms, 58.91%), *Kellicottia* (244 organisms, 71.85%), *Keratella* (139 organisms, 55.38%) and *Trichocera* (199 organisms, 73.16%) were highest in the wet season while *Lecane* was only found in the dry season 63 (100%) and none were found in the wet season.

Table 4.5: Seasonal Abundance of Zooplankton Based on Families and Species

Family	Species	Dry (%)	Wet (%)	Total (%)
Cladocera	*Bosmina spp.*	156 (36.11)	276 (63.89)	432 (12.15)
	Daphnia spp.	146 (52.14)	134 (47.86)	280 (7.88)
	Diaphaesoma spp.	117 (33.52)	232 (66.48)	349 (9.82)
	Macrothrix spp.	37 (100.00)	0 (0.00)	37 (1.04)
	Simocephalus spp.	71 (100.00)	0 (0.00)	71 (2.00)
	Polyphemus spp.	27 (100.00)	0 (0.00)	27 (0.76)
	Eurycercus spp.	24 (35.82)	43 (64.18)	67 (1.88)
		578 (45.76)	**685 (54.24)**	**1263 (35.53)**
Copepods	*Cyclops*	152 (40.21)	226 (59.79)	378 (10.63)
	Diatomas spp.	133 (50.00)	133 (50.00)	266 (7.48)
	Nauphilii	102 (48.34)	109 (51.66)	211 (5.94)
	Eubranchipus spp.	34 (27.87)	88 (72.13)	122 (3.43)
		421 (43.09)	**556 (56.91)**	**977 (27.48)**
Rotifera	*Branchionus spp*	159 (41.09)	228 (58.91)	387 (10.89)
	Kellicottia spp.	98 (28.65)	244 (71.35)	342 (9.62)
	Keratella spp.	112 (44.62)	139 (55.38)	251 (7.06)
	Lecane spp.	63 (100.00)	0 (0.00)	63 (1.77)
	Trichocera spp.	73 (26.84)	199 (73.16)	272 (7.65)
		505 (38.40)	**810 (61.60)**	**1315 (36.99)**
Season Total		**1504 (42.31)**	**2051 (57.69)**	**3555**

4.4 Monthly Abundance of Zooplankton Based on Families and Species

The family of Rotifera was recorded to have highest number of occurrences in the month of October(133 organism ,10.11%), May (125 organisms, 9.51%), June (112 organism, 8.52%), July(164 organism, 12.47%), August (209 organism, 15.89%) and September

(128 organism,9.73%). While the lowest abundance was observed for the family Copepoda in the month of October (45 organisms,4.61%),December (103, organisms,10.54%), January (103 organisms,10.54%), March (24 organisms, 2.46%) May (51 organisms, 5.22%), June (82 organisms,8.39%),July (115 organisms, 11.7%), August (169 organisms,17.30%), September (43 organisms, 4.40%) (Table 4.6a)

Based on species *Bosminaspecies* of the family cladocera. has the highest number of abundance across the monthsthan all other families (432 organisms, 12.15%), follow by Cyclops species was observed to be highest in the month of October (18 organisms, 4.76%) December (37 organisms, 9.79%), January (52 organism, 13.76%), March (11 organisms, 2.91%), April (45 organism, 11.90%), May (39 organism, 10.32%),June (26 organisms,6.88%), July(45 organisms, 11.90%),August(58 organism,15.34%), September (13 organism, 3.44%) while the lowest abundance was observed in *Eubranchipus* species in the month of October (5 organism,4.10%) December (12 organisms, 9.84%), January (10 organisms, 8.20%), February (6 organisms, 4.92%), March (10 organisms, 0.82%), April (12organisms 9.48%) May (1organism,0.82%) June (18organism, 14.75%) August(34 organism, 27.87%) September (7organism, 5.74%).

The species of *Branchionus* was observed to have highest abundance in the month of October (36 organisms, 9.30%), December (28 organisms, 7.24%), January (48

Table 4.6a: Monthly Abundance of Zooplankton Based on Families and Species

Family	Species	October	November	December	January	February	March
Cladocera	*Bosmina spp.*	16 (3.70)	22 (5.09)	38 (8.80)	37 (8.56)	28 (6.48)	15 (3.47)
	Daphnia spp	33 (11.79)	11 (3.93)	34 (12.14)	25 (8.93)	23 (8.21)	20 (7.14)
	Diaphaesoma spp.	15 (4.30)	19 (5.44)	35 (10.03)	26 (7.45)	21 (6.02)	1 (0.29)
	Macrothrix spp.	13 (35.14)	0 (0.00)	12 (32.43)	0 (0.00)	12 (32.43)	0 (0.00)
	Simocephalus spp.	16 (22.54)	21 (29.58)	0 (0.00)	12 (16.90)	22 (30.99)	0 (0.00)
	Polyphemus spp	14 (51.85)	0 (0.00)	0 (0.00)	13 (48.15)	0 (0.00)	0 (0.00)
	Eurycercus spp	0 (0.00)	1 (1.49)	0 (0.00)	12 (17.91)	11 (16.42)	0 (0.00)
		107 (8.47)	**74 (5.86)**	**119 (9.42)**	**125 (9.90)**	**117 (9.26)**	**36 (2.85)**
Copepoda	*Cyclops spp.*	18 (4.76)	16 (4.23)	37 (9.79)	52 (13.76)	18 (4.76)	11 (2.91)
	Diatomas spp	16 (6.02)	23 (8.65)	31 (11.65)	20 (7.52)	39 (14.66)	4 (1.50)
	Nauphilii	6 (2.84)	29 (13.74)	23 (10.90)	21 (9.95)	15 (7.11)	8 (3.79)
	Eubranchipus	5 (4.10)	0 (0.00)	12 (9.84)	10 (8.20)	6 (4.92)	1 (0.82)
		45 (4.61)	**68 (6.96)**	**103 (10.54)**	**103 (10.54)**	**78 (7.98)**	**24 (2.46)**
Rotifera	*Branchionous*	36 (9.30)	25 (6.46)	28 (7.24)	48 (12.40)	15 (3.88)	7 (1.81)
	Kellicottia	32 (9.36)	6 (1.75)	19 (5.56)	14 (4.09)	19 (5.56)	8 (2.34)
	Keratella	25 (9.96)	13 (5.18)	34 (13.55)	24 (9.56)	8 (3.19)	8 (3.19)
	Lecane	22 (34.92)	10 (15.87)	13 (20.63)	8 (12.70)	4 (6.35)	6 (9.52)
	Trichocera	18 (6.62)	11 (4.04)	15 (5.51)	22 (8.09)	2 (0.74)	5 (1.84)
		133 (10.11)	**65 (4.94)**	**109 (8.29)**	**116 (8.82)**	**48 (3.65)**	**34 (2.59)**
+Monthly Total		**285 (8.02)**	**207 (5.82)**	**331 (9.31)**	**344 (9.68)**	**243 (6.84)**	**94 (2.64)**

organisms, 12.40%) November (25 organisms, 6.46%) May (49 organisms, 12.66%), June (58 organisms, 14.99%) and September (43 organisms, 11.11%) While the lowest abundance of organisms was observed in *lecane spp*.in themonth of December (13 organisms, 20.63%) January (8 organisms, 12.70%) and was not found in April to December at all (Table 4.6b).

4.5 Number of Organisms per m^3 and per Litre

Comparison of the various families of organism observed among the families, shows that rotifera have the highest abundance of zooplankton in per m3 and per litre (39,900/m^3,39.9/l), followed by cladocera (16100/m^3, 16.1/l) and copepoda (10800/l, 10.8/l) respectively (Table 4.7).

Based on Stations among the species, *Branchionous* (14900/m^3, 14.9/L) in station I, *Diaphaesoma* (12800 m^3,12.8/L) in station II, *Bosmina* (9400m^3,9.4/L) in station III, Cyclops (53m^3,5.3/L) in station IV and *Bosmina* (51m^3, 5.3/L) in station V had the highest abundance in the stations while *Polyphemus* (300m^3, 0.3/L) in station I, *Polyphemus* (300m^3, 0.3/L) in stationII, *Macrothrix* (800m^3, 0.8) in station III, *Macrothrix*(500m^3,0.5/L) and *Lecane*(500m^3,0.5/L) in station IV, Macrothrix (600m^3,0.6/L) in station V had the lowest abundance in the stations. (Table 4.7)

Table 4.6 b: Monthly Abundance of Zooplankton Based on Families and Species

Family	Species	April	May	June	July	August	September	Total
Cladocera	*Bosmina*	22 (5.09)	44 (10.19)	64 (14.81)	43 (9.95)	69 (15.97)	34 (7.87)	432 (12.15)
	Daphnia	35 (12.50)	21 (7.50)	5 (1.79)	33 (11.79)	27 (9.64)	13 (4.64)	280 (7.88)
	Diaphaesoma	13 (3.72)	22 (6.30)	35 (10.03)	49 (14.04)	66 (18.91)	47 (13.47)	349 (9.82)
	Macrothrix	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	37 (1.04)
	Simocephalus	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	71 (2.00)
	Polyphemus	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	27 (0.76)
	Eurycercus	0 (0.00)	0 (0.00)	1 (1.49)	22 (32.84)	10 (14.93)	10 (14.93)	67 (1.88)
		70 (5.54)	**87 (6.89)**	**105 (8.31)**	**147 (11.64)**	**172 (13.62)**	**104 (8.23)**	**1263 (35.53)**
Copepoda	Cyclops	45 (11.90)	39 (10.32)	26 (6.88)	45 (11.90)	58 (15.34)	13 (3.44)	378 (10.63)
	Diatomas	24 (9.02)	8 (3.01)	19 (7.14)	39 (14.66)	32 (12.03)	11 (4.14)	266 (7.48)
	Nauphilii	15 (7.11)	3 (1.42)	19 (9.00)	15 (7.11)	45 (21.33)	12 (5.69)	211 (5.94)
	Eubranchipus	12 (9.84)	1 (0.82)	18 (14.75)	16 (13.11)	34 (27.87)	7 (5.74)	122 (3.43)
		96 (9.83)	**51 (5.22)**	**82 (8.39)**	**115 (11.77)**	**169 (17.30)**	**43 (4.40)**	**977 (27.48)**
Rotifera	*Branchionus*	23 (5.94)	49 (12.66)	58 (14.99)	22 (5.68)	33 (8.53)	43 (11.11)	387 (10.89)
	Kellicottia	24 (7.02)	38 (11.11)	14 (4.09)	71 (20.76)	59 (17.25)	38 (11.11)	342 (9.62)
	Keratella	15 (5.98)	19 (7.57)	5 (1.99)	27 (10.76)	41 (16.33)	32 (12.75)	251 (7.06)
	Lecane	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	63 (1.77)
	Trichocera	10 (3.68)	19 (6.99)	35 (12.87)	44 (16.18)	76 (27.94)	15 (5.51)	272 (7.65)
		72 (5.48)	**125 (9.51)**	**112 (8.52)**	**164 (12.47)**	**209 (15.89)**	**128 (9.73)**	**1315 (36.99)**
Monthly Total		**238 (6.69)**	**263 (7.40)**	**299 (8.41)**	**426 (11.98)**	**550 (15.47)**	**275 (7.74)**	**3555**

Table 4.7: Number of organisms per m^3 and number of organisms per litre Based on Stations

Family	Species	Stations									
		I		II		III		IV		V	
		No. Per m^3	**No. Per Litre**	**No. Per m^3**	**No. Per Litre**	**No. Per m^3**	**No. Per Litre**	**No. Per m^3**	**No. Per Litre**	**No. Per m^3**	**No. Per Litre**
Cladocera	*Bosmina*	14000	14	10100	10.1	9400	9.4	4600	4.6	5100	5.1
	Daphnia	10000	10	5900	5.9	3200	3.2	4200	4.2	4700	4.7
	Diaphaesoma	11000	11	12800	12.8	3800	3.8	4100	4.1	3200	3.2
	Macrothrix	1100	1.1	700	0.7	800	0.8	500	0.5	600	0.6
	Simocephalus	800	0.8	1300	1.3	1400	1.4	1900	1.9	1700	1.7
	Polyphemus	300	0.3	300	0.3	1400	1.4	700	0.7	0	0
	Eurycercus	2800	2.8	900	0.9	1300	1.3	900	0.9	800	0.8
		40000	**40**	**32000**	**32**	**21300**	**21.3**	**16900**	**16.9**	**16100**	**16.1**
Copepods	Cyclops	13400	13.4	8000	8	7600	7.6	5300	5.3	3500	3.5
	Diatomas	9800	9.8	5100	5.1	5800	5.8	3100	3.1	2800	2.8
	Nauphilii	5800	5.8	3600	3.6	4900	4.9	3400	3.4	3400	3.4
	Eubranchipus	4900	4.9	2300	2.3	2100	2.1	1800	1.8	1100	1.1
		33900	**33.9**	**19000**	**19**	**20400**	**20.4**	**13600**	**13.6**	**10800**	**10.8**
Rotifers	*Brachionus*	14900	14.9	9100	9.1	6000	6	4700	4.7	4000	4
	Kellicottia	11100	11.1	10900	10.9	6400	6.4	3300	3.3	2500	2.5
	Keratella	9300	9.3	6000	6	4600	4.6	2700	2.7	2500	2.5
	Lecane	2000	2	1500	1.5	1400	1.4	500	0.5	900	0.9
	Trichocera	8900	8.9	4600	4.6	7600	7.6	3000	3	3100	3.1
		46200	**46.2**	**32100**	**32.1**	**26000**	**26**	**14200**	**14.2**	**13000**	**13**
Stations Total		**120100**	**120.1**	**83100**	**83.1**	**67700**	**67.7**	**44700**	**44.7**	**39900**	**39.9**

4.6 Correlation of Physico-chemical Parameters and The Zooplankton

Cladocera are positively correlated to pH (0.6412) hardness (0.524), Alkalinity (0.5709) and calcium (0.5224),Copepoda (0.784), Rotifera (0.8519) while cladocera are negatively correlated to temperature.Copepoda are positively correlated to Calcium (0.5358) and negatively correlated to transparency (-0.575).Copepoda are positively correlated with rotifer(0.6157).Rotiferas are positively correlated to calcium (0.6411), pH(0.6419) and BOD(-0.5234) (Table 4.8).

Chloride is strongly correlated to hardness (0.7144 mg/l), Calcium (0.5431mg/l), Alkalinity (0.5222), pH (0.6272). Phosphate is correlated to NO_3 (0.5580), TDS (0.6550). Nitrate (NO_3) is strongly correlated to hardness (0.5853), TDS (0.6213), Electrical conductivity (0.6722), Transparency (0.7166) and DO(0.8437) and negatively correlated to SO_4 (-0.5364). Sulphate is positively correlated to EC (0.6682), TDS (0.5583). Hardness is positively correlated to Calcium (0.5285),Alkalinity (0.6323).Calcium is positively correlated to pH and negatively correlated to EC(-0.6551), TDS(-0.6281), Transparency (-0.5965) and BOD(-0.7290). Temperature is negatively correlated to pH(-0.5122) and DO (-0.5411). Electrical conductivity is positively correlated to TDS (0.8980), Transparency (0.5645), DO (0.5387) and BOD (0.6442). TDS is correlated to Transparency (0.5141) and BOD(0.5011).Transparency is positively correlated to BOD (0.5011). DO is positively correlated to BOD((Table, 4.8)

Table 4.8: Correlation of Phyisco-chemical Parameters and the zooplankton

	Cladocera	*Copepods*	*Rotifers*	*Cl*	*PO4*	*NO3*	*SO4*	*Hardness*	*Ca*	*Alkalinity*	*Temp*	*pH*	*EC*	*TDS*	*Transp.*	*DO*	*BOD*
Cladocera	1																
Copepods	0.7894*	1															
Rotifers	0.8159*	0.6157*	1														
Cl	0.4154	0.0885	0.4403	1													
PO4	-0.2054	-0.1495	-0.3141	0.1290	1												
NO3	-0.0522	-0.1736	-0.2807	0.2085	0.5580*	1											
SO4	0.2356	0.4510	0.3016	-0.1771	-0.2552	-0.5364 *	1										
Hardness	0.5715*	0.4545	0.3861	0.7144*	0.2522	0.5853*	-0.0649	1									
Ca	0.5224*	0.5358*	0.6411*	0.5431*	-0.3169	-0.2551	0.4713	0.5285*	1								
Alkalinity	0.5709*	0.2445	0.3111	0.5222*	-0.0386	0.3129	0.0182	0.6323*	0.2879	1							
Temp	-0.6452*	-0.3830	-0.4869	-0.1423	-0.0268	-0.2973	-0.1618	-0.4583	-0.3603	-0.3968	1						
pH	0.6412*	0.3891	0.6419*	0.6272*	-0.0190	-0.2601	0.2246	0.3690	0.6769*	0.2339	-0.5122*	1					
EC	-0.3038	-0.3998	-0.3586	-0.2965	0.4983	0.6722*	-0.6682*	-0.0834	-0.6551*	-0.2260	-0.1877	-0.3889	1				
TDS	-0.1987	-0.2458	-0.2969	-0.2722	0.6550*	0.6213*	-0.5583*	-0.0103	-0.6281*	-0.1554	-0.2296	-0.2917	0.8980*	1			
Transparency	-0.2980	-0.5575*	-0.4291	0.1051	0.4871	0.7166*	-0.4483	0.1436	-0.5965*	0.3358	0.0337	-0.4193	0.5645*	0.5141*	1		
DO	0.1449	-0.1670	-0.1875	0.1742	0.2345	0.8437*	-0.3984	0.4953	-0.1757	0.4991	-0.5411*	-0.0920	0.5387*	0.4089	0.6409*	1	
BOD	-0.2014	-0.2164	-0.5243*	-0.4468	0.1579	0.3954	-0.4951	-0.2583	-0.7290*	0.0052	0.0398	-0.4859	0.6442*	0.5011*	0.5076*	0.4590	1

4.7 Rotifers

Rotifers are the dominant of zooplankton in karidna reservoir accounting for about(1315 organisms,37%) of the total zooplankton (Table 4.6).Wet season having the highest population abundance (810 organisms, 61%) than dry season(505 organisms,38%). (Table 4.5). Correlation revealed there was positive relationship between rotifers and calcium, pH while there was negative correlation with Biological Oxygen Demand. The species recorded include; *Brachionus sp, Keratella sp, Kellicottia sp, Lecane sp,* and *Trichocerca sp.* Rotifers, *Brachionus sp.* has the highest number and highest abundance during the rainy season while *Lecane sp* has the least abundance with very few counts in the rainy season.. There was increase in rotifers abundance from October, December, January, May, June and July to September then there was abrupt decreased in the population abundance in the month of November, February, March April and August. Station I has the highest population count in the rainy season while the lowest was in the dry season.

4.8 Copepods

Copepods had the least abundance among the species of the zooplankton recorded in karidna reservoir (977 organisms,28%).(Table 4.6) Between the seasons, wet season had the highest abundance(556 organisms, 56.91%) than dry season(421 organisms,43.09%)

Copepods exhibited positive correlations with rotifers, Calcium while negatively correlated with Transparency. (Table 4.26). The species identified are *Eubrachipus sp. Cyclops sp. Nauphilii sp. Diatomus sp.* Among the copepods, *Cyclops sp.* has highest species abundance then followed by *Cyclops sp.;* the

species counts were more abundant in the rainy season than in the dry season. While *Eubranchipus sp.* has the least abundance. There was higher diversity of copepods during the wet season compared to that of the dry season as indicated by Simpson's and Shannon diversity index (Table 4.27). Table 4.7 shows monthly stations abundance of Copepods. Station I has the highest population count while Station II and III has the least during the dry season.

There was no significant difference between the three stations ($P > 0.05$). There was significant difference between wet and dry season abundance of Cladocera in Kadrina reservoir $P < 0.05$ (Table 4.24).

4.9 **Cladocera**

Cladocera was recorded to had the second most abundance of zooplankton species in karidna reservoir (1263 organism, 40%) (Table 4.6). between the seasons, wet season had the highest(685 organisms, 54%). (Table, 4.5)

Cladocera revealed positive correlation with Copepods, Rotifers, Hardness, Calcium, Alkalinity, pH and there was negative correlation with temperature (Table 4.26). The species observed are *Daphnia sp, Polyphemus sp, Bosmina sp, and Eurycercus sp. Diaphaesoma, Macrothrix sp. Simocephalus sp.* Among the Cladocerans *Bosmina sp.* has the highest abundance during the rainy season while *Eurycercus sp*. has the least abundance

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physico-chemical Parameters

5.1.1 Temperature

The maximum value of temperature for this study was obtained in the month of May (early wet season (31.54^0C)) and the lower temperature recorded in the wet season could be as a result of seasonal changes in air temperature, humidity and solar radiation. Temperature has no direct effect on aquatic life up to 39^oC in the river. Joshi and Singh (2011) observed that solubility of O_2 in water increases when water temperature decreases while the higher value for temperature increase in also wet season.the result of temperature for these findings was also similar with Fafioye *et al.,* (2005).

The low water temperature values recorded during the period of the study was attributed to the rainy season due to the effect of cloud cover, the extensive submerged macrophytes, water hyacinths (*Eichhoniacrassipes*) and the white and red mangroves which are characteristic of the study area particularly in station 1. The turbid nature of the River contributed to the reduction in temperature due to absorption of heat by the silts. This water temperature range is suitable for the production of plankton (Iloba, 2012). The negative correlations of temperature to pH and DO shows that the high temperature observed was in the early wet season which is still in the dry season. This observation shows the preference of zooplankton assemblage to low temperature in the reservoir, thus playing a vital role in the zooplankton assemblage of the reservoir.

5.1.2 pH

pH value recorded was high in the month of August which was non-significant (P>0.05) from September, June, July, November and the lowest was recorded in the month of April. This was probably within the recommended range (6.0 – 9.0) for aquatic life (Chapman and Kimstach, 2006). The highest value recorded in the wet season could be attributed to enhanced rate of evaporation coupled with human interference are partly to enhanced photosynthetic activity. Also, low pH indicates low acidity possibly due to the presence of CO_2 in the water, this was also in congruence with the findings of Inuwa (2007), and Mustapha (2008a) and (2008b).

5.1.3 Electrical conductivity

Electrical Conductivity was maximum in the month of November (dry) while lowest was recorded in the month of August (wet). The high dry season value may be due to the reduction in the water level and increases in nutrient due to runoff of inorganic fertilizer from nearby farmland. Atobatele and Ugwumba (2008) suggested that decrease in conductivity values during raining season might be due to dilution of rainfall. The higher values may be due to dilution of rainfall. The higher values may be due to chemical fertilizers from irrigated farmlands around the reservoir coupled with higher rate of evaporation that reduces the level of water during the dry season. Thus, conductivity of water depends upon the concentration of ions and its nutrients status.

The positive correlation of Electrical conductivity with Total Dissolved Solids, Transparency and Dissolved oxygen was extracted as influencing the zooplankton growth

and abundance. This also agrees with the findings of Hujare (2005) in Hatkanangale Tahsil, Kolhaur, India.

The value obtained for this study (64.20µS/cm) is also FEPA,2005 acceptable limit for conductivity of water supply (70µS/cm).

5.1.4Total dissolved solids

The highest TDS obtained in the month of December (dry) could be due to decaying of vegetation, higher rate of evaporation caused by increase in air temperature and wind during dry season leading to increase in water turbidity, this inturn decreases the light penetration, thus affects the photosynthesis, thereby suppressing the primary producers in the form of algae and microphytes. Similar observation was made by Atobatele and Ugwuba (2008) when they reported increase in the values of total dissolved solids during the dry season which may be due to most of the vegetation was decaying so there was a rise in amount of dissolved solids.

5.1.5 Transparency

The highest value for transparency was obtained in December and the lowest was obtained in August. Ibrahim (2009) reported that higher transparency occurred during dry season due to the absence of rain runoff and low flow of water as well as gradual settling of suspended particles. Inuwa(2007) also reported observation from Masoli reservoir that high water transparency as a result of dry season and temperature increases the euphotic zone in an aquatic ecosystem which in turns favours phytoplankton growth and primary productivity.

5.1.6 Water hardness

Water hardness was higher during the dry season than the rainy season. This could be as a result of low levels and concentration of ions and lower rainy season value could be due to dilution. It could be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature.This agrees with the findings of Kolo and Oladimeji (2004) for Shiroro lake.

5.1.7 Dissolved oxygen

The highest value for Dissolved Oxygen was obtained in the month of February (dry). This similar value for D.O. was also observed by Ibrahim *et al.* (2009) reported that the cool harmattan wind which increases wave action and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season. The high oxygen value for the dry season coincides with periods of lowest turbidity and temperature. The amount of dissolved oxygen in water has been reported not constant but fluctuates, depending on temperature, depth and wind and amount of biological activities such as degradation . In this study, the cool harmattan wind which increases wave action and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season, while the torrential rains, created increased turbidity and decreased oxygen concentration during rainy season oniye *et al.* (2002) made similar observation for Zaria dam.

The higher fluctuations of dissolved oxygen during dry season than in the rainy season periods could also be attributed to the peak of human activities along the catchment area of Karidna Reservoir during this season. The decomposition of organic matter, metabolic

activities of epiphytic organisms could also be responsible for reduced oxygen concentration in the river (Ibrahim,2009)

This also agrees with report of Araoye (2008) that high O_2 concentration recorded during the dry season was due to enhanced photosynthetic activities during the this season.

5.1.8 Biologicaloxygen demand

Biological Oxygen Demand (BOD) value was recorded during wet season (4.15 mg/l) could be as a result of massive amount of waste flowing into the river during rainy season hence oxygen will be consumed faster by microbial population. The biodegradation of organic materials exerts oxygen tension in the water and increases the BOD (Abida and Harikrishna,2008).

5.1.9 Phosphate- phosphorus

The high dry season mean value for phosphate phosphorus could be due to concentration effect because of reduced water volume.The relatively high values of Phosphate recorded in this study could be attributed to incoming effluents and human activities such as washing, bathing, fishing and fish farming. The values of phosphate in station 1 were considerably higher than other Stations. This may be due to the biodegradation of organic matter by bacteria.It could also be due to lower water hardness, thus less co-precipitation of phosphate with calcium carbonate, a phenomenon that has often been reported to occur in many freshwater lakes. Kolo and Ogugbuaja(2010) made similar observation in borno state in North -eastern Nigeria. The positive correlations of Phosphate with Nitrate-nitrogen and TDS may not necessarily be a direct relationship of the zooplankton

utilizing the nutrients, but could be attributed to the dependence of the phytoplankton (which serves as food for the zooplankton) on these nutrients.

5.1.10 Nitrate-nitrogen

The maximum value for nitrate was obtained in the month of November (dry) and October while the lowest value was obtained in the month of June. This findings was similar to that of Dimowo (2013) in Ogun river, Kolo and Ogugbuaja(2010) in lake chad basin of Borno state.

5.1.11 Alkalinity

The maximum alkalinity was obtained in the month of February (5.04mg/l) and the minimum value was obtained in November (2.51mg/l).The alkalinity values are an indication of low carbonate and bicarbonate ions in the water reflecting the absence of limestone in the water basin.

The alkalinity higher in the dry season and lower in the rainy seasoncould be due to low water levels with its attendant concentration of salts and the lower value in the rainy season could be due to dilution. The high level alkalinity during dry season also agrees with the findings of Ibrahim *et al.,* 2009.

5.1.12 Chloride

Chloride value was higher in wet season (4.12mg/l). the chloride ions are introduced into the river system via sewages. The higher value during the rainy season could be attributed to an increase in the flow sewage finding their way into the river during the rainy season. This observation also coincides with the findings of Farombi *et al.,* (2014)

in their study of Variations of biotic Conditions Of water Quality of river Osun, Osun state, Nigeria.

5.1.13 Sulphate

The highest rate of sulphate recorded during rainy season compare to the lower value for dry season could be attributed to the effluents which result to increase in oxidation of sulphate from the waste entering into the river. Similar findings was also made by kolo and Ogogbuaja(2010)

5.1.14 Calcium

Calcium the high rate of calcium during wet season could also be as a result of low level and concentration of ions (magnesium and calcium).

5.2 Zooplankton

The high population of zooplankton during the rainy season was traced to high population of phytoplankton food source which were highly abundant within the reservoir during the rains making rotifers highest. Cladorcerans (685 organisms), Copepods(556 organisms).

According to (Rocha *et al.,* 1999) increase in primary production (phytoplankton) lends to be followed by increase in zooplankton number and abundance. This also corresponds to the study of *Mulay*ert *et al.* (2003) that plankton usually reaches their peak source, low predation by fish during the rains as a result of their breeding could also have encouraged high population of the zooplankton. The diversity indices computed were across all the

stations and did not vary among sampling stations. This is a characteristics feature. This is in agreement with the earlier position of Imoebe and Ohiozebau (2009) of Okhuo river.

5.2.1 Rotifers

The dominant status of rotifers species in rivers comparative to the cladocerans and copepods is characteristics of tropical lakes and rivers and this has been reported in the studies of Imoobe and Adeyinka(2009. Edema *et al*.(,2002*)*hadreportedthat numerically, the rotifers constituted (72.60%) of plankton during an earlier preliminary studies of zooplankton of Okhuo river. As espoused in the work of Imoebe and Adeyinka (2009) the dominance of smaller zooplankton species in this case of rotifers may possibly be due to predation pressure from planktivorous fishes that selectively prey on larger sized zooplankton.

Rosemand *et al,* (1987) says that ability to adapt to food conditions and less predation may be the reasons for the significant abundance of rotifers, cladocera and copepods in the rains. The absence of some genera such as lecane could have occurred as a result of patchiness or dispersal. Dispersal has been noted to play a major role in structuring of zooplankton communities and abundance (Shurin, 2003).

Rotifers dominant in the reservoir was due to their short generation time and parthenogenetic reproduction pattern. Hutchinson (1970) mentioned that the availability of elements such as phosphate, NO_3, and Cl^- in slow current water and with a suitable organic load could significantly faster than development of rotifer population. Similar observation was also made by Akin-oriola (2003) and Mustapha and Omotosho (2006) as the most dominant zooplankton group in Nigerian aquatic ecosystem.

The dominance of *Branchionus* in the family of Rotifera was an indication that the reservoir is eutrophic and their abundance was due to the presence of high organic matter in the reservoir (Matsumura-Tundish, 1999). Similar observation was also made by Moshood (2009) in his study of zooplankton assemblage in Oyun, Reservoir, Offa, Nigeria.

The results obtained from a number of researches indicated that cladocera and rotifer constitute the major planktonic population and account for the bulk of zooplankton items observed.

5.2.2 Copepods

The relative low abundance of copepods was as a result of the hydrodynamics of the reservoir such as the low water volume, short residence time, relative old age of the reservoir and the morphometery. The low genera abundance of copepods and cladoceras have also been documented in other water bodies in Nigeria like Oyun and Ona rivers (Akin-oriola, 2003).

Genus Cyclops was the dominant of the copepods, its relatively low abundance in the reservoir is good. This is because of the medical implications of large population of the genus in water bodies of Africa where water is consumed directly from reservoirs without being treated. The low population of the genus could be due to their slow reproduction, growth and renewal rate. Absence of parthenogenetic forms of copepods might be responsible for their low population density. This was similar to that observed by Moshood (2009) in its study of zooplankton assemblage of Oyun Reservoir Offa,

Nigeria.The negative correlation of copepods with transparency was a result of low transparency of the water which hinders copepods growth and abundance.

5.2.3 Cladocera

The Cladoceran species recorded in this study are cosmopolitan in the tropical region. The dominance of *Bosmina sp.* in Karidna Reservoir agrees with the fact that the species are the most widely and frequently recorded planktonic species of the open water habitat in rivers.

The dominant of *Bosmina species*could have arisen due to its large bodied size which enables it to graze on large quantities and diverse forms of phytoplankton. The density and biomass of Cladocera were primarily determined by food supply.

(Imoobe *et al*., 2008)

Station I is characterised to have more abundance of the zooplankton species than the species because it is at the point of arthropogenic activities like bathing, washing, grazing and other domestic activities is carried out and it is also the point of human contact. The family cladocera of species *Bosmina*, *Daphnia*, and *Eurycercus* was abundance in site I than any other station this may due to the fact that they have large bodies and high resistant to disturbance of human and other domestic activities. While the lowest abundance was obtained in station 5 which is very closed and have contact directly with the thick vegetation, the floral close to the reservoir has the ability of purifying the waters in the reservoir so much zooplankton were not captured in that station (V).

(Dejen *et al*., 2004)

5.3 Test of Hypotheses

Three null hypotheses were formulated and tested with the aim to establish physical, chemical, and biological parameters of Karidna reservoir, and to provide better understanding of the reservoir ecosystems. Hypothesis one stated that the physico-chemical parameters of the reservoir do not vary between both seasons. The difference between the physico-chemical parameters and seasonal variation in the reservoir in which the results revealed there was significant difference of physico-chemical parameters between the wet and dry season in the reservoir, therefore hypothesis one was rejected. Hypothesis two states there was no significant difference in the distribution of zoo plankton between sampling stationsin the reservoir, in which the result shown there was significant difference in the distribution of zooplankton in the reservoir; the hypothesis was rejected. The thirdhypothesis states; there is no significant relation between zooplankton community and water quality of the reservoir but statistics revealed there was significant relation between zooplankton community and water quality of the reservoir, therefore hypothesis three was also rejected.

CHAPTER SIX

6.0 SUMMARY,CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The studies on the physico-chemical parameters and zooplankton composition of Karidna reservoir; Kaduna state was carried out for the period of twelve months in order to provide a baseline information on the ecological status of the reservoir. The physico-chemical parameters of the reservoir varied with months, seasons and stations. The variations of physico-chemical parameters may be due to change in weather cycle during the study period that occurs in the environment. The reservoir was more productive during the rainy season, because there was higher abundance of zooplankton during the rainy season than the dry season. Rotifers higher species abundance in the reservoir was an indication that the reservoir water was unpolluted and productive, because rotifers are sensitive indicators of changes in water quality. Anthropogenic activities such as farming and cattle rearing, washing and fishing that are taking place around the reservoir had some impact on the water quality of the reservoir, especially during the rainy season.

6.2 Conclusions

The physico-chemical parameters studied in Karidna reservoir are Water temperature, pH, transparency, Electrical conductivity, total dissolved solids, nitrate-nitrogen, hardness, dissolved oxygen, biochemical oxygen demand, dissolved oxygen, and phosphate-phosphorus, sulphate, calcium, All the physico-chemical parameters revealed monthly and seasonal variation, which was opposed to the hypotheses stated earlier. Rotifers, Copepods, Cladoceras. Zooplankton composition and abundance were increased

during rainy season and decreased with dry season.Water quality of the reservoir is influenced by anthropogenic activities as runoffs of inorganic fertilizers and pesticides; the reservoir water is suitable for irrigational and domestic purposes in terms of most of the physico-chemical and biological parameters analyzed. However, considering that the reservoir is a source of drinking water, the potential of the anthropogenic inputs gains significance. Hence, there is need for an effective anthropogenic inputs control program in the reservoir.

The zooplankton community composition of the reservoir also showed the reservoir to be productive and will support a diverse species and population of fishes. The assemblage was strongly influenced by the physico-chemical factors which showed the water quality to be good. Temperature, food abundance, nutrients were some of the factors that could limit zooplankton growth, composition and abundance in the reservoir. Maintenance of good water quality in the reservoir will enhance the zooplankton community structure and population dynamics and this will be a great advantage for fish production in the reservoir since the energetic trophic foundations for fish would have been well established.

6.3 Recommendations

Water quality of the reservoir is influenced by anthropogenic activities as runoffs of inorganic fertilizers and pesticides. Therefore, it is recommended that:-

1. Farmers and students around the reservoir should be enlightened on the effects of their activities into the body of the water especially application of inorganic fertilizers and pesticides, irrigation, washing when the water recedes.

2. More studies should be carried out to identify the zooplankton composition using polymerase Chain Reaction (PCR) and other Taxonomic identification methods that are not used during this work.

REFERENCES

Achembach, L. & Lampert,W.1997. Effects of elevated temperatures on threshold food concentrations and possible competitive abilities of differently sized cladoceran species. Oikos 79: 469-476.

Adakole, J.A., Balogun, J. K and Lawal, F.A. (1998). The effects of pollution on benthic fauna in Bindare stream, Zaria, Nigeria. *Nigerian Journal of Chemical Research*.3: 13 – 16.

Adakole, J.A., Abolude, D.S. and Balarabe, M.L. (2008). Assessment of Water Quality of A Man-Made Lake in Zaria, Nigeria. *Proceedings of Taal*: The 12th World Lake Conference: 1373-1382.

Adeniji, H.A. (1998). A pre-impoundment fisheries study of the River Niger in the proposed Jebba Lake Area. Kainji Lake Research Institute Annual Report : pp. 4550.

Agbaire, P.O. and Obi C.G. (2009) Seasonal Variations of Some Physico-Chemical Properties of River Ethiope Water in Abraka, Nigeria J. Appl. Sci. Environ. Manage. *March*, 2009 Vol. **13**(1) 55 – 57.

Ajuzie,C.C. (2012). Aspects of biodiversity studies in a small rural tropical reservoir (Lamingo Reservoir) in Jos, Nigeria. *World Rural Observations ;* **4**(1):23-33.

Alekseev, R.,(2002) "Copepoda," in A Guide to Tropical Freshwater Zooplankton: Identification Ecology and Impact on Fisheries, C. H. Fernando, Ed., pp. 123–187, Backhuys Publishers, Leiden, The Netherlands.

Araoye, P.A. and Owolabi, O. (2005). Some Changes in the Animal and Fish Species Composition Due to the Construction of Kampe (Omi) dam and irrigation project in Kogi State, Nigeria. *Nigerian Journal of Pure & Applied Science* **20**(1): 1781-1789.

Araoye, P.A. (2008). Physical factors and their Influence on Fish Species Composition in Asa Lake, Ilorin, Nigeria. *International Journal of Tropical Biology*,**57** (2): 167-175.

Ayoade, A. A., Fagade, S.O., and Adebisi A. A. (2006). Dynamics of Limnological features of Two Man-Made Lakes in Relation to Fish Production. *African Journal of Biotechnology*,5(10): 1013-1021. Retrieved fromhttp;//www.academicjournals.org/AJB.on23/12/2011.

Asaolu, S.S., Olaofe, O. (2004). Biomagnification factors of some heavy and essential metals in sediments, fish and crayfish from Ondo State Coastal region. Bio. Sci. Res. Commu., 16: 33-39.

Asaolu S.S., Ipinmoroti, K.O., Adeyinowo, C.E. Olaofe O. (1997). Interrelationship 0f heavy metals concentration in water, sediment as fish samples from Ondo State coastal Area, *Nig. Afr. J. Sci* 1: 55-61.

Ayoade, A.A (2009). Changes in Physico-chemical Features and Plankton of Two Regulated High Altitude Rivers Garhwal Himalaya, India. *European Journal of Scientific Research*.**27**(1):77-92 Retrieved from http://www.eurojournals.com/ejsr.htm on 25/12/2011

Atobatele, O.E. and Ugwumba, O.A (2008). Seasonal Variation in the Physico-chemistry of a Small Tropical Reservoir (Aiba Reservoir, Iwo, Osun, Nigeria). *African Journal of Biotechnology* **7** (12):62-171.

Akin-Oriola, G.A. (2003). On the phytoplankton of Awba Reservoir, Ibadan, Nigeria. *Revista De Biologia Tropical*,51(1):99-106.

Akindele, E.O. Adeniyi,I. F. (2013) and I. Indabawa, "Spatio-temporal assessment and water quality characteristics of Lake Tiga, Kano, Nigeria," Research Journal of Environmental and Earth Sciences, vol. 5(2):67–77.

APHA(1995). *Standard methods for the examination of water and wastewater.16th edition* .American Public Health Association. New York, USA. 1268pp.

APHA (2005). Standard methods for the examination of water and waste water.21st Edn., Washington, D. C.pg.126

APHA. (1999) Standard methods for the examination of water and wastewater. 18th ed. American Public Health Association, Washington, DC. Pg.127

Ashton, P.J and Schoeman, F.R(1983). Limnological studies on the Pretoria salt p an ,hypersaline Maar Lake. *Hydrobiologia*, 99: 61 – 73.

Balogun,J.K and Auta,J.(2005).Fisheries resources and development potentials Of lake Kangimi , Kaduna State.*Nigeria.Journal of.Bio. Sciences*,**2**(1):50-56.

Balarabe, M.L.(2001). Effect of Limnological Characteristic on Zooplankton composition and distribution in Dumbi and Kwangila Ponds, Zaria, Nigeria.Ph.D. Thesis, Department of Biological Sciences, Ahmadu Bello University.

Bhatti, M.T. and Latif, M. (2011). Assessment of Water Quality of a River using an Indexing Approach during the Low-flow Season Irrigation Drainage, *Journal of Agriculture and Environment*,(60): 103-114.

Beyruth, Z. (2000). Periodic disturbances, trophic gradient and phytoplankton characteristics related tocyanobacterial growth in Guarapiranga reservoir. Sao Paulo Stae, Brazil. *Hydrobiol.* 424: 51-60

Chapman and Kimstach(2006) "Selection of water quality variables," in Water Quality Assessments, D. Chapman, Ed., pp. 65–122, Chapman and Hall, London, UK.

David.O.A. (2009). *Living at Micro Scale*.Cambridge, Massachusetts: Harvard University Press.

Denton B. (2007).*"Branchiopoda"*.In Sol Felty Light & James T. Carlton.*The Light and Smith Manual: Intertidal Invertebrates from Central California to Oregon*

Douglas G.S. and Kirstern, W. (2001)."CladoceranBranchiopoda (water fleas)".In Douglas Grant Smith.*Pennak's Freshwater Invertebrates of the United States: Porifera to Crustacea* (4th ed.). John Wiley and Sons. pp. 453–488.

Edema, C.U.Ayeni J.O.,and Aruoture A . (2002). Someobservations of the Okhuo River, *Nigeria journal of aquatic sciences*, **17** (2): 145 – 149.

Fernando, C.H. (2002). *A Guide to Tropical Freshwater Zooplankton; Identification, Ecology and Impact on Fisheries*.Backhuys Publishers, Leiden.p. 291.

Garcia P.R.,S. Nandini S.S. Sarma E.R(2002). Seasonal variation of zooplankton abundance In freshwater reservoir Valle de Bravo (Mexico) Hydrobiologia, pp: 99-108

Gupta, A., (2004) . Drinking Water Quality in Barak Valley.Proceedings of the 2nd APHWConference. Asia Pacific Association of Hydrology and Water Resources, Japan. pp: 6

Hanna (2003). The Hanna Catalog. Hanna Instruments Inc. Woonsocket RI, USA

Holden, M.J and Green J.(1960). The hydrology and plankton of the River Sokoto. *Journalof Animal Ecology*,29(1):65–84.

Howey, Richard L. (1999). "Welcome to the Wonderfully Weird World of Rotifers". Micscape Magazine. Retrieved 19 February 2010.

Hujare, M. S. (2005). Hydrological studies on some water reservoirs of Hatkanangale Tahsil Maharashtra. Ph.D Thesis, Shivaji University, Kolhapur, India.

Hujare, M.S., (2008), Seasonal variation of physico-chemical parameters in the

perennial tank of Talsande, Maharashtra, Ecotoxicology and Environmental Monitoring, 18(3), pp 233-242.

Hutchinson, E.A., 1970. A study of planktonic Rotifer of river Ganard, Essex Ontario, MSC. Thesis University of windsov, Ontario Canada pp:58-86

Ibrahim,B.U.Auta, J.Balogun, J.K. Some Aspect of the Physico-chemical Parameters Of Kontagora Dam, Niger State, Nigeria. *In proceedings of the 23rd Annual Conference of the fisheries society of Nigeria (*FISON) Pp 189-194

Ibrahim S (2009). A survey of zooplankton diversity of Challawa River,Kano and Evaluation of some of its physico-chemical conditions. Bayero J. Pure Appl. Sci.**2**(1):19-26.

Indabawa, I. I. (2009). Studies on Limnological Parameters and Phytoplankton Dynamics of Nguru Lake, Yobe State, Nigeria. *Bioscience Research Communications,* **21**(4), 183-188.

Imoobe, T. O. T. and Adeyinka, M. L. (2010). Zooplankton-based assessment of the trophic state of a tropical forest river. International Journal of Fisheries and Aquaculture, **2**(2): 64-70.

Inuwa, B. (2007): Studies on Aspects ofPhysicochemical Conditions and the Fish Biology in Jakara Dam, Kano, Nigeria. An M.Sc. Dissertation Submitted to theBiologicalSciences Department, Bayero University,Kano (Unpublished).

Iloba, K. I. (2012). The Physico-chemical Characteristics and Plankton Ethiope River, Nigeria Ph.D Thesis, Delta State University Abraka, Delta State. pp 444.

Kemdirim,E.E (1993). Prelimary studies on the productivity of Pankshin reservoir using Physico-chemical characteristics and morpho-edaphic index. *Journal of Aquatic Sciences.***8**: 23 – 31.

Khan, M.A. (1984)Limnology and plankton periodicity of Jos Plateau water reservoir, Nigeria, West Africa.*Hydrobiologia;* 114:189-199.

Kigamba, B.M. (2005). Limnological Studies in a Fish Pond at Birdman, West Bengal, India, *Japan Journal of limnology*, 40: 10-18
Retrieved from www.ccsenet.org/enrr on 02/07/2011

Kutikova L.A. (2002). Rotifera In: Fernado.CH(ed). A guide to Tropical Freshwater Zooplankton; Identification, Ecology and Impact on Fisheries. Backhuys Publisher, Leiden pp. 23-68

Kolo, R.J. and Oladimeji A.A. (2004) Water quality andsome nutrients level in Shiroro Lake, Nigerstate, Nigeria. Journal of Aquatic sciences **19**(2) :99 – 106.

Kolo, B.G., Ogugbuaja, V.O and Dauda, M. Department Of Chemistry, University Of Maiduguri Borno State, Nigeria

Langenegger, O.T (1994). Ground water quality and hand pump corrosion in Africa. UNDP World Bank Water and sanitation Program Technical Report.Washington D.C., NO. 8: 143pp.

Lind, O.T. (1979) A handbook of limnological methods C.V. Mosby Co. St. Louis 199p

Lind, O.T. (1979).A hand book of common methods of water analysis for limnology.C.V.Moshy publishers, St.Loius, U.S.A. 69pp.

Mahar, M.A. (2003). Ecology and Taxonomy of Plankton of Manchhar lake (Distt. Dadu), Sindh, Pakistan.Unpublished PhD. Thesis University of Sindh, Pakistan.

Matsumura-Tundisi., E.L.G. Espindola., K.F. Roche & A.C. Rietzler. 1999. Ecological theory applied to reservoir zooplankton, p. 29-51. *In* Tundisi, J.G & M. Straskraba (eds.). Theoretical reservoir ecology and its applications. International Institute of Ecology, Brazilian Academy of Sciences. Backhuys Publishers, Leiden, Holland.

Moshood k. Mustapha (2009): Zooplankton Assemblage Of Oyun Reservoir, Offa, Nigeria.

Mustapha, M.K. and Omotosho.J.S. (2006). *Hydrobiological studies of Moro Lake, Ilorin, Nigeria. Nig. J. Pure & Appl. Sci. Vol 21: 1948-1954*

Mustapha, M.K. (2008). Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, using Selected Physico-chemical Parameters. *Turkish Journal of Fisheries and Aquatic Sciences*, **8**: 309-319.

Mustapha, M.K. (2011). Perspectives in the Limnology of Shallow Tropical African Reservoirs in Relation to Their Fish and Fisheries. *Journal of Transdisciplinary Environmental Studies* **10**(1):16-23

Mustapha, A. (2008a): Environmental Pollution inKano: The Contribution of wastewater Discharge from Kano Old City and BompaiIndustrial Estate to Jakara River Basin system, Techno Science J. **2**(1): 83-88.

Mustapha, A. (2008b): An Assessment of theSuitability of Water in Jakara-Getsi River

System, For Fadama Production at the KanoRegion, Kano State, Techno Science J. **1**(1):118-124.

Muylaert, K., Declerck, S. Geenens, V. Wichelen, J.V. Deegans, H. Vandekerkhove, J. Vyverman, W.(2003).Zooplankton, Phytoplankton and the Microbial food web in two turbid and two clear shallow lakes in Belgium.*Aquatic. Ecoogy,* **37**: 137-150.

Majumber A.K. (2009) physicochemical analysis of karnafully River water of Bangladesh, Science and Technology: Environmental issues community.

Muhammad B.G., Ismail B.S., Ekhwan T., Sujaul I.M. Tan C.C. (2007) A physico–chemical assessment of the Behar River" Pahang ,Malaysia. *Global journal of Environmental Research,* **3**(1): 7-11.

N'Diaye A. D., El Kory, M.B., Sid M. O, Kankou A. O. (2013). Study of Water Quality during Rainy Season using Physico-chemical and Metallic Parameters of Senegal River in Mauritania. *Scieince of Africcan Journal of Scientific Issues, Research, and Essays* **1**(1): 1-10.

Oketola A. A., Osibanjo O., Ejelonu B. C., Oladimeji Y. B., and Damazio O. A., 2006, Water Quality Assessment of River Ogun around the Cattle Market of Isheri, Nigeria, Journal of Applied Sciences, **6**(3): 511-517.

Oniye, S·L, Ega, R.A., Ajanusi, O.J. and Agbede, R.I.S. (2002). Some aspects of the physicochemical parameters of Zaria Dam, Nigeria. *Journal of Agriculture and Environment*,**11**(2): 367- 379.

Park, S., Brett, M.T. Oshell, E.T. & Goldman, C.R. (2003). Seston food quality and *Daphnia* productionefficiencies in an oligo-mesotrophic Subalpine lake. *Aquat. Ecol*., 37: 123-136.

Rao TR, R Kumar. 2002. Patterns of prey selectivity in thecyclopoidHarada. Aquat. Ecol. **36:** 411-420.

Reynolds, C.S. (1999). Non-determinism to probability, or N:P in the community ecology of phytoplankton:Nutrient ratios. *Arch. Hydrobiology.,* **146**: 23-35.

Robert, D. Barnes (1982). *Invertebrate Zoology*.Philadelphia, Pennsylvania: Holt-Saunders International. pp. 683–692.

Rocha,O.T. Matsumura-Tundisi., E.L.G. Espindola., K.F. Roche & A.C. Rietzler (1999). Ecological theory applied to reservoir zooplankton, p. 29-51. *In* Tundisi, J.G & M. Straskraba (eds.). Theoretical reservoir ecology and its applications. International Institute of Ecology, Brazilian Academy of Sciences. Backhuys Publishers, Leiden, Holland.

Rowe, C.L.(2000). Global distribution, phylogeny and taxonomy of the freshwater zooplankton *genus Holopedium* .Mastersthesis.University of Guelph, Guelph, Ontario.

Rosemond, A.D., P. Mulholland & J.W. Elwood. 1993. Top-down and Bottom-up control of stream periphyton: effects of nutrients and herbivores. Ecology 74:1264-1280.

Sabkara, J. and M. Makarami, (2002). A review on the planktonic density and distribution in Maku Lake. J. 17

Salavatian, M. and M. Fallahi, (2005). A study on the growth rate and green algae biomass; *Chlorella* 16. Williams, L.G., 1966. Dominant Planktonic Rotifers of *vulgareis*. *Journal of Fisheries Science,* **14:** 79-86.

Schwab.E.A.(2012).*Evolution's Witness: How Eyes Evolved*. *Oxford University Press*.p. 231.

Shurin, J.B. & Havel, J.E. (2002). Hydrologic connections and overland dispersal in an exotic freshwatercrustacean. *Biol. Invasions*. **4**: 431-439.

Singh, A., Dr. Sanamacha Meetei, N. Dr.L. Byen Meitei: Seasonal Variation Of Some physico-chemical parameters of three Major Riversin Imphal, Manipur: A comparative Evaluation

Simciv, T. (2005). The role of plankton, zoobenthos, and sediment in organic matter degradation in oligotrophicand eutrophic mountain lakes. *Hydrobiol*., 532: 69-79.

Taylor.C.R.(2002). Ishikane and R.A. Haney. The systematics of Holarctic bosminids and a revision that reconciles molecular and morphological evolution.Limnology and Oceanography.**47** (5):1486-1495.

Thirupathaiah M.(2012)Diversity of zooplankton in lower manair reservoir,Karimnagar, AP India, *Journal of. Biological Sciences,* **1**(7)**:** 27-32

Tropical Freshwater Zooplankton; Identification, Ecology and Impact on Fisheries. Backhuys Publishers, Leiden, pp.123-187.

Ude, E. F., Ugwu, L. L. C., Mgbenka, B. O. and Nwani, C. D (2011). Trends in Nitrate-Nitrogen, Nitrite-Nitrogen and Phosphorus Concentration in Ebonyi River, Nigeria.

Continental Journal Fisheries and Aquatic Science **5** (1):1-7, 2011. Retrieved from http://www.wiloludjournal.com

Umavathi, S., Longkumar K. Subhashini (2007), Studies on the nutrient content of sulur pond in combiator Tamil Nadu , Journal of ecology and environmental conservation**13(**5),pp 501-504.

Van de Velde,I. (1998). Cladocera and Copepoda from the valley of the river Senegal.Biologisch Jaarboek Dodonaea 1978; 46: 192-201.

Venkatesharaju K., Ravikumar.p., Somashikar (2010), Physicochemical and Bacteriological Investigation on the river Cavvery of kollegal stretch in Karnataka, journal of science. Engineering and technology, **6**(1). Pp 50-59

Walsh, C.J., Sharpe, A.K. Breen, P.F & Sonneman, J.A. (2001). Effects of urbanization on streams of theMelbourne region, Victoria, Australia. I. Benthic maroinvertebrates communities. *Freshwat. Biol.,* 46: 535-551.

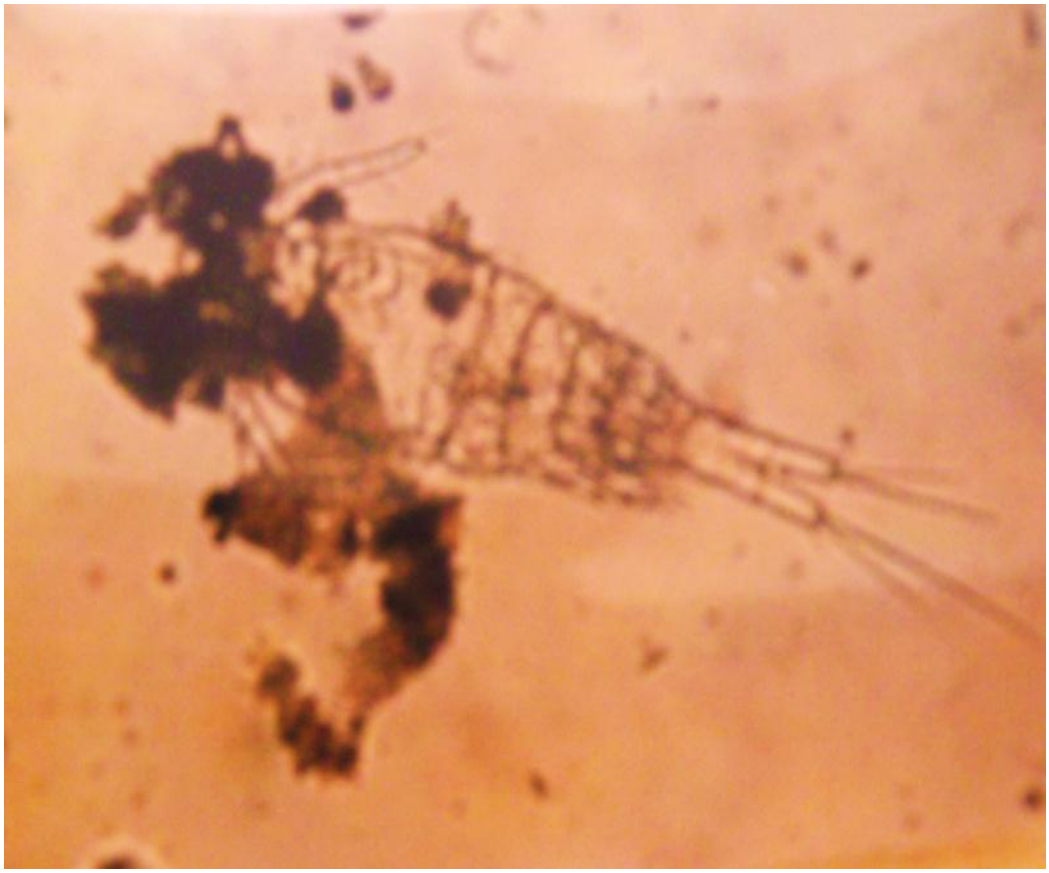
Wetzel RG, Likens G.E (2000). Limnological Analyses, Third Edition springer, New York p.429

Wood, A. (1995). Constructed wetland in water pollution control fundamental to theirs understanding. Water science and Technology. **32**(3): 21 –29

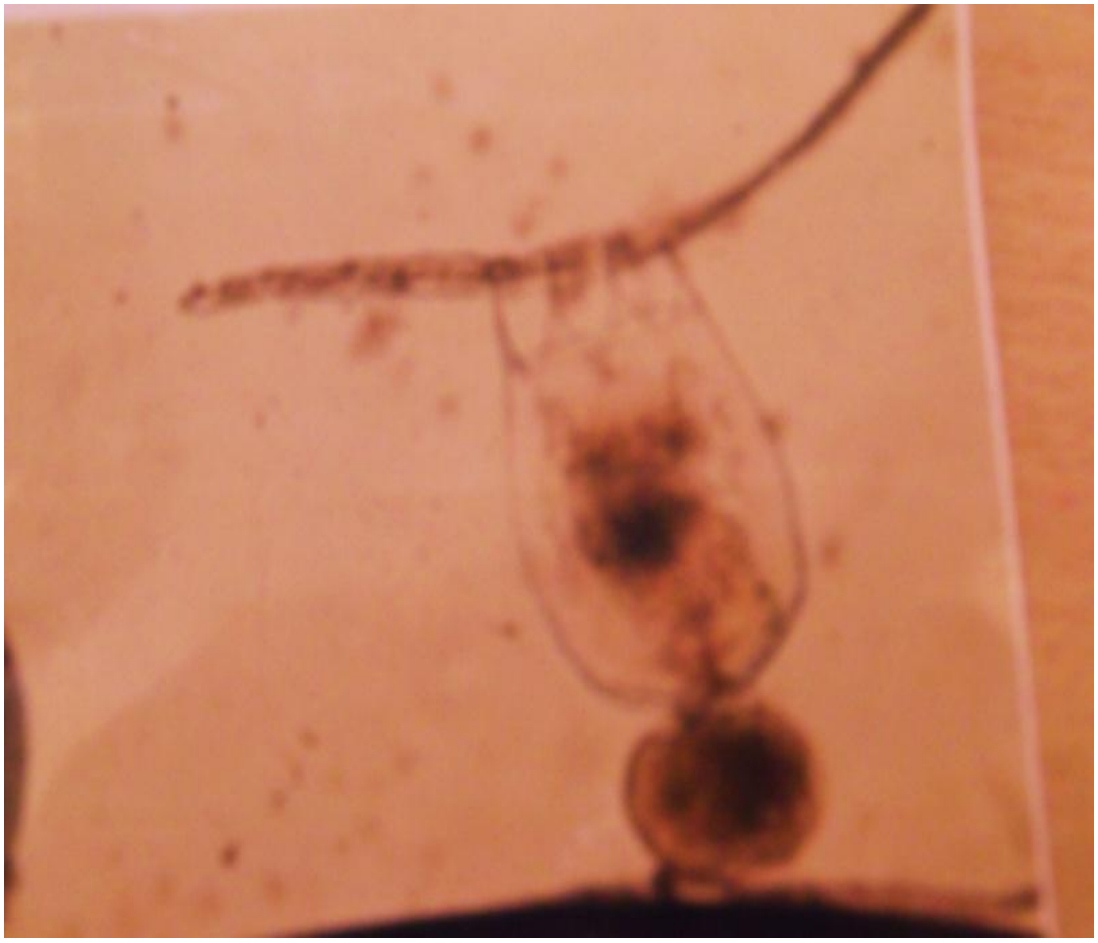
Wright, R.(1982) Seasonal variations in water quality of a West African river (R. Jong in Sierra. Leone)*RevistaHydrobiologia Tropical,***15**: 193–199.

Zeb, B.S., A.H. Malik, A. Waseem and Q. Mahmood, (2011).Water Quality Assessment of Siran River, Pakistan.*International Journal of Physical Science*. **6**: 789-798.

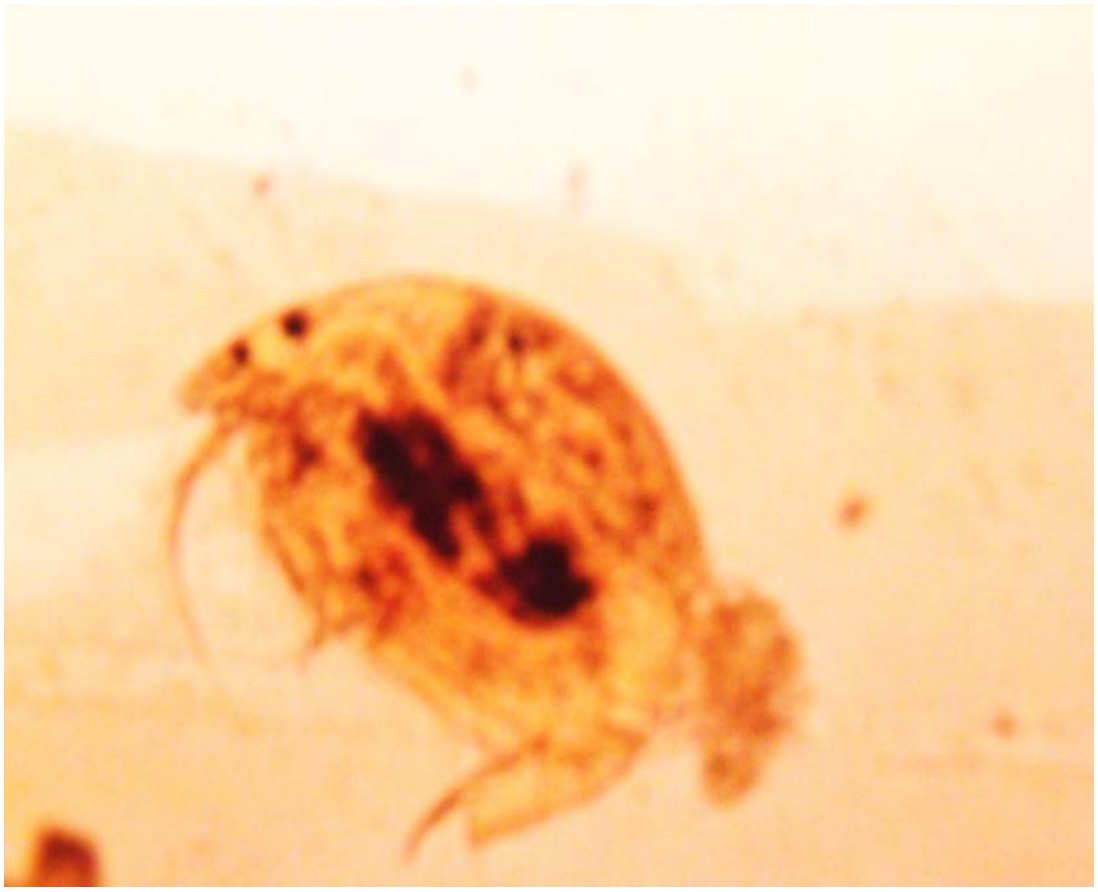
APPENDICES



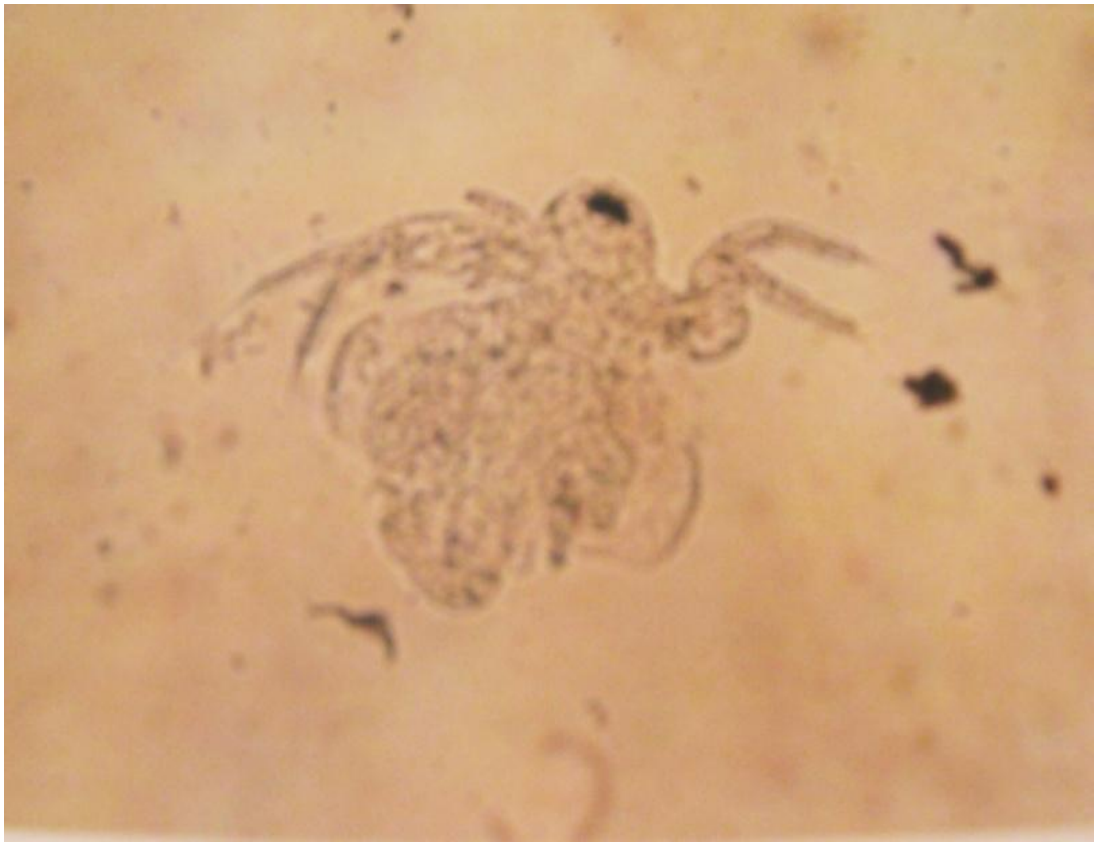
Appendix I: Plate of identified Copepod species in Karidna Reservoir



Appendix II: Plate of Rotifera species identified in Karidna Reservoir



Appendix III: Plate showing identified Cladocera species in Karidna Reservoir



Appendix IV: Plate showing Identified Nauphilii larvae In Karidna reservoir