

**DETERMINATION OF THE PHYSICO-CHEMICAL AND BIOLOGICAL  
PARAMETERS OF SABUWA RESERVOIR, KATSINA STATE, NIRIA**

**BY**

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**DETERMINATION OF THE PHYSICO-CHEMICAL AND BIOLOGICAL  
PARAMETERS OF SABUWA RESERVOIR, KATSINA STATE, NIGERIA**

**BY**

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**OCTOBER, 2014**

## DECLARATION

I hereby declare that this thesis entitled Determination of Physico-Chemical and Biological Parameters of Sabuwa Reservoir, Katsina State, Nigeria has been carried out by me in the Department of Biological Sciences. The information derived from 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 or diploma at this or any other institution

Mustapha Yahaya MOHAMMED \_\_\_\_\_  
signature

\_\_\_\_\_  
Date

## CERTIFICATION

This thesis entitled “DETERMINATION OF PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS OF SABUWA RESERVOIR KATSINA STATE, NIGERIA” by Mustapha Yahaya MOHAMMED meets the regulations governing the award of the Degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its Contribution to knowledge and literary presentations.

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## **DEDICATION**

This work is dedicated to my entire family, especially Hafsat, Maryam and Umar.

## **ACKNOWLEDGEMENT**

I wish to express my sincere appreciation to Prof. M.L. Balarabe for accepting to supervise me and for his continuous effort in encouraging me to finish this work and for his constructive criticism, advice and time devoted to read and correct my manuscript. I am also grateful to my second supervisor, Prof. I.S. Ndams for much encouragement and assistance he rendered to make this work a success.

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## ABSTRACT

Studies on some aspects of physic-chemical parameters, phytoplankton and zooplankton composition were carried out for a period of twelve months in Sabuwa reservoir. Five sampling stations were selected for the research using standard methods of experimental analysis. Water depth, temperature, pH, transparency and electrical conductivity, ranges between 40 – 502cm, 22°C – 29°C, 6.44 – 9.32, 22.5cm – 54cm, 11 - 85 $\mu\text{mho}^{-\text{s}}$  respectively. Dissolved oxygen concentration, biochemical oxygen demand, nitrate-nitrogen, phosphate-phosphorus and alkalinity varied significantly between seasons ( $P < 0.05$ ). Four classes of phytoplankton belonging to Chlorophyta, Cyanophyta, Bacillariophyta and Dinophyta were observed during the study with Chlorophyta accounting for 41%, followed by Cyanophyta 34% then Bacillariophyta and Dinophyta. Phytoplankton exhibited significant seasonal and spatial variations. Four classes of zooplankton belonging to Rotifera (35.9%), Cladocera (28.6%), Copipoda (18.8%) and Protozoa (16.7%) were observed during the study. The zooplankton groups exhibited significant variation between seasons where ( $p < 0.05$ ). Three groups of macro-benthic invertebrates comprising of Mollusca, Annelida, and Nematoda were observed to be present. Stations 2 and 3 were found to be most productive while stations 1, 4 and 5 are less productive. The seasonal variations observed in plankton and macro-benthic composition, abundance and distribution were mainly a reflection of physic-chemical changes associated with the reservoir and their respective responses by the biota.

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## CHAPTER ONE

### 1.0 INTRODUCTION

Limnology is the study of physical and chemical factors occurring in inland water bodies. Nigeria is blessed with about 15 million hectare of inland water mass capable of producing over 1.5million metric tones of fish annually (Ita, 1993).

Water is a primary natural resource and its availability has played a vital role in the evolution of human settlements. Humans depend mainly on freshwater available in inland lakes and rivers, which constitute less than 50% of the total amount of the water in biosphere (Wetzel, 1983). As a result, there has been a growing necessity for conservation of water as a result of growing populations and increase in pollution of surface waters (Abubakar, 2013).

Inland water bodies depend on the amount of annual rainfall, size, seepage, climate and geographical location. Most water bodies in the savannah region of Nigeria are seasonal. The quality of a given water body is controlled by its physical, chemical and biological factors, all of which interact with one another to influence the quality of water.

Availability of safe and reliable water is an essential prerequisite for sustained development (Adakole *et al.*, 2008). It is important to constantly protect and control the quality of water (WHO, 2000; Chia *et al.*, 2009a; Mamba *et al.*, 2009; Chigor, 2012). Over-growing population has resulted to the impoundment of many dams and reservoirs. Auta (1983), also reported that some water quality standards such as pH, transparency,

dissolved oxygen and plankton composition are some important factors necessary in pond fisheries management.

It is therefore necessary to maintain our reservoirs by addressing the consequences of present and future threats of contamination and degradation of our water bodies. Azionu (2004) showed that soil structure and composition, natural environmental variables dissolved oxygen, biochemical oxygen demand, pH, temperature, transparency etc. All influence the quality of the medium which in turn determines the health of the fish and their performance. The freshwater ecosystem is categorized into lotic (river, stream/springs) which could be perennial or seasonal and lentic, that is standing waters (ponds, lakes and swamps) which could be perennial or temporary depending upon the geological basin (Balarabe, 1989). As population continue to increase, industrialization and intensification of agriculture had led to increase pollution of surface of surface waters. This induces ecological imbalances, deleterious for sustained development of fisheries resources which has necessitate the suspension of the beneficial uses of these water bodies in some placed (Kawo, 1986). Azionu (2004) showed that soil structure, composition and natural environmental factors all influence the quality of the medium which in turn determines the health of the fish and their performance.

The impoundment of river and subsequent creation of Sabuwa reservoir has assisted to provide water for drinking, irrigation and have also led to the establishment of school of fisheries, Ahmadu Bello University, Sabuwa, katsina State. However, human activities in these catchments may have cause pollution resulting from deforestation, farming activities, grazing and bush burning which enhances accelerated silting, addition

of large quantities of nutrients chemicals, herbicides and organic matter in water bodies through surface run-offs (Gopalet *al.*, 1981). Ezealoret *al.*, (1999) noted that extensive human activities through agricultural practices, fertilizer application and overgrazing around the catchment areas of aquatic habitats results in marked fluctuations in the physicochemical parameters of lentic ecosystems.

Eutrophication alters these specific compositions of biota which lead to changing composition of phytoplankton which in turn constitute food for zooplankton (Sendacz, 1984). Sabuwa reservoir is relatively old and was constructed in 1980 and commissioned in 1982 by Katsina State Government to overcome shortage of water and largely driven by economic needs while ecological consequences and anthropogenic inputs have received less attention with resultant effect on biotic life (KATARDA).

The research work was aimed to determine the physicochemical parameters and the distribution of its biota.

## **1.1 Statement of Research Problem**

About half a million people are living in Sabuwa Local Government Area. Most of these settlers depend on the reservoir for their socio-economic needs, irrigation farming and fishery. However, since the dam's construction, a lot of farming activities had sprang up around its surrounding catchment especially its banks. As a result of this, the livelihood of the people is been threatened at an alarming rate. The large population of people around the reservoir most of whom are farmers, sometimes use fertilizers and pesticides as well as domestic waste that collectively contaminate the water, causing pollution,

Also, there is no documented information on the physic-chemical characteristics of the reservoir, its productivity and biodiversity.

## **1.2 Justification**

No documented information with respect to Sabuwa reservoir despite its importance of providing drinking water, livestock farming, irrigation and fishing activity. There is therefore the need to carry out research with the aim of establishing baseline information and the actual status and potentials of the reservoir. The research will provide information on the limnology and water quality with the view to promoting the sustainable use of the reservoir for the benefit of both human and animal communities.

The study will provide information on the levels of pollution, by determining the physic-chemical parameters of the reservoir. The research will also provide information on macrobenthic invertebrates of the reservoir. Also, effective management practices are usually not given due attention, it is in line with this that this research work is been initiated.

## **1.3 Aim**

The aim of this research is to determine water quality status, zooplankton, phytoplankton and macro-invertebrates composition of Sabuwa reservoir.

#### **1.4 Objectives**

1. To determine the physicochemical characteristics of the Sabuwa reservoir in dry and rainy seasons.
2. To evaluate the distribution of zooplankton, phytoplankton as well as macro-benthic invertebrate in the reservoir.
3. To determine the seasonal variation of physico-chemical parameters in relation to benthic macro invertebrates of Sabuwa reservoir.

#### **1.5 Hypotheses**

1. There is no significant difference in physicochemical parameters with season.
2. There is no significant difference within the population of zooplankton and phytoplankton between sampling stations and seasons.
3. There is no significant relationship between benthic macro invertebrates and the water quality parameters.

## CHAPTER TWO

### 2.0

### LITERATURE REVIEW

The quality of any water body is influenced by physical and chemical factors. These physico-chemical parameters interact with one another and with more than one parameters at a time to greatly influence the water quality characteristics (Balarabe, 1989). Therefore, there is need to understand the factors that influence survival and distribution of diverse species of organism in water bodies. Monitoring of biological and physic-chemical characteristics of water body is essential for both short term and long term trend (Stent, 1981). Kusmalet *al.*, (1988) states that there is great diversity in the composition of plankton not only in different seasons and at different depths, but also at different hours, and probably even in different years in the same place and depth. As stated by Barlow *et al.*, (2006) the phytoplankton is a stable food supply for zooplankton and pelagic fish. They pointed out that diatoms blooms provide a food supply for large copepods, which are the preferred prey for anhovya (*Engraulis encrasicolus*). Both phytoplankton and zooplankton are used in various ways as indicators of water quality, especially of eutrophic waters which is essentially determined by the quality of algae. According the Pannardet *al.*, (2007), depending on the season, the phytoplankton responses differ with respect to nutrient and light conditions and to the intensity of stratification and mixing.

Bankole and Omorunkoba (1992), suggested that quantitative and qualitative assessment of water bodies along with background information for optimum use and exploitation of these resources are vital. Morpho edaphic index (M.E.I) is a good measure of potential lake productivity (Wade and Anadu, 1981). It is the ratio of the total dissolved

solid to average depth. The phytoplankton population was generally abundant during the day time than at night. Phytoplankton and zooplankton form the first and second step of food chain in an aquatic ecosystem. Studies by Boyd *et al.*, (2000) have shown that the mineral element iron can cause increased blooms of many kinds of phytoplankton.

## **2.1 Influence of Physico-chemical Parameters on Aquatic Organisms'**

### **2.1.1 Water Temperature**

Jonasson *et al.*, (1990) reported that the main abiotic factors which determine the suitability of an environment were temperature and dissolved oxygen. Most fishes get their bulky food from planktons and temperature fluctuations affect planktons distribution. Ridly and Steel (1975) reported that respiration, photosynthesis and nutrient uptake are temperature dependent. Temperature can also influence egg development time, growth rate, size and mortality of zooplankton (Orchutt and Porter, 1983). Fish adjust their body temperature and metabolic rate by moving into cooler or warmer water.

### **2.1.2 Water Depth**

Ashton and Schoema (1983) showed that electrical conductivity and concentration of major ions increase with water depth. The relationship between mean depth and conductivity known as morpho-edaphic index (M.E.I) can be used to calculate the productivity of a lake. Temperature generally decreases with depth.

Cominet *et al.*, (1983) showed water level fluctuations to be inversely related to temperature. It is generally believed that shallower lakes are more productive than deep

lake. Siltation has also been a major problem to lentic habitat as it seriously reduces the depth of these lakes (Bakoet *al.*, 2005).

### **2.1.3 Transparency (Secchi Disc)**

This is the amount of light that can penetrate a given water body. Turbidity in water reduces light penetration which may lower the rate of photosynthesis. Large amount of particles in suspension can cause decrease in algal production due to reduction in light penetration and can also affect respiratory and locomotory organelles of zooplanktons (Patricia and Paul, 2002). High turbidity could also be due to planktonic organisms or clay particles (Kolo and Oladimeji, 2004).

Adeniji (1989) showed that flood water during the rainy season that fill up these man-made lakes after the draw down are usually turbid and this reduce the transparency of the lakes' water. Successive fish culture depends largely on the efficient utilization of incident light Adeniji, (1985) in studying the Jebba lake concluded that transparency is one of the factors that control pelagic production.

Light penetration is very essential in our lakes because photosynthesis depend largely on it.

### **2.1.4 Water pH**

pH is the measure of the acidity or alkalinity of water. Low pH creates a stress situation in most organisms resulting in a decrease in metabolism. Oladipo and Williams (2003) opined that a pH range of 6.5-9.0 is suitable for maximum growth and abundance of phytoplankton.

Kemdrin (2000) also showed that maximum pH values coincided with period of high phytoplankton activity as a result of depletion of carbondioxide by photosynthetic activity of the phytoplankton. Godfrey (1972) stated that increase in acidity, decrease species diversity.

Temperature and solar radiation accelerates photosynthesis, which in turn increase carbondioxide absorption altering the bicarbonate equilibrium and producing OH<sup>-</sup> thus raising the pH (Chapman and Kimstach, 1996).

### **2.1.5 Electrical Conductivity**

This is the measure of the amount of ions present in a water body and this can be used to measure the productivity and fisheries potential of water body. Conductivity is a general indicator of water quality (Thomas *et al.*, 1996).

Ashton and Schoeman (1983) showed that electrical conductivity and ion concentration in lakes increase with depth. Kimstsach (1996) report that conductivity of most freshwater range from 10-1000 $\mu\text{scm}^{-1}$  but may exceed 1,000 $\mu\text{scm}^{-1}$  especially in polluted waters or those receiving large quantities of land run-off.

### **2.1.6 Water Hardness**

Hardness generally indicate water type, buffering capacity and productivity. Saki (1982) reported that softwater has low buffering action while hard water has high buffering action. Softwater is mostly neutral to acidic while hardwater is alkaline.

Hardness is important in fish culture because it allow fishes to grow well. Some fish species such as cat fish do not grow well in water deficient of hardness (Buttner *et al.*, 1993).

Betram and Balance (1996) also noted that seasonal variation in water hardness often occur, reaching the highest level during low flow conditions and lowest value during flood.

### **2.1.7 Dissolved Oxygen (DO)**

Dissolved oxygen is essential for the metabolism in all aquatic organism that possess aerobic biochemistry and it is commonly taken as indicator of potential production of primary production (Wade, 1985).

The high level of oxygen in water is a positive sign for the health and stability of the aquatic ecosystem, while its absence is a signal of severe pollution. Volume of oxygen increases as temperature decreases. Decrease in oxygen concentration can be attributed mostly to respiration by plants, animals and abiotic bacterial decay (Cole, 1979). Concentration below 5mg/l may adversely affect the functions and survival of biological communities and below 2mg/l can lead to death of most fishes (Chapman and Kimstach, 1996).

### **2.1.8 Biochemical Oxygen Demand**

Biochemical oxygen demand (BOD) measure the level of organic pollution. It show biochemically degradable organic matter present in a sample (Deas and Orlob, 1999).

Microorganisms use oxygen dissolved in water which is their source of carbon for biochemical oxidation of organic matter. Where there is high pollution, most of the dissolved oxygen is used with the resultant effect on the living biota.

### **2.1.9 Carbondioxide**

Carbondioxide is readily soluble in water. Carbondioxide is produced within water bodies by the respiration of aquatic biota and anaerobic heterotrophic decomposition of suspended and sedimented organic matter (Bertram and Balance, 1996).

### **2.1.10 Nitrate – Nitrogen**

The major source of nitrogen is from atmospheric nitrogen which is available in water as a result of diffusion at the air-water interface from run-off on agricultural activities by the nitrogen fixing ability of some species of bacteria and blue green algae (Lind, 1979).

Osborne *et al.*, (1980) attributed lower summer nitrate-nitrogen concentrations to leaching of the nitrate formed during mineralization of soil organic matter in autumn and winter. High concentration of nitrates-nitrogen may be a healthy hazard to juvenile mammals. Nitrates are reduced to nitrites in the digestive system.

### **2.1.11 Phosphate – Phosphorus**

Phosphorus stimulates growth of aquatic organisms (Wade, 1985). Phosphorus is one of the essential elements of living organisms because it is associated with energy transfer. Eutrophication of the lake is attributed to the external input of phosphate which is

the most important factor in the regulation of phytoplankton production (Vollenweider, 1975).

Brain (1989) noted that the sum of all the forms of phosphorus is a renewable measure of the fertility of a lake.

### **2.1.12 Alkalinity**

Chapman and Kimstach (1996) reported that the presence of carbonates ( $\text{CO}_3^{2-}$ ) and bicarbonates ( $\text{HCO}_3^-$ ) influence the hardness and alkalinity of water. Alkalinity in excess of 300mg/l does not adversely affect fishes but interferes with actions of certain commonly used chemicals, e.g. copper, sulphate (Buttner *et al.*, 1993). Water with low alkalinity ( $<24\text{mg}^{-1}$  of  $\text{CaCO}_3$ ) have low buffering capacity and can therefore be susceptible to alteration in pH.

## **2.2 Biological parameters**

### **2.2.1 Phytoplankton**

The phytoplankton are assemblage of small plants whose power of movement is insufficient to prevent them from being moved by water currents. According to Bidanna and Benner (1997), one of the main sources of carbohydrates in many aquatic systems is phytoplankton, where biomass is typically made up from 15 to 35% carbohydrate. The phytoplankton are the primary sources of food upon which the zooplankton and other aquatic organisms depend.

As stated by Barlow *et al.*, (2006), the phytoplankton is a stable food supply for zooplankton and pelagic fish. The quality of water, especially of eutrophic waters is essentially determined by the quantity of algae. Most of the nutrition of phytoplankton is derived from dissolved chemicals in water and therefore they should indicate the chemical environment (Kigamba, 2005).

Barone *et al.*, (1990) stated that plankton size, structure and species diversity are related to trophic state of water bodies. Phytoplankton do not only produce oxygen, but also uses ammonia produced by fish as nutrients (Swann, 2004). The phytoplankton are responsible for a percentage of all primary production in any given water body.

### **2.2.2 Zooplankton**

The zooplankton grazes upon the phytoplankton. Therefore, the availability of phytoplankton directly affects the abundance and distribution of zooplankton. Various workers Fermin, (1991); Ovie *et al.*, (1993) had highlighted the importance of zooplankton as fish food. Rotifers, copepods and cladocera are main group of zooplankton. Hanezato and Suno, (1985) concluded that temperature and food production are the most important factors controlling the density and production of zooplankton.

Certain zooplankton species have been used as indicators of apparent and subtle changes in the quality of freshwater ecosystems (Gibbons and Funk, 1982). Goldman and Horne (1987) reported the vertical migration to deep water during day light and the tendency to be transparent, reduce predation on zooplankton by fish and other sight-feeding predators.

### **2.2.3 Benthic Macro-invertebrates**

Benthic macro-invertebrates play a vital role in the circulation and recirculation of nutrient in aquatic environment. It was recognized by Wetzel (1983) that the composition, abundance and diversity of benthos can be modified overtime by continuous and or increased artificial eutrophication of an aquatic ecosystem. As a result, these organisms have been found useful and reliable as biological indicators of the quality of the water.

Composition and abundance of benthos vary spatially due to several factors among which the most important are the physicochemical characteristics of the sediment associated with depth and the speed of water current (Wetzel, 1983). Morgan (1988) suggests that water speed in excess of 2-3m/s inhibit the development of benthos in any water channel. The role of benthos as fish food is well known.

## CHAPTER THREE

### 3.0 MATERIALS AND METHODS

#### 3.1 Study Area

Sabuwa reservoir is about 42km from Funtua town in Katsina State. It covers about 30 hectares with about 11.10 million cubic meters water capacity.

Sabuwa reservoirs is located at latitude  $11^{\circ}14'N - 11^{\circ}24'N$  and longitude  $6^{\circ}10'E - 6^{\circ}14'E$ . The dam was impounded in 1980 and commissioned in 1982. About half a million people depend on the dam for their water supply, livestock farming, irrigation and fishing (Katarda, 1983). There is also the spill over from farmlands into the reservoir.

#### 3.2 Sampling Stations

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 with a depth of 78cm.

Station 2: At the tower point where there are less human activities with a depth of 120cm

Station 3: At the deepest part of the reservoir with a depth of 369cm and station 4 and 5 at the longest arm of the reservoir with a depth of 188cm and 177cm respectively. Distance between station 1 and 2, 2 and 4 and 5 and 1 were 60m while distance between 3 and other stations was 40m (Fig 3.1).

The sampling procedure used during the research work involve duplicate collection of water at each station. In this method, water was sampled at surface level by dipping 1

litre plastic sampling bottle sliding over the most upper surface of the water with their mouth against the water current to permit undisturbed passage of water into the bottle. Water samples were then transported to the laboratory for the analysis of physic-chemical and biological parameters.

### **3.3 Experimental Design**

The research was a year duration (March, 2012 – February, 2013). The research involve a monthly sampling for all physico-chemical parameters and biological parameters throughout the period of the research. Water samples were collected between the hours of 6 and 7 as described by Burns *et al.*, (1999).

### **3.4 Physico-chemical Parameters Studied**

#### **3.4.1 Water temperature**

Hannan instrument model H198129 was used to measure the temperature. Water temperature was measured when the electrode was submerged in the water to be tested for 1-2 minutes. The measurement was taken when the stability symbol O on top of the ICD disappears.

#### **3.4.2 Water depth**

A calibrated measuring rod weight at one end was used to measure the average water depth at each station.

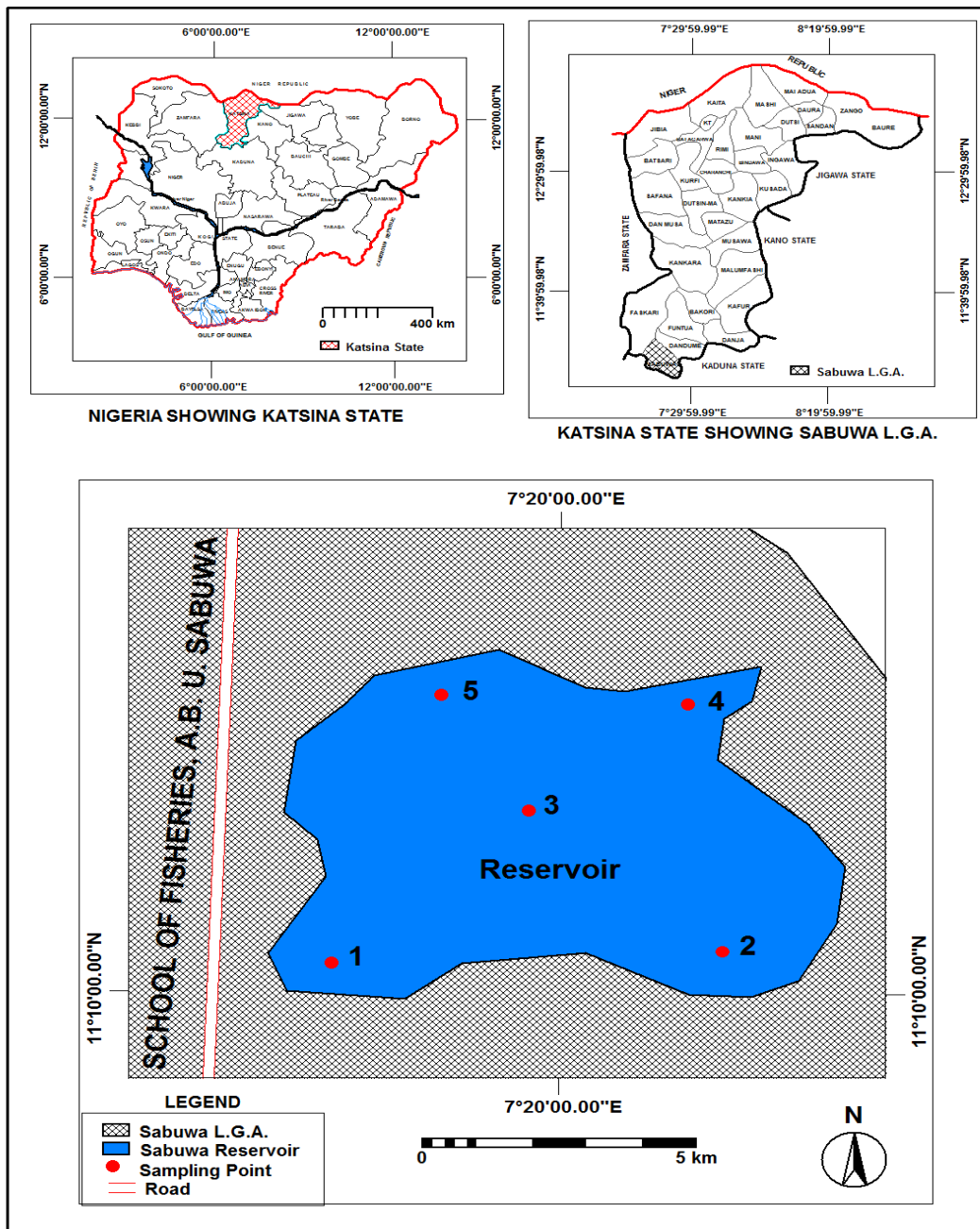


Fig. 3.1. Map showing Sabuwa reservoir and the sampling points  
 Source: Adapted and modified from Katsina State map  
 3.4.3 Water pH

Hannan instrument model H198129 was used to measure the temperature of each sample by inserting the electrode into the water for 1-2 minutes. The measurement was taken when the stability symbol O in the top left of the secondary ICD disappears.

#### **3.4.4 Electrical conductivity**

Hannan instrument was used to measure the electrical conductivity of each sample. The electrode was inserted into the water and the reading was taken when the stability symbol O on the top left of the ICD disappears. Plastic beakers were used to minimize any electromagnetic interference.

#### **3.4.5 Transparency**

This was determined by the use of a 25cm diameter Secchi disc. The procedure involves lowering the Secchi disc into the water at each station until it ceases to be visible. The depth of appearance and disappearance were measured to the nearest cm and the average taken.

#### **3.4.6 Hardness**

Hardness was determined by diluting 25mls water sample to 50ml with distilled water. Two millimeter (2ml) of buffered water solution and 0.1g of Erichrome black T-dye was then added followed by EDTA-titrant drop until a blue colour end point was observed. The calculation was based on the equation by Lind (1979) and APHA (1995).

EDTA hardness (mg/l-CaCO<sub>3</sub>) = M/titran x 40

### 3.4.7 Biochemical oxygen demand

For the determination of biochemical oxygen demand, 100ml of water sample were incubated for five days at room temperature (25°C) in the dark after addition of 2ml each of manganese chloride solution and Winkler reagent, the resultant precipitate was then dissolved by the addition of 2ml concentrated H<sub>2</sub>SO<sub>4</sub>. The differences obtained between the initial dissolved oxygen and the final dissolved oxygen concentration obtained after five days at three days. BOD is expressed in milligrams per litre of the sample (Markereth, Herow, Tailing (1978), Lind (1979) and APHA, (1985).

$\text{BODmg}^{-1} = \text{Dissolved oxygen on day} - \text{Dissolved oxygen on days.}$

$$\text{BODmg}(\text{MgL}^{-1}) = x - Y\text{mgL}^y$$

### 3.4.8 Dissolved oxygen

This was determined by the modified Winkler azide method (Lind, 1979 and APHA, 1995). Duplicate water samples were collected in 25ml BOD stopper bottles, they were then fixed in the field with 2ml manganese sulphate (MnSO<sub>4</sub>), this was followed by the addition of 2ml alkaline-iodine azide and 2ml concentrated sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) was added. In the laboratory, 100ml of sodium thiosulphate was added until it turned pale yellow, then 1ml of starch solution was added which turned the solution to blue colour. The titration continued until the blue colour disappeared. The volume of thiosulphate titrate used is equivalent to milligram of dissolved oxygen per litre (Lind, 1979).

$$\text{DO}_2 = \frac{1000 \times 8 \times n \times v^{-1}}{v}$$

Where  $v^{-1}$  = volume of thiosulphate used (titre value)

n = normality of thiosulphate (0.0121N)

v = volume of sample used (200ml)

### **3.4.9 Chloride**

This was carried out using the method described by Lind (1979) and Alpha, (1995). In this method, 100ml of water sample was measured into 250ml conical flask and 1ml of potassium chromate was added and titrated with silver nitrate solution, until the colour changed from yellow to brown. It is expressed in milligram per litre (mg/l).

### **3.4.10 Calcium**

The procedure applied for the determination of calcium ion concentration was described by ALHPA (1995). 50ml of water sample was measured into a conical flask and 2ml of NaOH solution was added and a pinch of meroxide indicator and titrated with 0.1MNa<sub>2</sub>EDTA solution until the colour changed from purple to violet. Calcium ion was obtained using this formula;

Milligram per litre  $A \times B \times 400.8 = \text{volume of sample}$

Where A = MI of titrant (EDTA) B = 1.0ml. ALPHA (1995).

### **3.4.11 Iron**

In this method, 100ml of water sample was mixed with 100ml acid solution (mixture of 3:1 concentrated HCl and concentrated HNO<sub>3</sub>) and immersed in waste bathe

(90°C) for 30 minutes followed by analysis with atomic absorption spectrometer (A.A.S.), Model A.A.S 2010 (APHA, 1995).

#### **3.4.12 Magnesium**

This was determined by using spectrophotometer model Hatch 2010 as described by ALPHA (1995) and Lind (1979).

#### **3.4.13 Nitrate Nitrogen (NO<sub>3</sub> – N)**

The procedure employed was that described by the United States Environmental Protection agency (1979) using hatch model 2010 spectrophotometer. 100ml of water sample was filtered by suction to remove turbidity as described by ALPHA (1995). Two test tubes were then placed on a metal rack, each to which 7.0ml of the filtered water sample whose pH has been adjusted to 7+02 was added, another two separated test tubes were each allotted with 7.0ml of similarly tested solution of 100mg/l potassium nitrate as standard. Then two test tubes were also treated but with 1.00mg/l potassium nitrate as the standard B. A pair of test tubes were used as a reagents blank.

#### **3.4.14 Phosphate-Phosphorus**

The determination of phosphate ion concentration was done as described by USEPA (1979) using HatchDR-EL2010 model spectrophotometer, 50ml of the filtered sample was transferred into each of the two 125ml capacity conical flask. Two other flasks of the same capacity, containing 50.0ml each of 50l/l phosphate solution as standard A and another similar set each containing 5.0ml/k phosphate solution standard B. However, two additional flask were made available to contain blank using distilled water.

To each flask, 1.0ml of 1M  $\text{NH}_2\text{SO}_4$  was added. This mixture 0.4g of ammonium persulphate was also added. The solutions were gently boiled on a preheated hot plate until each reaches a volume of about 10ml, the pH values of the solution were adjusted to 7-02, maintained by a gradual addition of 1M NaOH solution using Swiss made metro/m model 620 electrode pH meters. Each of the flask content was then finally diluted to approximately 50ml with distilled water. To each of the flask, 4ml of ammonium phosphate solution was added and mixed, Followed by addition of 2.0ml of ascorbic acid and finally mixed. After about 5 minutes, the absorbance for each titrate sample was spectrophotometrically observed at a wavelength 650nm, by placing 25ml solution into sample cell to the mark and the reading were obtained from phosphate absorbance calibration scale. However, the standards and reagent blank were not similarly chemically treated, ALPHA (1995) and Lind (1979).

### **3.4.15 Total alkalinity**

In this method, 100ml of water sample was measured in 250ml conical flask and 3 drops of methyl red indicator solution was added and titrated with 0.1 $\text{NH}_4\text{Cl}$  until colour changes from red to yellow. The amount of acid used was recorded, this was repeated three times and the average volume of acid used was recorded.

Alkalinity concentration was calculated from the expression given below

$$\text{Alkalinity (methyl orange)} = A \times B \times 50,000 \times F$$

Where A = volume of acid used

B = molarity of the acid

F = (1.0ml for HCl)

### **3.5 Biological analysis**

#### **3.5.1 Phytoplankton sampling**

Phytoplankton was sampled from the reservoir with the aid of plankton net, (made of clothing with a fine aperture of 0.01mm, 25cm long and small bottle of 50ml capacity container attached to the narrow end of the net). It has an opening of about 20cm diameter. At each station, the net was toyed just beneath the water surface and towed for a distance of 5 meters at rowing speed.

The collected water samples were transferred to small plastic bottles and preserved in lugos iodine solution. The collection from each station was taken to the laboratory for identification. For the samples needed for dissolved oxygen determination, 2mls of Magnesium chloride and 2ml of Winkler reagent were added immediately before taken to the laboratory.

#### **3.5.2 Laboratory analysis of samples**

##### ***3.5.2.1 Identification of Phytoplankton***

The identification of phytoplankton was carried out by the use of keys and identification guide described by Palmer (1980), and Helley, (1992) and Mission Greek (2004).

### ***3.5.2.2 Counting phytoplankton***

For quantitative estimation, 1ml of the 50ml water collected was counted under the microscope and the number of algal cells expressed per litre. Identification was done using Prescott (1979).

Relative abundance of various taxa were calculated using the formula

$$N = a/b n$$

Where N = estimated number of species per sample

n = number of species in sub sample

a = volume of water sample (ml) (50ml)

b = volume (ml) of sub sample (1ml)

The abundance of taxa in each sample was calculated using the formula;  $D = N/V$

D = abundance of species (individuals per litre)

N = estimated number of species per sample

V = volume (litres) of water originally filtered, Wade (1985) and APHA (1995).

### ***3.5.2.3 Zooplankton Sampling and Analysis***

Zooplankton were collected using a silk plankton net of 20cm diameter and 70 $\mu$  attached with 50ml capacity bottle at base. At each station collection was done by sinking the net and towed through a distance of 5 meters. The sample was poured into plastic bottle

of 70ml capacity and preserved in 4% formalin. Counting was done by shaking the preserved sample and pipetting 1ml of it into SedgwickRafter counting and then mounted on a microscope for identification. Identification was carried out using various keys described Needham and Needham (1975), Wetzel (1975), Pennah (1978) and APHA (1995).

#### ***3.5.2.4 Benthic Macro Invertebrate Analysis***

Ekman grab model no 923, measuring 19cm by 14cm with an area of 0.266m<sup>2</sup> was used in collecting the macro benthic fauna from all the five stations. At each station, 3 grab were taken and bridge materials were washed through U.S. standard sieves number with 0.41mm mesh size. The residues were immediately transferred into labeled plastic storage bottle and preserved with 4% formalin prior to sorting out and identification. Sorting was done by pouring out content of each jar into separate large plastic basin. Enough water was picked with the aid of a pair of forceps or pipette as required. Dissecting and compound microscope was used in the identification of the specimen with the aid of the same keys as for zooplankton (Jeje and Fernando, 1986). Different groups of organisms were counted and preserved in 70% alcohol. All macro-invertebrates species were counted, identified to family and species level using available keys by Needham and Needham (1962) and Pearnak (1989).

### **3.6 Statistical Analysis**

ANOVA was used to determine the level of significance at  $p < 0.05$  among the parameters measured and DMRT was used to separate the means. Pearson correlation

coefficient was used to determine relationship between the different parameters. Statistical packages for social sciences (SPSS) version 20.0 software was used to analyze the data. Comparismwere made using ANOVA and T-test on log transformed values. Where there are significant differences at  $p = 0.05$ , the test was subjected to Fisher Protected LSD to determine the differences between the mean.

## CHAPTER FOUR

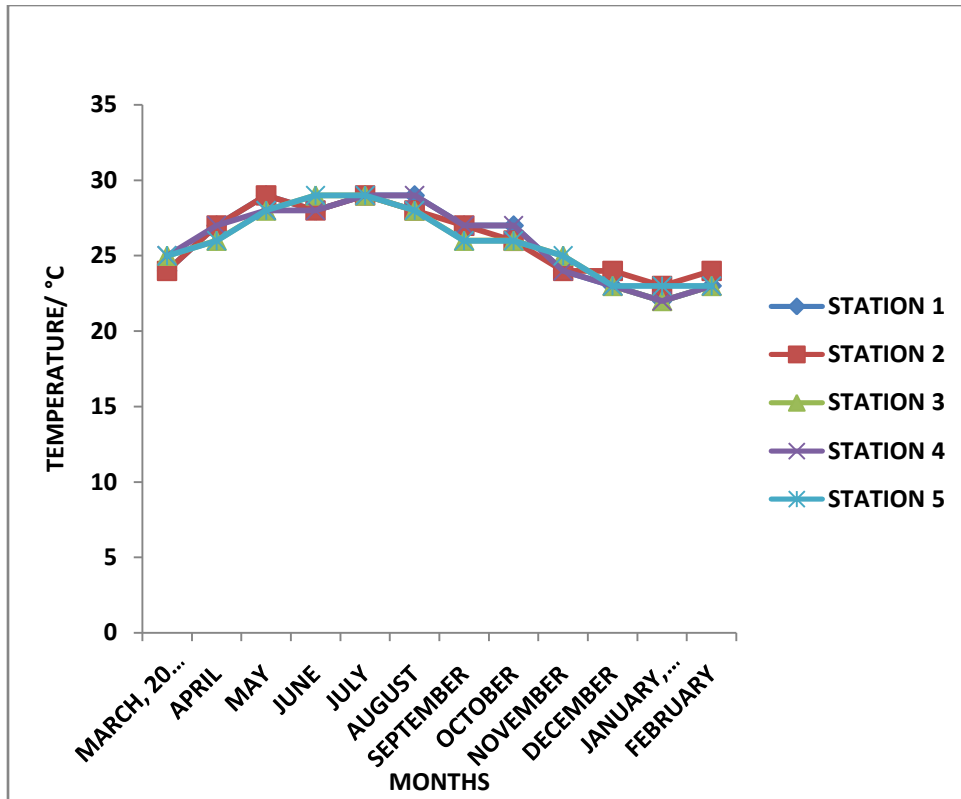
### 4.0

### RESULTS

#### 4.1 Water Temperature

Water temperature for the entire reservoir ranged between 22 to 29°C as revealed in Figure 4.1. Low temperatures were recorded between November to March (22°C – 25°C) and high temperatures between April to August (27°C – 29°C). The lowest temperature was recorded in January in station 1,3 and 4 (22°C), while the highest temperature of 29°C was recorded in station 1 and 4. Analysis of variance in Appendix I showed no significant difference between stations ( $p \geq 0.05$ ) but there was significant difference between seasons ( $p \leq 0.05$ ). There was no significant difference between season and stations ( $p \geq 0.05$ ). The month of March, April and May shows a gradual increase in temperature for all stations, while June/July form the peak with the exception of station 2. Lowest temperature was recorded in station 3 in August while November and December temperature were lowest for all stations. September, October, November and December showed a gradual decrease in temperature which was significantly different at  $p < 0.05$ .

Correlation coefficient analysis between temperature was found to correlate positively with transparency, conductivity, hardness, dissolved oxygen, phosphate-phosphorus, a negative correlation existed between water, temperature, calcium, biochemical oxygen demand.



**Fig 4.1: Shows the mean monthly variation of temperature in relation to months and stations.**

## 4.2 Water Depth

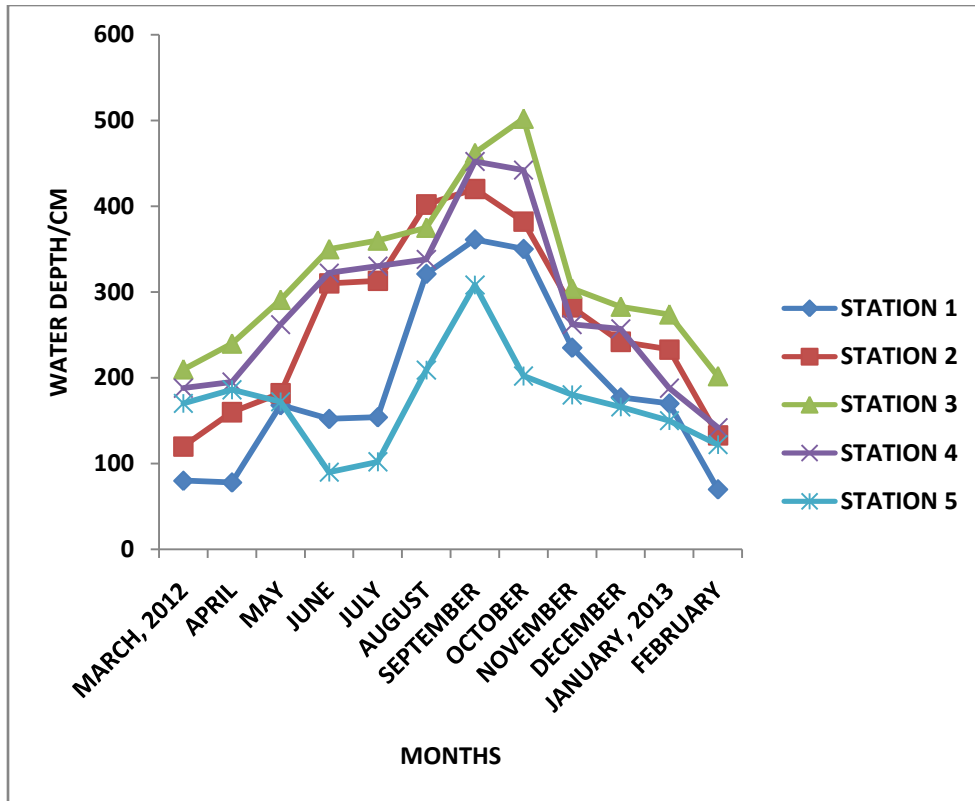
Sabuwa reservoir mean monthly variations in water depth were as presented in Figure 4.2. The minimum of 40cm was recorded in station 1 during the dry season in the month of March, while maximum depth of 462cm was recorded in the month of September in station 3 during the rainy season. Figure 3 showed the month of May, June and July shows a gradual increase in water depth while the month of August and September shows the highest peak of water depth in station 3 (462cm). Lowest water depth was recorded in dry season (40cm) in the month of March.

The analysis of variance in Appendix I showed significant difference between station and there was no significant difference between the season stations ( $p > 0.05$ ). Correlation coefficient analysis revealed highly significant correlation between depth and water temperature, nitrate-nitrogen but negative correlation with chloride, calcium, alkalinity and BOD.

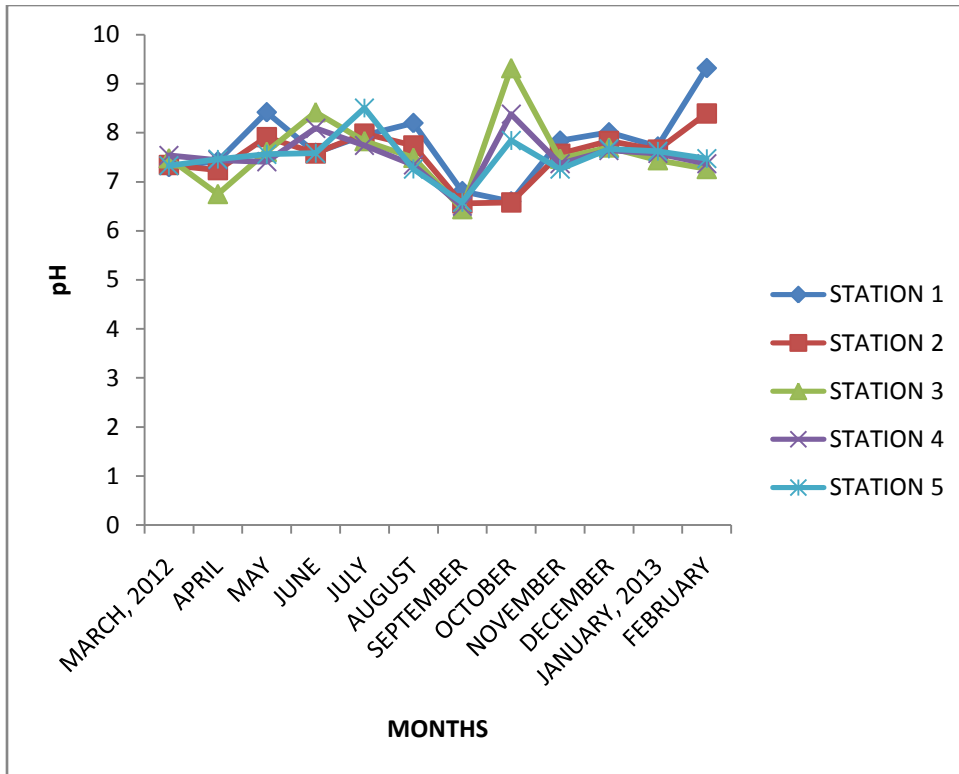
## 4.3 Water pH

The monthly variation of water pH of Sabuwa reservoir range from 6.4 to 9.3 as shown in figure 4.3. The dam is acidic during rainy season period, slightly alkaline with the onset of dry season months. Stations 3, 2, and 4 show highest pH values than stations 1 and 5.

Analysis of variance in Appendix I showed no significant difference between stations ( $p \geq 0.05$ ) but variation between season was significant ( $p \leq 0.05$ ) and no significant difference between stations and seasons ( $p \geq 0.05$ ).



**Fig 4.2: Shows the mean monthly variation of water depth in relation to months and stations**



**Fig. 4.3: Shows the mean monthly variation of pH in relation to months and stations**

Correlation coefficient analysis in Appendix VI revealed highly significant correlation between pH and conductivity, BOD, dissolved oxygen and negative correlation with temperature, magnesium and iron.

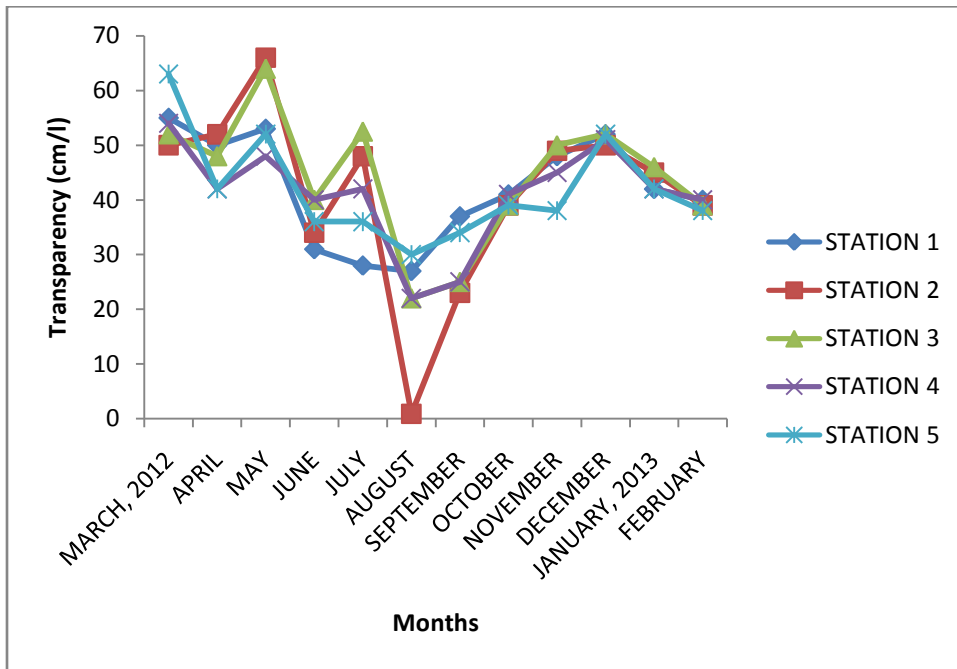
#### **4.4 Transparency**

The mean monthly variation for transparency in the five stations were presented in Fig 4.4. The lowest transparency of 0.9cm was recorded in station 2 in the month of August while the month of march recorded the highest value of 54cm. There was a progressive increase in turbidity from April through November, leading to a decline in transparency of the water as the season progresses with the month of August been the most turbid. Analysis of variance (Appendix I) showed no significant variation between season and stations ( $p \geq 0.05$ ). While there was significant difference between the seasons and stations.

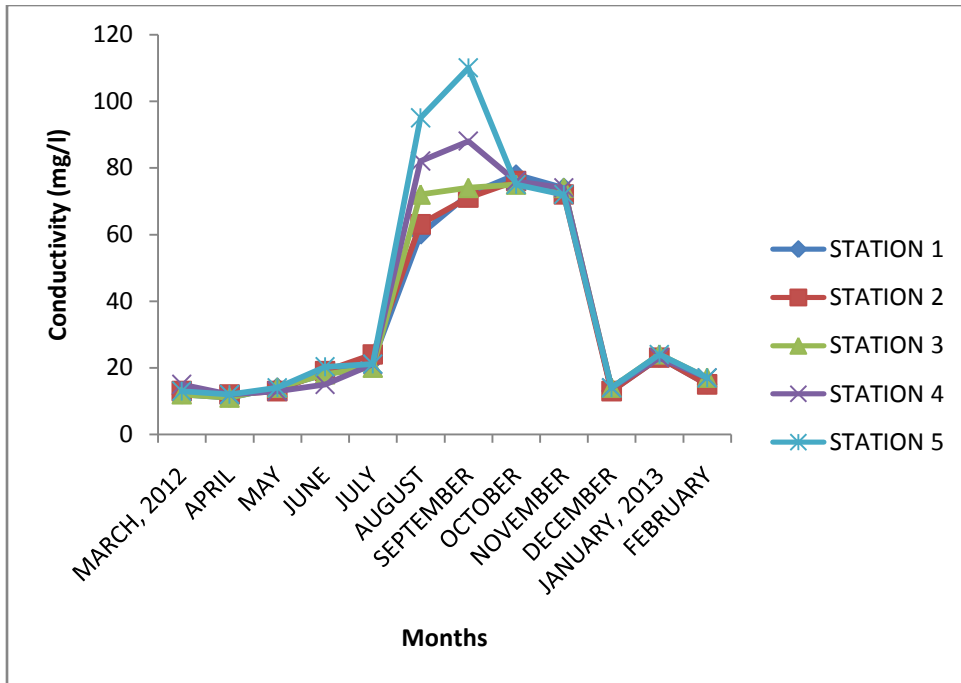
Correlation coefficient with other parameters revealed significant positive correlation with water hardness, BOD, dissolved oxygen, calcium and magnesium and negative correlation with depth was significant, in that as the water depth increases, the transparency decreases and vice versa.

#### **4.5 Conductivity**

The mean monthly variation of electrical conductivity in Fig. 4.5 showed variations in all the months. The conductivity of the reservoir was lower during the rainy season. The lowest conductance of  $11\mu/\text{cm}$  was recorded in station 3 in the month of March and it progressively built up to  $110\mu/\text{cm}$  in station 3 in the month of September.



**Fig. 4.4: Shows the mean monthly variation of transparency in relation to months and stations**



**Fig 4.5:Shows the mean monthly variations of conductivity in relation to months and stations**

Analysis of variance (Appendix I) revealed non significant variation between seasons stations and station by months ( $p < 0.05$ ). A highly significant variation however, existed between months ( $p < 0.05$ ). Correlation coefficient with other parameters, showed significant positive correlations with calcium and magnesium but correlate negatively with water, temperature, pH, dissolved oxygen, water depth respectively.

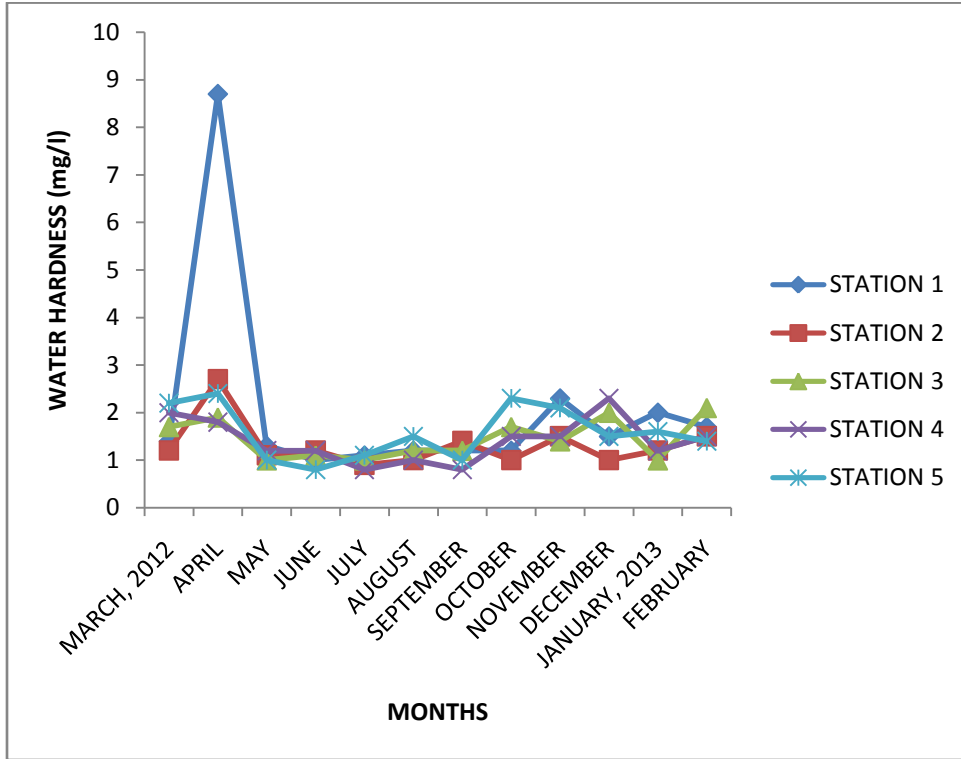
#### **4.6 Water Hardness**

The mean monthly variation in water hardness were as represented in figure 4.6. The values ranged from  $33\text{mg l}^{-1}$  to  $84.2\text{mg l}^{-1}$  obtained from June to August. Higher values were obtained during the dry season in station 3. Analysis of variance in appendix II showed no significant difference between stations and no significant difference between seasons and stations ( $p \geq 0.05$ ).

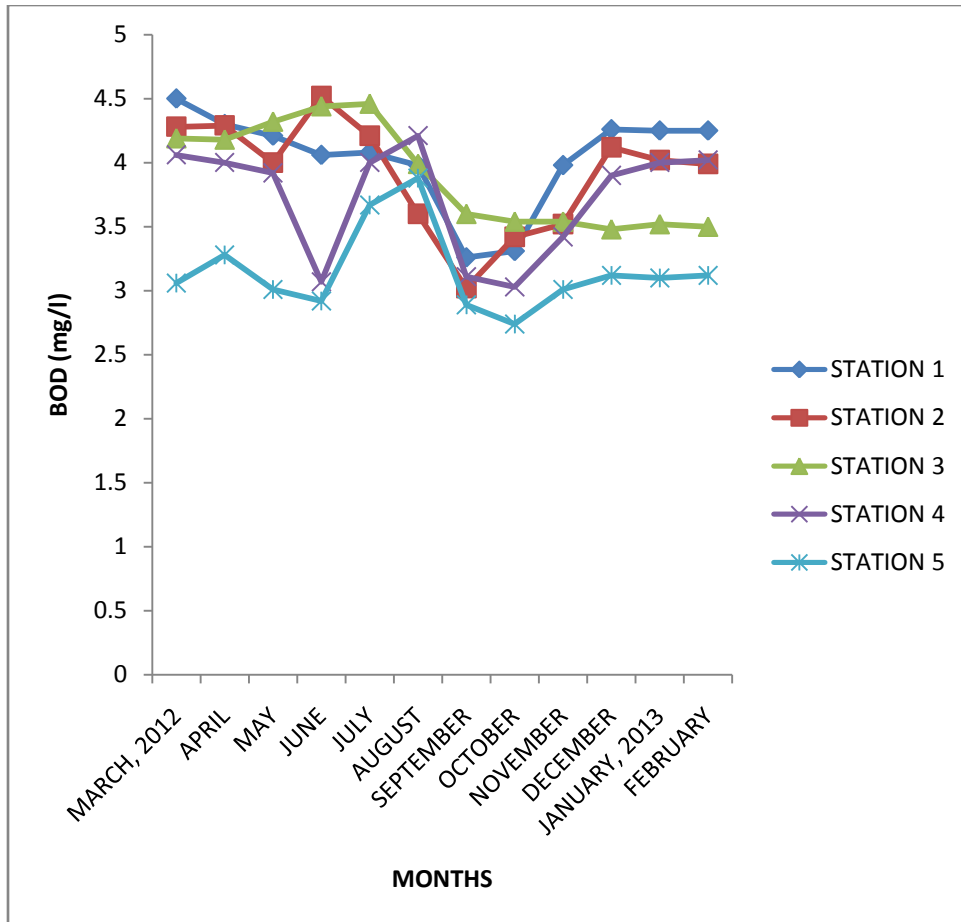
Correlation coefficient analysis in Appendix VI showed positive correlation between water hardness with conductivity, BOD, dissolved oxygen but negative correlation with magnesium, nitrate-nitrogen and alkalinity.

#### **4.7 Biochemical oxygen demand**

Biochemical oxygen demand of Sabuwa reservoir showed mean monthly variations as illustrated in figure 4.7. There were higher BOD values during the dry season than the rainy season. The highest value obtained ( $4.5\text{mg l}^{-1}$ ) was in March and the lowest value ( $3.02\text{mg l}^{-1}$ ) was in September. Stations 1, 2 and 4 showed higher BOD values than 3 and 5 respectively. Analysis of variance in Appendix II revealed there was significant difference between stations and no significant difference between seasons.



**Fig. 4.6: Shows the mean monthly variation of water hardness in relation to months and stations.**



**Fig. 4.7: Shows the mean monthly variation of biological oxygen demand in relation to months and stations**

Correlation coefficient analysis showed that there was positive and significant correlation between BOD and conductivity, calcium, magnesium but negative correlation between alkalinity, depth, transparency and iron.

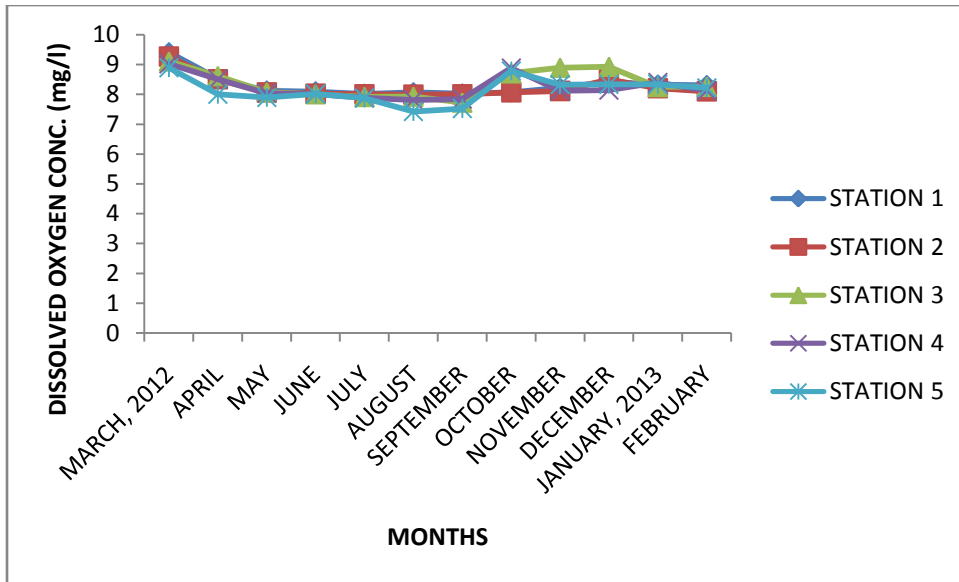
#### **4.8 Dissolved oxygen**

Higher mean value of dissolved oxygen was obtained in March ( $9.4\text{mg l}^{-1}$ ) and the lowest value was recorded in August ( $7.42\text{mg l}^{-1}$ ). Figure 4.8 reveal values of dissolved oxygen concentration was higher in the dry season than in the rainy season. The month of April, May and June showed a gradual decrease in dissolved oxygen for all stations while there was an increase in the month of October, November and December in dry season.

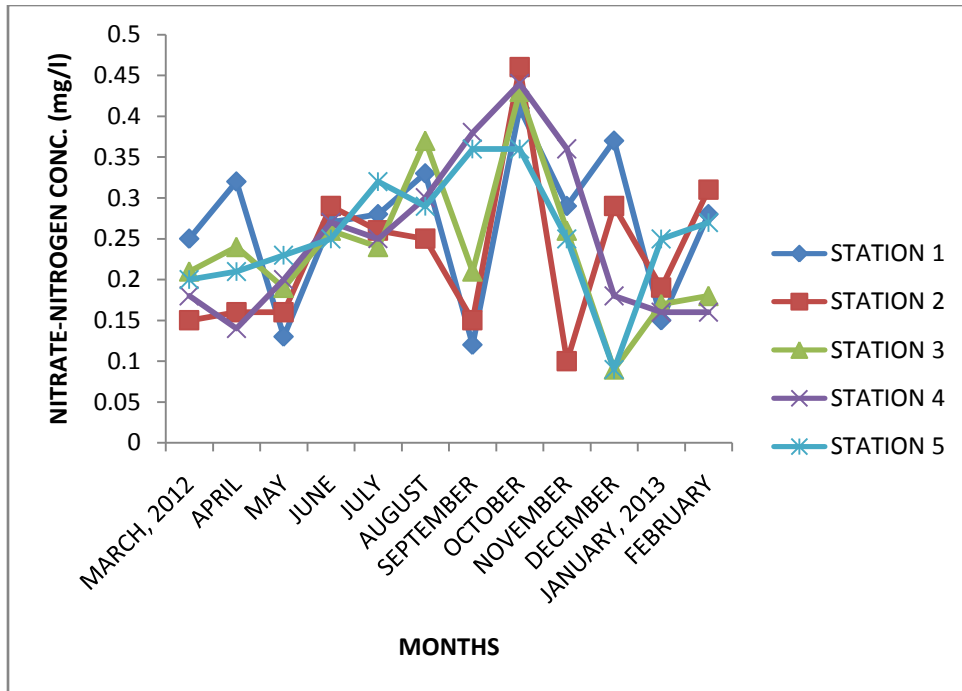
Analysis of variance in Appendix II revealed there was a significant variation of dissolved oxygen concentration between seasons ( $p \geq 0.05$ ) but no significant difference within stations. Correlation coefficient analysis showed that there was positive and significant correlation between dissolved oxygen with calcium and conductivity but a negative correlation with alkalinity, water depth and transparency.

#### **4.9 Nitrate-Nitrogen**

The values of nitrate-nitrogen in Sabuwa reservoir fluctuated throughout the period of study and it ranged from  $0.12\text{mg l}^{-1}$  to  $0.46\text{mg l}^{-1}$ . The lowest value of  $0.12\text{mg l}^{-1}$  was recorded in station 1 in the month of September, while the highest value was recorded in October ( $0.46\text{mg l}^{-1}$ ) in station 2. Stations 2 and 3 revealed highest concentration of nitrate nitrogen than stations 1, 4 and 5 as revealed in Fig 4.9.



**Fig. 4.8: Shows the mean monthly variation of dissolved oxygen in relation to months and stations**



**Fig.4.9: Shows the mean monthly variation of nitrate-nitrogen concentration in relation to months and stations**

Result of analysis of variance in Appendix II revealed that there was no significant variation between stations but there was significant difference between seasons ( $p \geq 0.05$ ). Correlation coefficient analysis between nitrate-nitrogen with pH, hardness, alkalinity, conductivity and dissolved oxygen but a negative correlation with BOD, calcium and water depth.

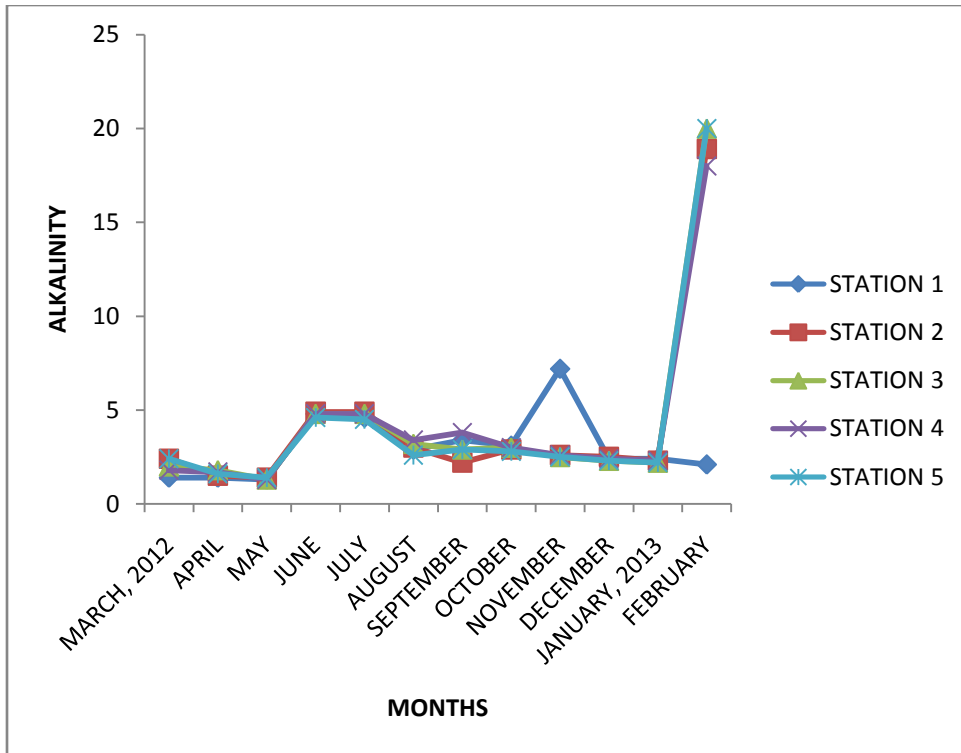
#### **4.10 Alkalinity**

Alkalinity values were found the range from  $1.3\text{mg l}^{-1}$  to  $4.9\text{mg l}^{-1}$ . Highest values of alkalinity were recorded during raining season than in dry season. The months of June and July showed gradual increase of alkalinity in stations 2 and 4, while a decrease in the month of dry season as revealed in fig 4.10. Analysis of variance revealed that there was no significant difference ( $P \leq 0.05$ ) within the stations and there was significant difference between the two season ( $P \leq 0.05$ ) and no significant variation between the stations and the seasons was observed ( $P \geq 0.05$ ).

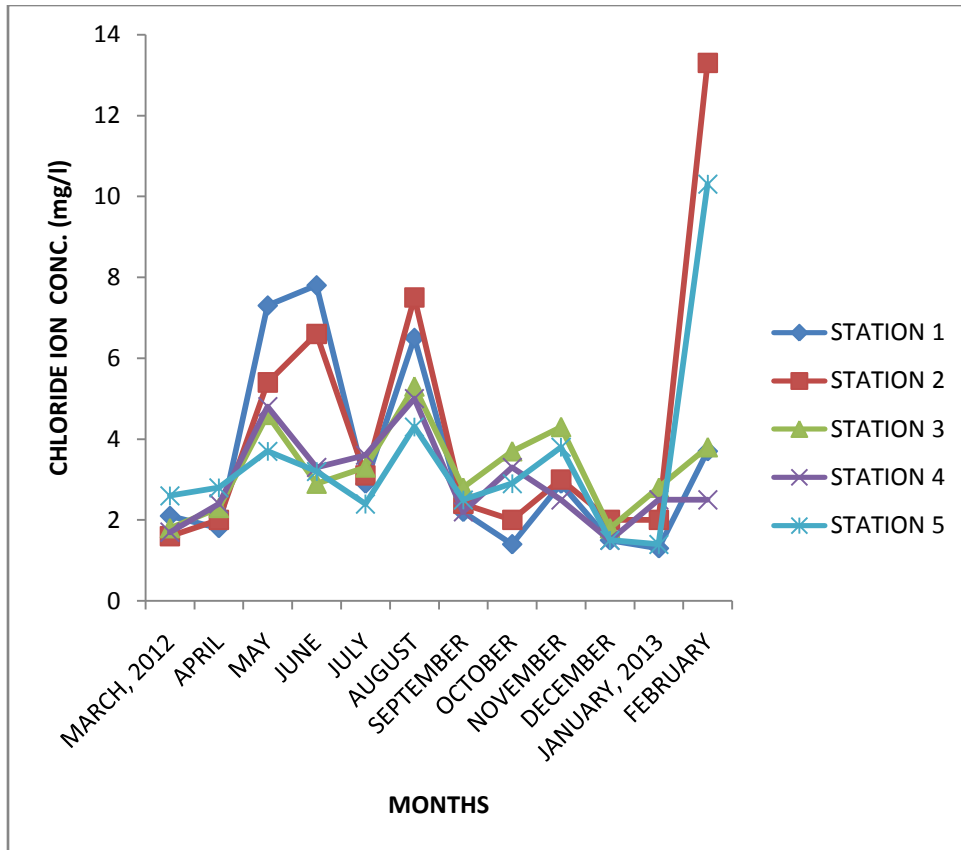
Correlation coefficient showed that there was positive correlation with water pH, temperature, dissolved oxygen and conductivity but negative correlation exist with water depth.

#### **4.11 Chloride**

The highest chloride value was observed in March with  $7.8\text{mg l}^{-1}$  in station 3 during the dry season. The lowest value of  $1.4\text{mg l}^{-1}$  in October during rainy season. Highest chloride concentration was recorded in stations 2 and 3 in the months of dry season and the lowest was recorded in stations 1 and 4 as shown in Fig 4.11. Analysis of variance in



**Fig. 4.10: Shows the mean monthly variation of alkalinity in relation to months and stations**



**Fig. 4.11:** shows the mean monthly variation of chloride ionin relation to months and stations

Appendix II revealed significant difference of chlorides ion concentration between the seasons ( $P \geq 0.05$ ) and no significant difference in chlorides ion concentration between stations ( $P \geq 0.05$ ) and stations by seasons.

The correlation coefficient in Appendix VI showed positive correlation between chlorides ion with conductivity, calcium but negative correlation was observed with water depth, turbidity and dissolved oxygen

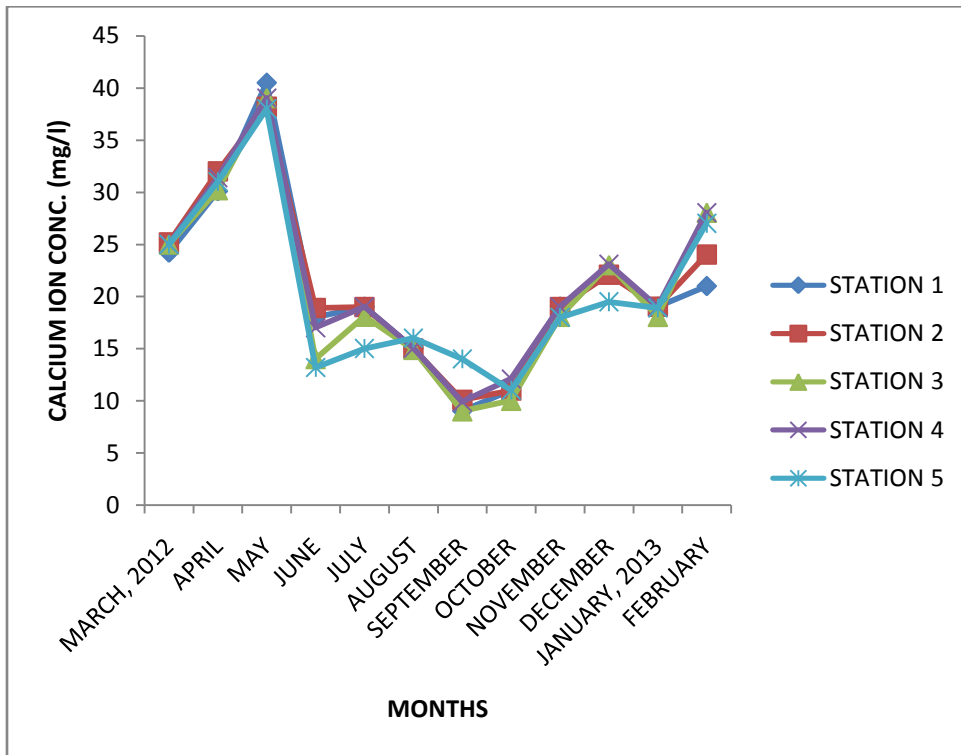
#### **4.12 Calcium**

The highest value of  $40.5\text{mg l}^{-1}$  was recorded in the month of May and the lowest value in September, with  $9.02\text{mg l}^{-1}$  as shown in Fig. 4.12. The result indicated higher values of calcium ions are obtained in the dry season than in rainy season. Station 2 and 4 show higher values than stations 1, 3 and 5 respectively. Analysis of variance in Appendix II revealed no significant difference between stations, seasons ( $p \geq 0.05$ ) and interaction of station by season at ( $p \geq 0.05$ ) respectively.

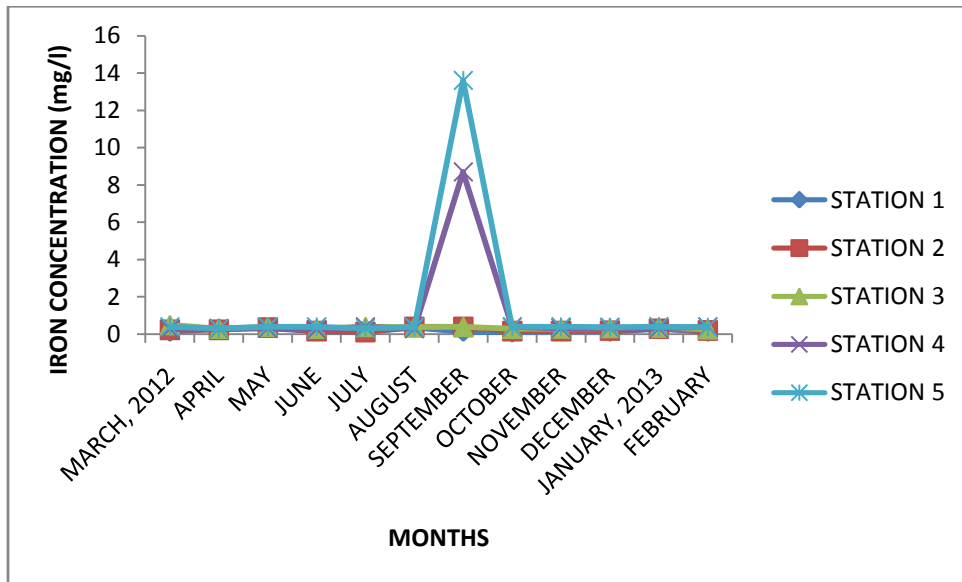
Correlation coefficient in Appendix VI showed positive and significant correlation between calcium ion concentration with pH, dissolved oxygen and water depth but was negative with nitrate-nitrogen and water temperature ( $p \geq 0.05$ ).

#### **4.13 Iron**

The values of iron concentration across the stations of Sabuwa reservoir showed slight variation. The highest value was obtained during the rainy season ( $0.39\text{mg}^{-1}$ ) and lowest in dry season ( $0.13\text{mg l}^{-1}$ ) as revealed in Fig 4.13.



**Fig 4.12: Shows the mean monthly variation of Calcium ionin relation to months and stations**



**Fig. 4.13: Shows the mean monthly variation of iron in relation to months and stations**

The result of the analysis of variance revealed that there was significant difference in the seasonal occurrence of iron concentration between stations.

Correlation coefficient in Appendix VI showed that there was a positive correlation between iron concentration with conductivity, water depth, hardness and calcium ion but negative correlation between iron concentration with BOD and dissolved oxygen.

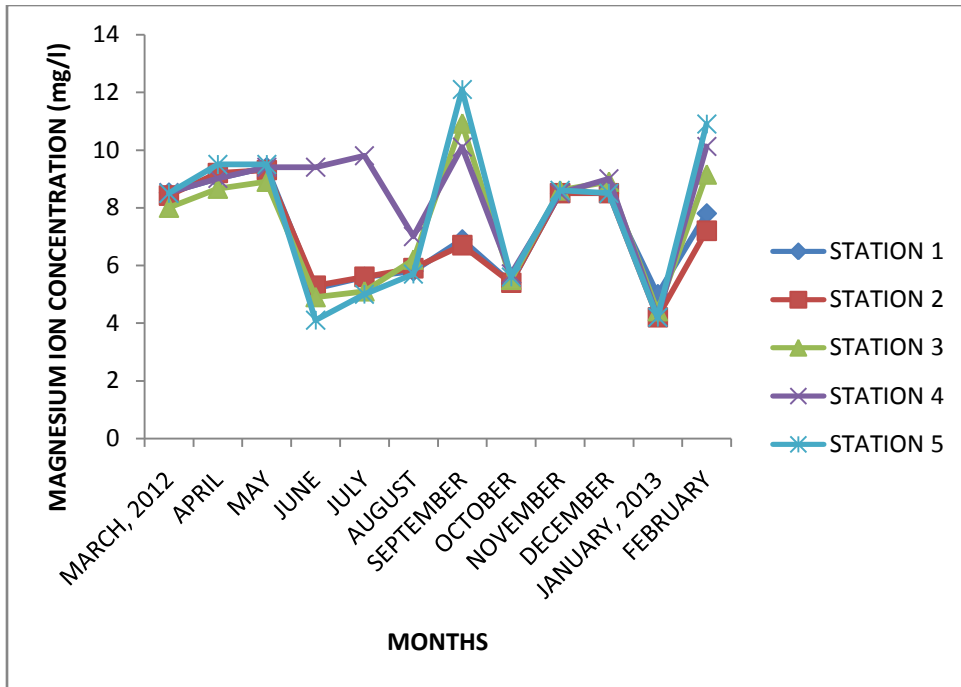
#### **4.14 Magnesium**

The mean monthly magnesium ion concentration revealed high magnesium ion concentration in the month of February ( $10.12\text{mg l}^{-1}$ ) and lowest ( $3.7\text{mg l}^{-1}$ ) in rainy season as shown in Fig 4.14. Stations 4 and 5 show higher values of Magnesium ion concentration than stations 1, 2 and 3. The result of analysis of variance showed no significant difference within the station and seasons ( $p \geq 0.05$ ).

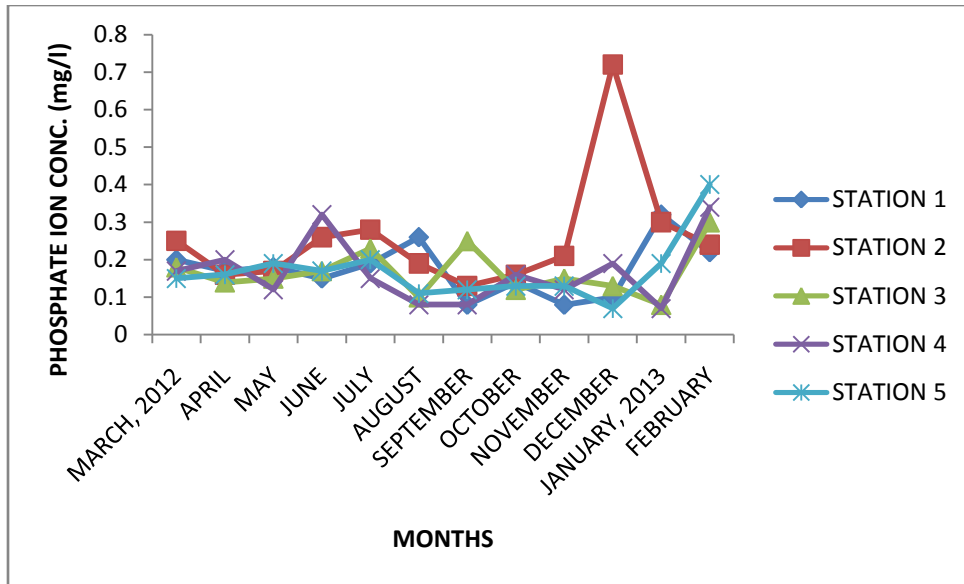
Correlation analysis in Appendix VI revealed positive correlation of magnesium ion with pH, dissolved oxygen, BOD and conductivity but negatively with nitrate ions, water depth and iron.

#### **4.15 Phosphate-phosphorus**

The mean monthly variation of phosphate-phosphorus was represented in figure 4.15. The maximum phosphate ion concentration was observed during the rainy season in the month of October ( $0.40\text{mg l}^{-1}$ ) and dry season recorded the lowest value of  $0.10\text{mg l}^{-1}$  in the month of February. Stations 2 and 4 revealed maximum phosphate ion concentration than stations 1, 2 and 5. Result of analysis of variance revealed no significant difference



**Fig. 4.14: Shows the mean monthly variation of Magnesium ionin relation to months and stations**



**Fig. 4.15: Shows the mean monthly variation of Phosphate ion in relation to months and stations**

within stations ( $p \geq 0.05$ ), also there was no significant difference between the two seasons and no correlation between station and seasons ( $p \geq 0.05$ ).

Correlation coefficient in Appendix VI revealed positive correlation with water depth, dissolved oxygen, nitrate-nitrogen ion concentration and BOD but negative correlation with pH, Fe, chlorides and conductivity ( $p \leq 0.05$ ).

#### **4.16 Biological characteristics**

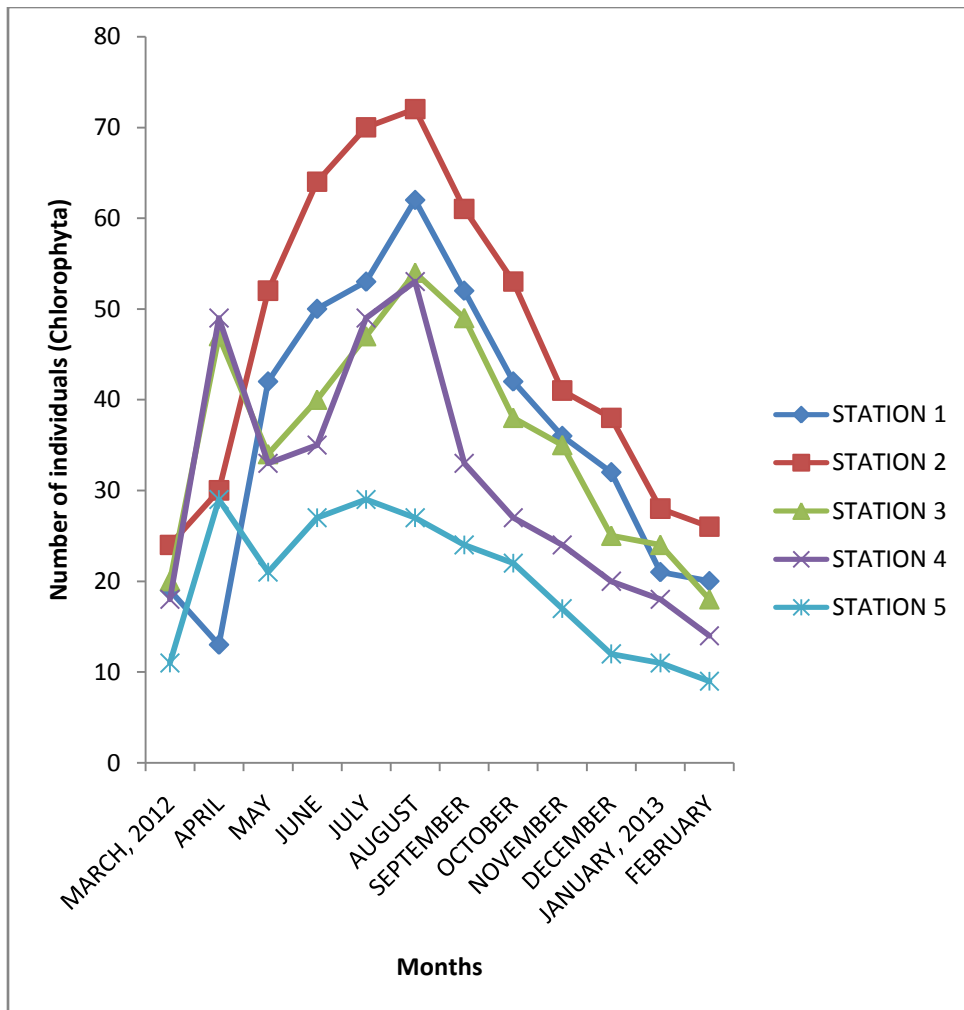
##### **4.16.1 Phytoplankton**

The phytoplankton of Sabuwa reservoir comprises of 4 phyla, 12 families and 15 species. The 4 phyla are Chlorophyta, Cyanophyta, Bacillariophyta and Dinophyta. The percentage composition of Chlorophyta was 41%, followed by Cyanophyta 34%, Bacillariophyta 20% and Dinophyta 18%.

##### **4.16.2 Chlorophyta**

The Chlorophyta were represented by five species; *Spirogyrasp*, *Ndgoniumsp*, *Closteriumsp*, *Volvoxsp*, and *Scenesmus sp*. There was high algal count in stations 1,2 and 3 per litre. Early rainy season showed high algal count as revealed in Fig 4.16. Appendix III revealed high occurrence of Chlorophyta during rainy season than dry season. Stations 2 and 3 show high occurrence of Chlorophyta than stations 1, 4 and 5 respectively.

Result of analysis of variance in Appendix VII revealed a significant variation between stations and seasons ( $p \leq 0.05$ ) but no significant difference along stations by seasons ( $p \leq 0.05$ )



**Fig. 4.16: Shows the mean monthly variation of Chlorophyta in relation to months and stations**

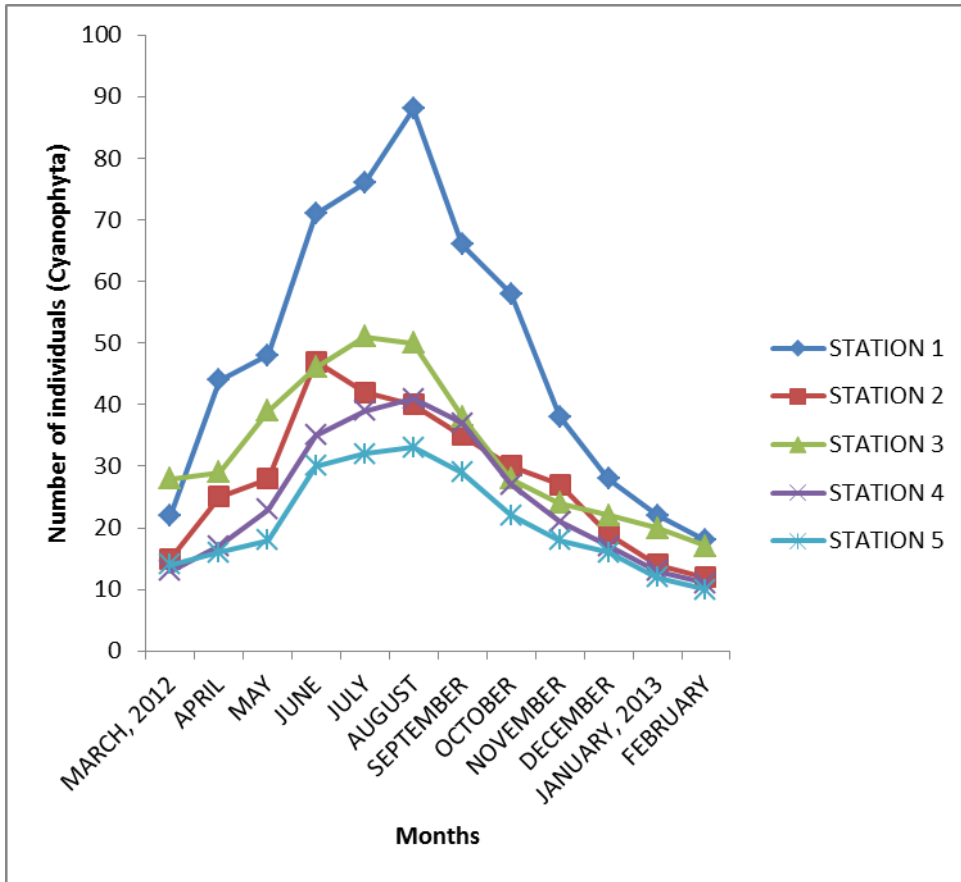
#### 4.16.3 Cyanophyta

Cyanophyta (blue-green algae) are represented by *Microcystis* sp, *Anabaena* sp, *Oscillatoria* sp, *Coelosphaerium* sp. The mean monthly distribution shows that the density of the rainy season (June, July and August) species were more than that of the dry season as shown in Fig. 4.17. Cyanophyta accounted 2051 of the total number of Phytoplankton identified. Stations 2 and 3 show high occurrence of Cyanophyta than station 1, 4 and 5. Low algal count was recorded between November to April. Analysis of variance revealed a significant variation between season, station and no significant difference in algal count within stations and month ( $p \leq 0.05$ ).

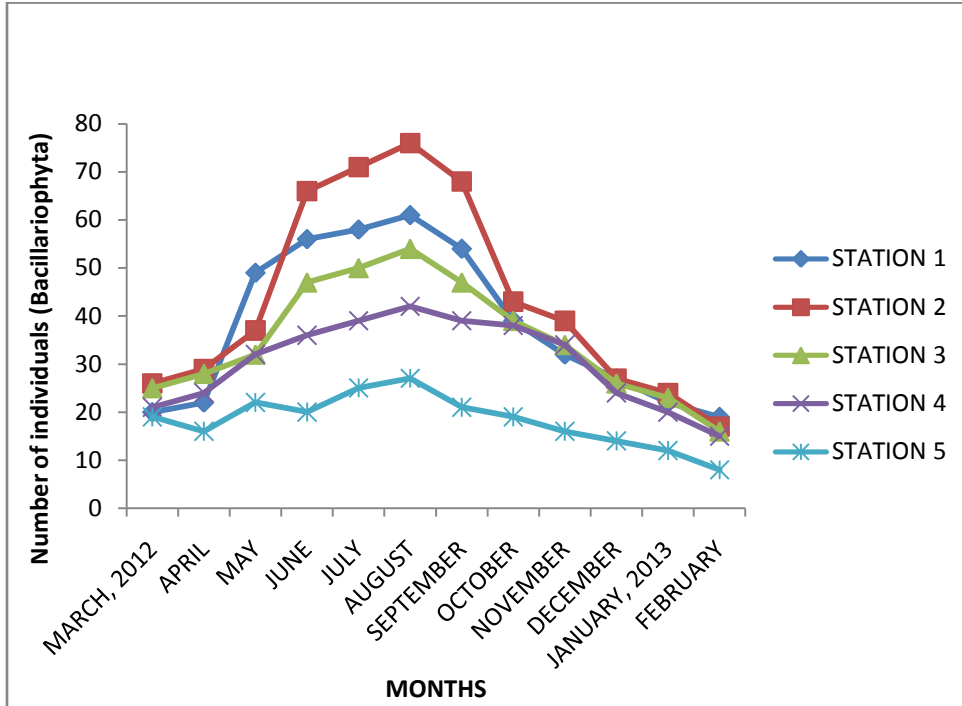
The correlation coefficient showed that there was positive correlation between cyanophyta with calcium, chloride ion and conductivity but there was negative correlation with dissolved oxygen, water depth and pH.

#### 4.16.4 Bacillariophyta

The Bacillariophyta are represented by three species; *Diatom* sp, *Tabellaria* sp and *Pinnularia* sp with a percentage diversity of 5.12%, 6.10% and 6.29%. It was revealed that there was high population density during rainy season and low count in dry season as revealed in Fig.4.18. The months of June, July and August recorded the highest number of Bacillariophyta while the months of October to February in dry season recorded a low number of Bacillariophyta. Analysis of variance showed that there was a significant variation between seasons and stations ( $p \leq 0.01$ ) and no significant difference between stations by month.



**Fig 4.17: Shows the mean monthly variation of Cyanophyta relation to months and stations**



**Fig. 4.18:** Shows the mean monthly variation of Bacillariophyta relation to months and stations

Correlation coefficient analysis revealed highly positive correlation between Bacillariophyta and dissolved oxygen and copepod but negative correlation with water depth.

#### **4.16.5 Dinophyta**

The Dinophyta were represented by *Spirotaniasp* and *Characium* sp. Algal count was higher in August (22 algal count) and lowest was recorded (3 algal count) in the month of January and February in Fig. 4.19. There was high algal count during the rainy season than in dry season, Station 1,2, and 3 showed high algal count than stations 4 and 5.

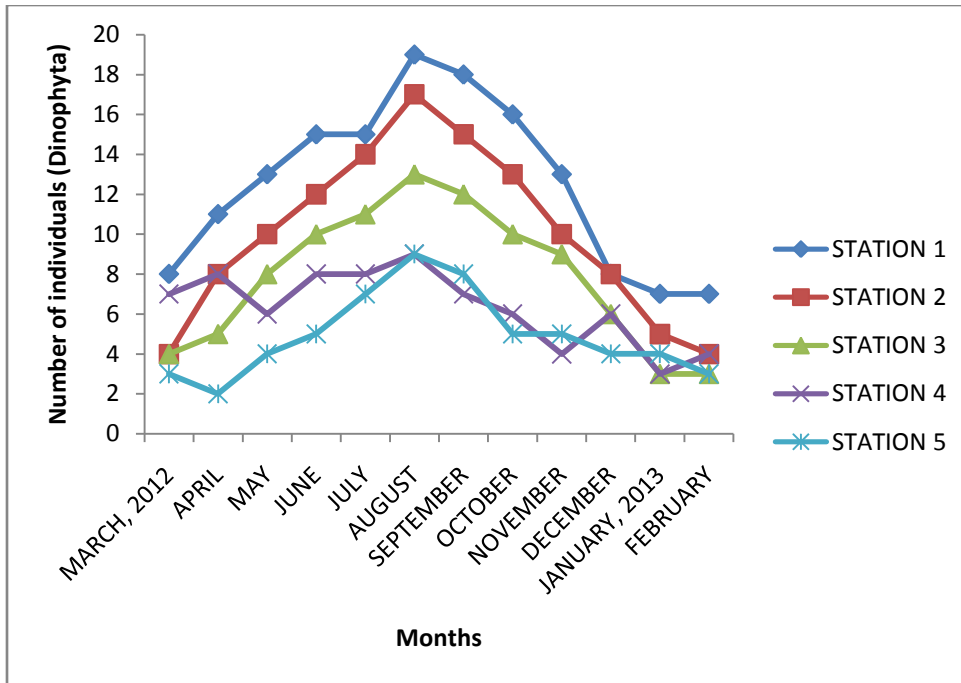
Result of analysis of variance in Appendix III revealed significant variation between seasons and stations and no significant variation between stations and month interactions. The correlation coefficient revealed that there was positive correlation between Dinophyta and water depth, temperature, transparency and conductivity, but there was negative correlation of Dinophyta with pH, conductivity, BOD, chlorides and calcium.

#### **4.17 Zooplankton**

The Zooplankton community of Sabuwa reservoir were represented by four groups; Cladocera (35.9%), Copepoda (28.6%), Rotifera (18.8%) and Protozoa (16.7%). Fifteen species of Zooplankton were identified in all the five sampling stations.

##### **4.17.1 Protozoa**

The Protozoa that were identified include *Euglenasp*, *Parameciumsp*, and *Chlamydomonas* sp. There was high population density of protozoa during rainy season



**Fig 4.19: Shows the mean monthly variation of Dinophytain relation to months and stations**

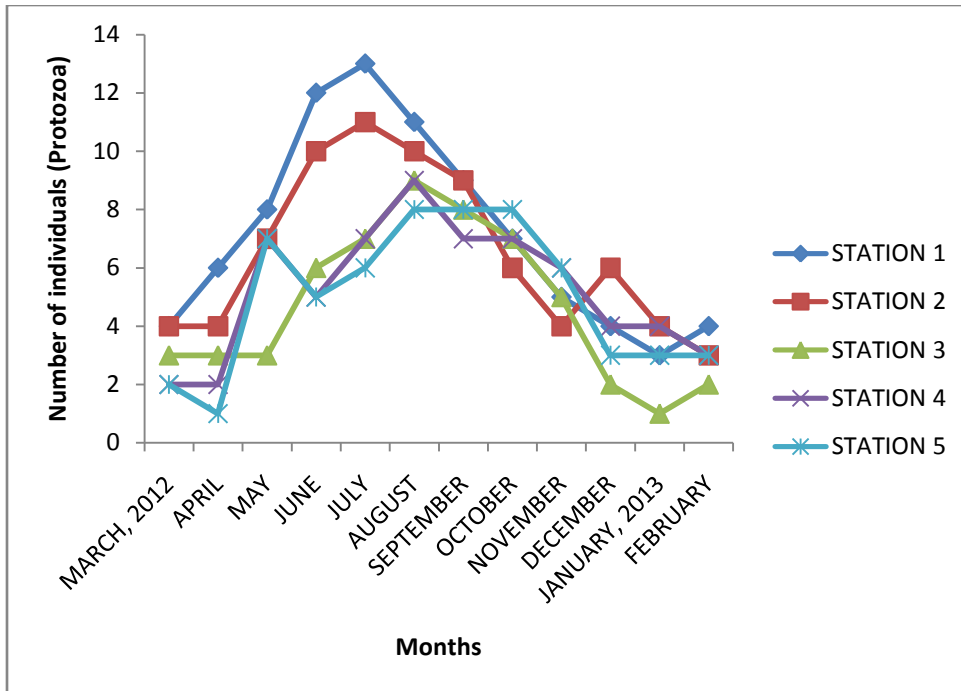
(May – September) than dry season (November – April) as revealed in Fig. 4.20. The month of July had the highest count in station 1 and 2 and the lowest count between February and March. The months of June to August show higher number of Protozoa than the month of October to February in dry season.

The analysis of variance showed that there was significant difference along the stations and seasons ( $p \leq 0.05$ ) but no significant difference between stations and month. Correlation coefficient revealed that there was positive correlation between phosphates, conductivity, nitrates ions, hardness and pH but negative correlation with alkalinity, transparency, temperature and water depth.

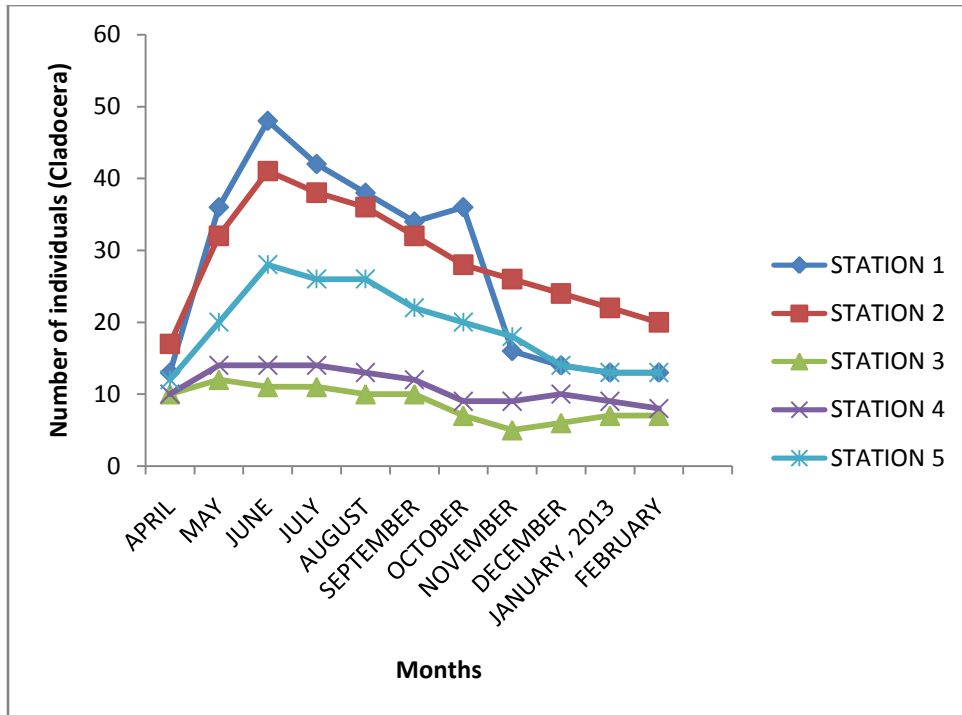
#### **4.17.2 Cladocera**

The Cladocera accounted for 25.9% of the population count of Zooplankton. The cladocera identified were *Diaphinasp*, *Macrothrixsp*, *Bosminasp*, *Polyphenussp* and *Simocephalus* sp. The mean seasonal distribution indicated that the cladocera were more in the rainy season than in the dry seasons. The highest peak recorded for individual per litre was in the month of July. Stations 2 and 4 recorded higher number of Cladocera than stations 1, 3 and 5 respectively as revealed in Fig. 4.21.

Analysis of variance revealed significant difference among stations, seasons and stations by month ( $p \leq 0.05$ ). There was positive correlation between the Cladocera and dissolved oxygen, nitrogen, calcium, phosphate and chloride ions but negative correlation with transparency, water depth, conductivity, turbidity and temperature.



**Fig. 4.20:**Shows the mean monthly variation of protozoain relation to months and stations



**Fig 4.21: Shows the mean monthly variation of Cladocera in relation to months and stations**

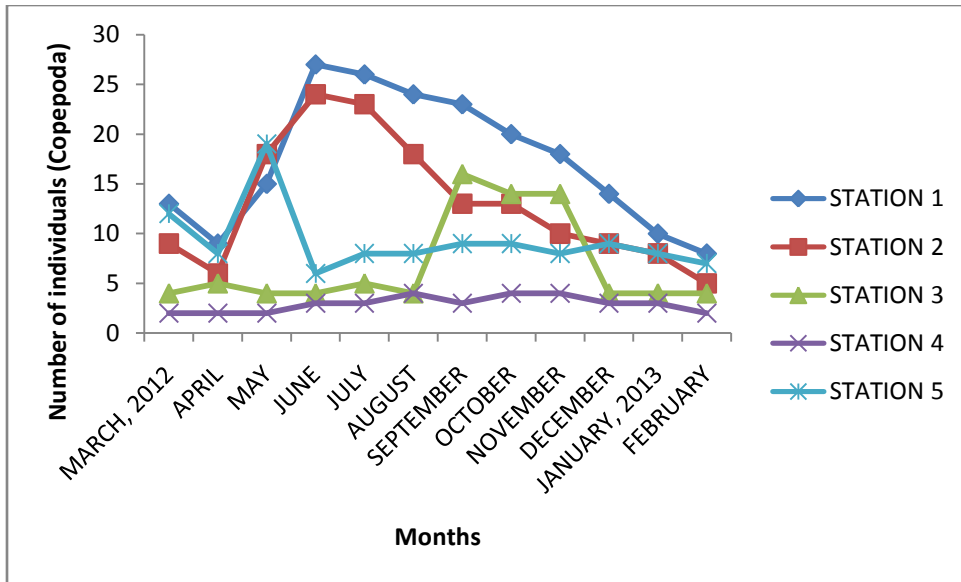
### 4.17.3 Copepoda

The copepoda accounted for 28.6% of the population count of zooplankton. The copepod were represented by *Diaptomus* sp, *Cyclops* p, *Tropodiaptomus* sp and *Eubrarchipus* sp. Their densities during the rainy season were higher than that of the dry seasons. Stations 1, 2 and 3 show high occurrence of Copepoda than stations 4 and 5 respectively. Lowest values were obtained in the months of dry season as revealed in Fig. 4.22. Result of analysis of variance revealed significant difference among station, seasons and station by month interactions.

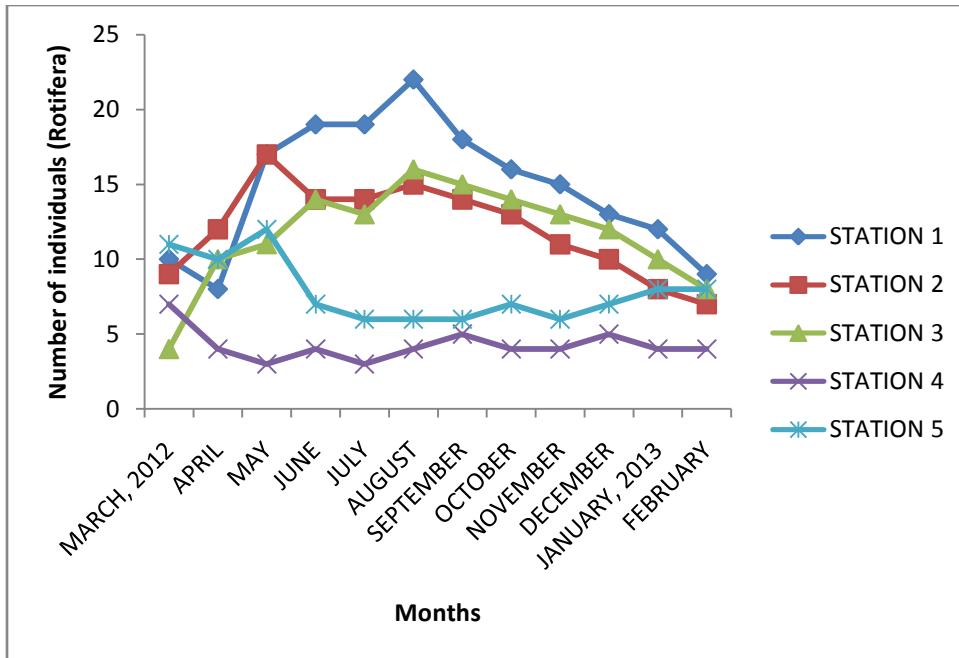
Correlation coefficient revealed that there was positive correlation between copepod with temperature, dissolved oxygen, BOD, phosphate-phosphorus, nitrate-nitrogen and chlorides, but negative correlation with pH and alkalinity, conductivity, water depth

### 4.17.4 Rotifera

The rotifers constitute 18.8% of the total count of zooplankton. They were represented by *Kellicotias* sp and *Branchionus* sp. Seasonal variation from the two seasons showed that there was high population count of rotifer during rainy season and low population count was obtained in the dry season. Station 1, 2 and 3 show high occurrence of Rotifera than station 4 and 5 as revealed in Fig. 4.23. Lowest value of Rotifera were recorded in dry season. Analysis of variance revealed that there was significant difference among the stations, seasons and season by month ( $p \leq 0.01$ ).



**Fig. 4.22 Shows the mean monthly variation of Copepoda in relation to months and stations**



**Fig. 4.23:** Shows the mean monthly variation of rotifera in relation to months and stations

Correlation coefficient revealed positive correlation between rotifers with phosphate ions, nitrate-nitrogen, BOD, dissolved oxygen, calcium, chlorides but negative correlation with pH, water depth, alkalinity and conductivity.

#### **4.18 Benthic Macro-invertebrates**

Three major classes identified in the reservoir are Mollusca, Annelida and Nematoda. Mollusca accounted for 62.3% of the total Benthic macro-invertebrate population identified. Rainy season recorded higher population count than dry season. Stations 1, 2 and 3 revealed high population count of between 645, 663, and 910 than station 4 and 5.

Table 4.1 and 4.2 revealed the phytoplankton and zooplankton species respectively.

##### **4.18.1 Mollusca**

The species within the phylum molusca collected from the five sampling stations were composed of two orders – Gastropoda and Bivalve composed of *Lymaneapolustria*, *Itelosomasp*, *Magaritiferasp*, *Bulinussp* and *Corbiculafluminae*. Based on seasonal observation, rainy season recorded higher population count than dry season. Fig. 4.24 showed that there was high occurrence of Mollusca from May to September and low count was recorded in the months of dry season. Analysis of variance revealed significant difference in both stations and seasons but there was no significant difference at station by seasons.

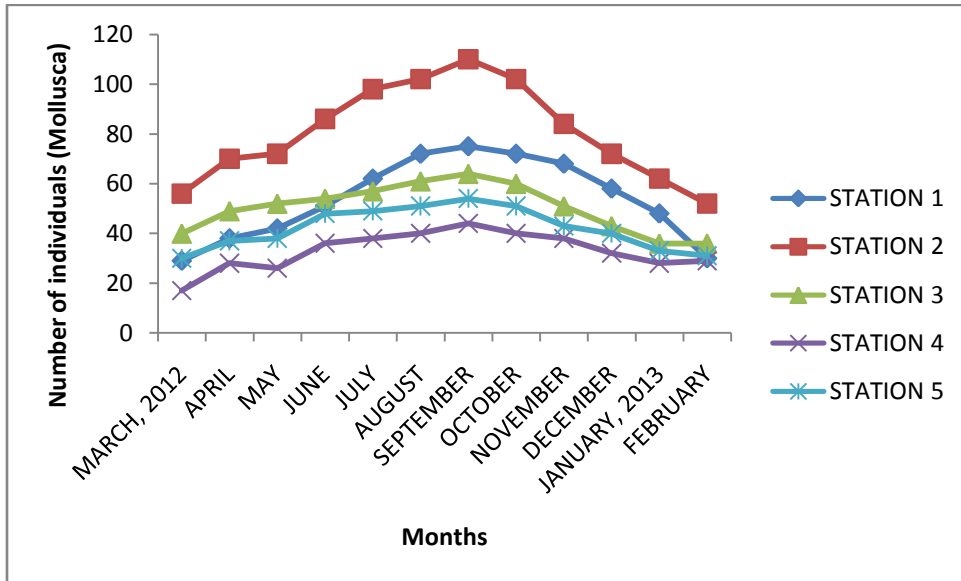
There was positive correlation between Mollusca with chlorides, phosphate ions, nitrate ions, turbidity and alkalinity but negative correlation with conductivity, transparency and dissolved oxygen.

Table 4.1: Phytoplankton count of Sabuwa reservoir

Chlorophyta Count	Cyanophyta count	Baccilariophyta count	Dinophyta count
<i>Spirogyra</i> sp	<i>Microcystis</i> sp	<i>Diatom</i> sp	<i>Spirptaria</i> sp
<i>Ndogonium</i> sp	<i>Anabaena</i> sp	<i>Tabellaria</i> sp	<i>Characium</i> sp
<i>Closterium</i> sp	<i>Oscillatoria</i> sp	<i>Pinmularia</i> sp	
<i>Volvox</i> sp	<i>Coelospherium</i> sp		
<i>Scendesmus</i> sp			

Table 4.2: Zooplankton count of Sabuwa reservoir

Protozoa count	Cladocera count	Copepoda count	Rorifera count
<i>Euglenasp</i>	<i>Diaphinasp</i>	<i>Diaptomussp</i>	<i>Kellicottiasp</i>
<i>Parameciumsp</i>	<i>Macrothrixsp</i>	<i>Cyclopssp</i>	<i>Branchionussp</i>
<i>Chlamydomonasp</i>	<i>Bosmiassp</i>	<i>Tropodiaptomussp</i>	<i>Keratellasp</i>
	<i>Polyphenussp</i>	<i>Eubbranchipussp</i>	
	<i>Simocephalussp</i>		



**4.24: Shows mean monthly variation of Mollusca in relation months and stations**

#### **4.18.2 Annelida**

The annelids were represented by *Lumbriculussp* and *Hirudomedicinalis*. The highest observation was recorded in the month of September during rainy season as revealed in Fig. 4.25. Result of the analysis of variance revealed a significant difference between stations and seasons but no significant difference between stations by seasons.

Correlation coefficient in Appendix VII showed that there was positive correlation between annelida with water depth, dissolved oxygen, BOD and transparency, but a negative correlation with phosphate ions, nitrate ions, hardness, conductivity and temperature.

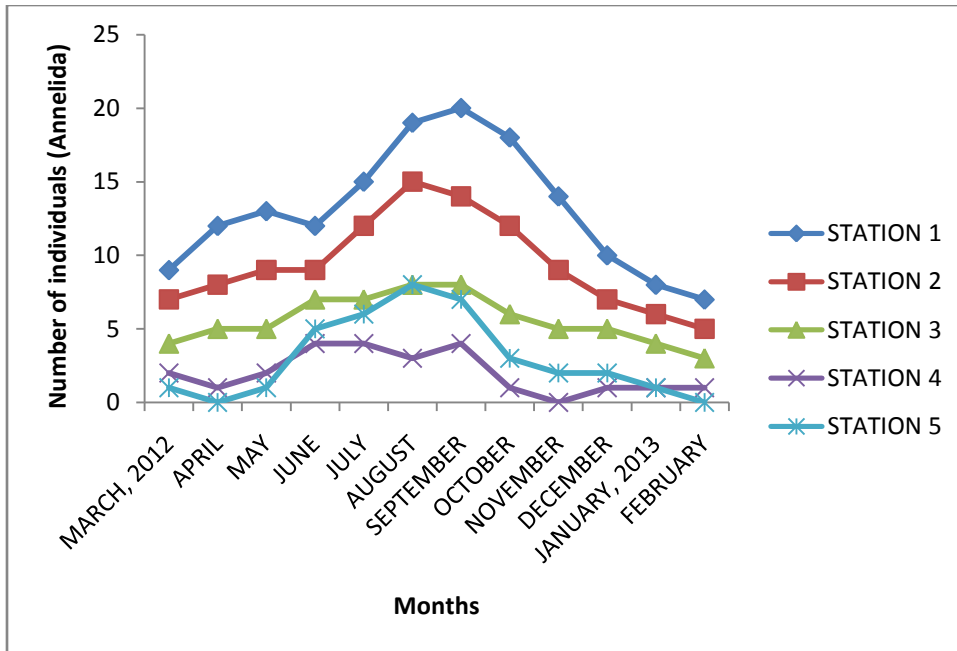
#### **4.18.2 Nematoda**

Benthic macroinvertebrates identified at the five sampling stations have 1.8% relative abundance, Seasonal variation revealed that rainy season months between may – September recorded higher value and low population count of nematodes was obtained during the dry season between the month of February and May as revealed in Fig. 4.26.

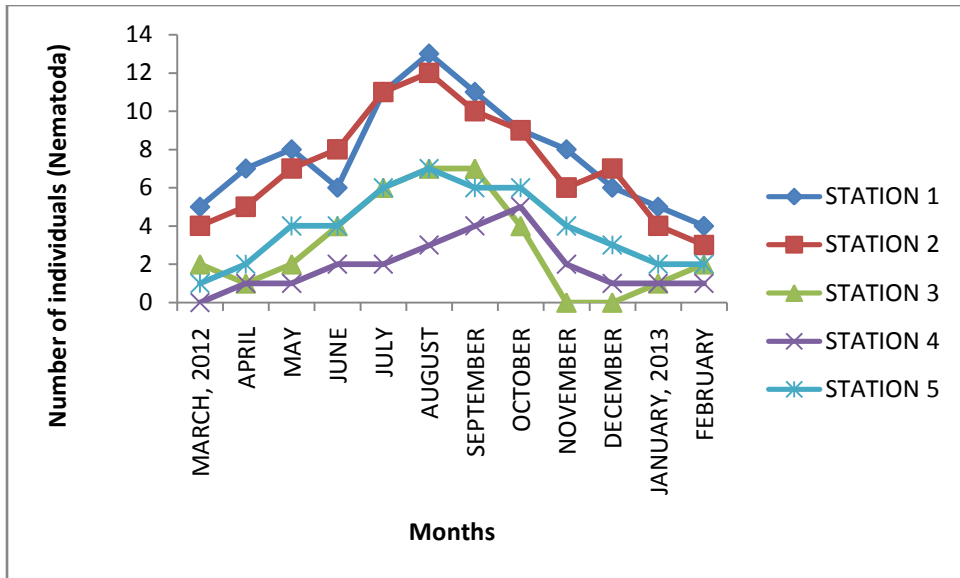
Result of the analysis of variance revealed that there was significant difference between stations and seasons. However, there was no significant correlation between stations by month interaction ( $P \leq 0.05$ ).

Correlation coefficient revealed positive correlation between Nematode with nitrate ions, phosphate ions, temperature, water depth, dissolved oxygen, BOD, but negative correlation was observed with transparency, turbidity and pH.

Table 4.3 revealed the phylum, family and species of benthic-macro invertebrate of Sabuwa reservoir.



**Figure 4.25: shows monthly variation of Annelida in relation to months and stations**



**Figure 4.26: Shows monthly relationships of Nematoda in relation to months and stations**

Table 4.3: Bentic Macro-invertebrates of Sabuwa reservoir

Phylum	Family	Species
Mollusca	Prosobranchis	<i>Bulinusjousseaumi</i>
		<i>Lymneapolustria</i>
		<i>Itelosomasp</i>
	Megaritaferidae	<i>Megariferasp</i>
		<i>Pisidiumsp</i>
Annelida	Oligochaeta	<i>Lumbriculusp</i>
		<i>Hiridomecinalis</i>
Nematoda	Hirudidae	<i>Rhapholaimussp</i>

## CHAPTER FIVE

### 5.0 DISCUSSION

#### 5.1 Physico-chemical parameters

Result of many studies have shown that physical and chemical condition of aquatic ecosystem determine the occurrence, distribution, diversity and density of both flora and fauna in any given habitat which may change with season of the year (Ayodele and Adeniji, 2006). The low temperature recorded between the months of November to March ( $23^{\circ}\text{C} - 25^{\circ}\text{C}$ ). This could be due to the prevalent northern harmatanwind which extended to March in some areas. Similar observation was made by the findings of Kemdirim (1987) and Kolo and Oladimeji (2001) in Shiroro dam. Also, the low temperature recorded could be as a result of response to seasonal changes in air temperature. This affects the occurrence and distribution of planktons and macrobenthic organism as reported by Edemaet *al.* (2002).

Temperature plays an important role in the occurrence, species composition, density of fresh water organisms. The resultant rise in temperature during rainy season could be as a result of high air temperature. The high algal bloom at the beginning of the rainy season corresponds with high temperature during that period. The high temperature influences the distribution of macrobenthic invertebrates that migrates and become more active and this corresponds with the findings of Abdullahi and Indabawa (2005). High water temperature, lower amount of dissolved oxygen may also affect the growth rate of some fish species. The variation in spatial temperature may be due to human activities in

the various stations. Temperature affects the distributions of phytoplankton. There was high occurrence of phytoplankton and zooplankton during the months of rainy season because of high temperature. Also, high occurrence of macro benthic invertebrates were recorded during the rainy season

Water depth ranges from 40cm in October which is the peak of rainy season. This could be due to the fact that the rainfall progressively increase from June to October. Increase in water volume leads to increase in water depth.

pH is one of the most important attribute of any aquatic system since all biochemical activities depend on pH of the surrounding medium. It was well established that the pH of the natural water is controlled largely by the interaction of hydrogen ions resulting from the hydrolysis of bicarbonate. Figure 4 shows the monthly variation of pH at Sabuwa reservoir for 1 year. The highest value of pH was recorded in the month of June (8.42) while the lowest pH recorded was 6.4. The reservoir was acidic during the rainy season and this was found to have increased with the onset of rainy season and slightly decrease in dry season. The low pH indicates acidity possibly due to the presence of CO<sub>2</sub>, nitrate and sulphate ions in water. Olaniyan, (1968) shows the level of pH to be closely related to the amount of carbonates present in solution because these carbonates acted as buffer, tending to neutralize any acidity.

Transparency revealed lower visibility during rainy season (May – October) while the month of March recorded the highest transparency. The highest turbidity recorded during the dry season could be due to surface run-off from the catchment area and increase in siltation as well as re-suspension of dissolved materials and flooding. The high

transparency during the dry season could be due to low water volume favouring settling of suspended materials as well as the absence of flood water and evaporation due to high temperature. Similar observation was recorded reported by Kemdrim (1990). The low transparency as the rainy season progressed could be due to dilution as a result of high water level and flooding. Increase in total dissolved solid result to increase in turbidity but decrease in benthic fauna and increase in the algal bloom. This agrees with the observation of Adakole (1995).

Electrical conductivity shows slight variation in all months of the rainy season with values  $13\mu/s$  to  $78\mu/s$  and slightly high in dry season. The increase in conductivity could be due to the effect of dilution and the reduction of sediment re-suspension. There was positive significant correlation between conductivity with BOD, chloride and calcium but no significant correlation with phosphate and the algae population in Sabuwa reservoir.

Also, the gradual decrease in conductivity during rainy season could be attributed to the effect of dilution and the reduction of sediment re-suspension. Increase in total dissolved organic matter result to increase in conductivity but a decrease in benthic fauna (Adakole, 2000). According to Umeham (1989) a high water electrical conductivity coupled with shallow depth in a lake could be used to assign a high morpho-edaphic index to the water body and therefore a high fish production potential. This findings in this study was consistent with the observation of Anwi and Ofori-Danson, (1993), who observed that the dilution as a result of rain have a moderate effect in Lake Volta.

Low values of water hardness were recorded in the month of May to August. There was progressive increase during the dry season, then a significant drop with the onset of

the rains. Increase of water hardness noticed during the dry season could be due to low water level and the concentration of ions and the decrease level during the rainy season could be due to dilution as a result of wind action and light intensity which improve evaporation in turn increase hardness. Ufodikeet *al*, (2001) and Kolo and Oladimeji, (2001) also reported similar result in their studies in Docomo Lake and Shiroro Lake.

There were higher BOD values during dry season than the rainy season. In dry season, BOD was higher because it coincided with the period of oxygen consumption by decomposers. It is significant because of the degradation activities within the stations. The low value could be due to reduce degradation. This was similarly reported by Awanda (1987). Unpolluted waters have BOD values of 2mg/l or less (Chapman and Kimstach, 1996). Limnologist had utilized the demand for oxygen by oxidizable organic matter as a means of comparing waters, especially those thought to be affected by organic pollution (Adakoleet *al*., 1999).

There was significant difference with season. Dissolved oxygen (DO) concentration was higher in the dry season than in rainy season. Lowest concentration during rainy season could be attributed to the peak time of biochemical oxygen demand due to bacteria and other decomposers. The higher the temperature, the lower the dissolved oxygen and the lower the temperature, the higher the dissolve oxygen. This was due to increased solubility of DO at lower temperature. The higher DO in dry season coincided with minimum water temperature in December and January due to hamatan.

According to Adakole (1995), different organisms have different oxygen requirements and as such, dissolved oxygen is an important factor, which determines their behavior, growth and distribution.

High concentration of nitrate-nitrogen was recorded in rainy season and the lowest in dry season. The high concentration could be due to runoff from the farmlands into the dam and also the application of fertilizers by farmers from catchment area. Another reason could be as a result of nitrates released from sediments during decomposition of organic matter. Low nitrate-nitrogen values indicate period of extreme dry season could be due to utilization by algae (Adeniji, 1987). Hain (2002) reported nitrate-nitrogen to increase with surface runoff and deeper depths.

Highest alkalinity was obtained in July and lowest values were obtained during the dry season. The dry season increased may be due to the reduce water volume and dilution. Ufodike *et al*, (2001) also reported similar result in Dokoma Lake. This shows that as rains continue to fill ponds, the rise water produce rapid increase in alkalinity.

Phosphate-phosphorus values was higher during rainy season period than dry season and this may be due to runoff from nearby farmland. Since phosphate fertilizer application is common around the catchment area. Relatively higher dry season mean values of phosphate observed could be as a result of the effect of reduction in water volume, water hardness and could be attributed to algae uptake. Karikari, *et al*, (2007) in their study on water quality in Angaw River concluded that phosphorus is the limiting factor for algal growth. Wetzel (2001) states that the rate of phosphorus release into the water can double when sediment are frequently disturbed.

There were low chloride ion concentration during the rainy season than dry season and this could be due to water depth, presence of submerged decaying woods which uses up dissolved oxygen. Similar observation was made by Kolo and Adeniji (2004). Higher values of calcium were obtained during dry season than rainy season. Higher concentration of magnesium was obtained in rainy season and this could be due to application of fertilizer, insecticides and herbicides in the dam. Higher dry season means observed may be due to decrease in water volume. High values of iron concentration during the rainy season could be attributed to a lot of farming activities and pollution from surrounding community. According to Baldantoniet *al*, (2005) analysis of plant tissues and sediment provide time-integrated information on the amount of heavy metals in an aquatic system. The low value of metals in Sabuwa reservoir were probably due to uptake by aquatic macrophytes and phytoplankton.

## **5.2 Phytoplankton**

The phytoplankton was characteristically dominated by four group of phytoplankton. The phytoplankton of Sabuwa reservoir were dominated by Chlorophyta and Bacillariophyta with Dinophyta being the least represented. This result was similar with the findings of Abdullahi (1997) and Abubakar (2007) who worked on Hadejia Nguru wetlands and Nguru Lake respectively. The dominance of cyanophyta was an indication of the deterioration of water quality. Observation by Odhiambo and Gichuki (1998) revealed that the chlorophyta and the cyanophyta dominated algae of Lake Baringo and that of Lake was in state of gradual deterioration of water quality. There was no significant difference in the occurrence and distribution of this phyla in both station and season and this agree with

the findings of Balarabe (1989). The high algal bloom corresponds with high temperature. Chlorophyta were represented by *Spirogyrasp*, *Oedogoniumsp*, *Closteriumsp*, *Volvoxsp* and *Scenedesmussp* while cyanophyta were represented by four individual species of *Microcysticsp*, *Anabaenasp*, *Oscillatoriasp* and *Coelosphaeriumsp*. The bacillariophyta by *Diatomsp*, *Tabelleriasp* and *Pinularia sp*. While dinophyte were represented by *Spirotaeniasp* and *Characium sp*. The abundance of cyanophyta in dry season could be attributed to their ability to utilize directly atmospheric nitrogen and their dominance in rainy season could be due to relative high temperature. Studies by Mpawenayo and Cocuyt (2007) indicated that algae such as *Gomphonema*, *Nitzshia*, *Pinnularia* and *Spirogyrasp* were associated with aquatic macrophytes such as *Pistia*, *Azolla* and *Ludwigia sp*.

### **5.3 Zooplankton**

The zooplankton community comprises of copepod, rotifer, cladocera and protozoa. The density of each genera varied with season. Zooplankton population rose with the early rainy season and gradually decreased as the rainy season progresses. Similar observation was made with the research findings of Balarabe (1989), Agwigo (1977) at ABU farm Lake and NnamdiAzikiwe University stream respectively. Their abundance in rainy season could be due to availability of nutrients (phytoplankton) and low transparency. Their low number in dry season could have been due to high transparency which aid predation or due to high temperature.

Fifteen species of zooplankton were identified during the study period, of which members of cladocera dominated with seven species followed by four species of copepod.

Rotifera were represented by three species while protozoans were represented by three species. Vijverberg and Richter (1982) showed in their work that fish predation was the most important factor regulating zooplankton population in Tjenkemeer Lake.

#### **5.4 Benthic macro-invertebrate**

The macro-benthic invertebrate community show variation during the study period. There was high significant difference in occurrence and distribution of these benthos and their availability has been due to nutrients, run off and siltation. Similar reports were reported by Kawo, (1959). Environmental variables affect their distribution and occurrence. The high temperature influence the distribution of macrobenthic invertebrates that migrate and become more active Abdulahi and Indabawa (2005). Benthos dominance in the study showed the following order; Mollusca > Annelida > Nematoda. This may be due to water quality. Similar observation was reported by Adakole and Annune (2003). There was a good correlation between macro-invertebrate and nutrient load. Mollusca, Annelida, Nematoda show significant positive correlation with other benthic macro-invertebrate in the reservoir.



## CHAPTER SIX

### 6.0 SUMMARY, CONCLUSION AND RECCOMENDATIONS

#### 6.1 SUMMARY

The physico-chemical properties and composition of the biota of Sabuwa reservoir were studied for the period of twelve months, March 2012 to January 2013. Water samples were collected at each of the five selected sampling stations and analyzed. Temperature, water pH and electrical conductivity were measured. Dissolved oxygen, alkalinity by titration. Total phosphorus, total nitrogen were determined spectrophotometrically, Metals were analyzed by digestion and analysis using Spectrophotometer, Plankton were collected using plankton net. The result of analysis of variance revealed that temperature, water, depth, conductivity, hardness, transparency, dissolved oxygen, biochemical oxygen demand, phosphate-phosphorus, nitrate-nitrogen, calcium, chlorine ions, magnesium and alkalinity showed significant difference between the seasons ( $p \leq 0.05$ ) but there was no significant difference between stations. Fifteen species of zooplankton belonging to four major classes were identified, cladocera (35.9%), copepod (28.6%), rotifer (18.8%) and protozoa (16.7%).

Four group of phytoplankton comprising of Chlorophyta, Bacillariophyta, Cyanophyta and Dinophyta were recorded. The Chlorophyta which constitute 41%, followed by the Cyanophyta (34%), Bacillariophyta (20%) and the Dinophyta (22%). Fifteen species were identified during the study period.

The Macro-invertebrates of Sabuwa reservoir were composed of three phyla – Mollusca, Annelida and Nematoda. The distribution and composition of benthic-macro

invertebrates were affected by seasonal variation as a result of environmental variables and nutrient concentration

## **6.2 CONCLUSION**

The physic-chemical parameters such as water temperature, water depth, transparency, conductivity, hardness, dissolved oxygen, phosphate phosphorus, calcium were identified. Species composition, density, and distribution of plankton and macrobenthic invertebrate of Sabuwa reservoir were investigated.

The distribution and composition of the biota of Sabuwa reservoir were affected by seasonal variation through changes in environmental variables such as temperature, pH, dissolved oxygen, biochemical oxygen demand, etc.) and nutrients concentration.

## **6.3 RECOMMENDATIONS**

The study sought to establish a baseline data for Sabuwa reservoir that can be used for good management of the reservoir. It is therefore recommended that further limnological research should be carried out on its conductivity, quality and microbial fauna.

## REFERENCES

- Abba, Y.A. (1987). A Biological Survey of Fishes of Kangimi Reservoir, Kaduna State. Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, pp 34-54.
- Abba, Y.A. and Musawa, I.S. (2005). Preliminary report on the pre-post impoundment impact study of Sabke dam. Unpublished report for National Special Programme for Food Security, Abuja, Nigeria, pp 21.
- Abdullahi, B.A. and Indabawa, I.I. (2005). Ecology of freshwater Phytoplankton of River Hadejia, Jigawa State. *Biological and Environmental Sciences Journal for the Tropics*, 1(2):141-145.
- Adakole, J.A. (1995). The effect of pollution on a stretch of River Kubani, Zaria, Nigeria. Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, pp 33-41.
- Adakole, J.A. (2000). The effects of domestic and industrial effluents on water quality and biota of Bindere streams, Zaria-Nigeria. PhD Thesis, Department of Biological Sciences, A.B.U., Zaria, Nigeria. pp 256.
- Adakole, J.A. and Annune (2003). Benthic Macro-invertebrates as indicators of environmental quality of an urban stream, Zaria, Nigeria. *Journal of Aquatic Science*, 18(2):85-95.
- Adeniji, H.A and Ovie S.I. (1981). Study of the abundance and distribution of zooplankton in Asalake, *Kainji Lake Research Institute Annual Report*, pp4.
- Adeniji, H.A. (1973). Preliminary investigations into the composition and seasonal variations of Plankton of Kainji Lake, Nigeria. *Geophysics monograph serials*, 17:617-619.
- Adeniji, H.A. (1978). Diurnal vertical distribution of Zooplankton during stratification in Kainji Lake, Nigeria. *Verhandlungen der Internationale Vereinigung Limnologia*, 26:1977-1983.

- Adeniji, H.A. (1979). Circadian vertical migration of zooplankton during homothermy and its significance in Kainji Lake, Nigeria. *Proceedings of International Conference on Kainji Lake and River Basin Development in Africa, Ibadan, Nigeria*, 11-17 December 1977, 1:203-207.
- Adeniji, H.A. (1987). Preliminary investigation into the composition and seasonal variation of plankton in Kainji Lake, Nigeria. *Geophysics Monograph Serials*, 17:617-619.
- Adeniji, H.A. (1989). Limnological characteristics of man-made Lakes in Nigeria in: Ayeni and Olatunde (eds). *Proceedings of the National Conference of Two Decades of Research on Lake Kainji*, pp 41-52.
- Adeniyi, F. (1978). Studies of the physico-chemical factors and the planktonic algae of lake Kainji, Nigeria. Unpublished PhD. Thesis, University of Ife, Ile-Ife, Nigeria, pp31-34.
- Aguigwo, I.N. (1997). Studies on Plankton productivity in relation to water quality parameters and nutrient level. *Journal of Aquatic Sciences*, 12:15-22.
- Amyst, M., Pinel-Alloul, B and Campbell, P.G. (1994). Abiotic and seasonal factors influencing trace freshwater anykpod *Gammanusfaliatus* in two fluvial Lakes of St. Lawrence River. *Canadian Journal of Fisheries and Aquatic Sciences*, 51:2003-2016.
- Antonie, S.E. and Al-Saadi, H.A. (1982). Limnological studies on the polluted Ashar canal at Basrah (Iraq). *Revegés Hydrobiologica*, 67:405-418.
- APHA (American Public Health Association) (1980). *Standard Methods for Examination of Water and Waste Water, Sixteenth edition*. Washington D.C. pp221-305.
- APHA (American Public Health Association) (1980). Standard methods for examination of water and waste water, 16<sup>th</sup> edition. Washington D.C. 416pp.

- Ashton, P.J. and Schoeman, F.R. (1983).Limnological studies of the Pretona Salt Pan, a hypersaline lake, morphometric, physical and chemical features. *Hydrobiologia*, 99:61-73.
- Atule, A.A. (1985). Seasonal Variation in Water Transparency and its effect on Pelagic Primary Production in Kigera Reservoir, New Bussa, Nigeria. Unpublished HND Project in Fisheries management at the Federal Freshwater Fisheries School, New Bussa, pp 74.
- Azionu, B.C. (2004). Salvaging the freshwater ecosystem in Nigeria. Great threat to sustainable fisheries and aquacultural development in: *Proceedings of the 19<sup>th</sup> Annual Conference of Fisheries Association of Nigeria (FISON)*, pp 186-193.
- Bako, S.P. and Balarabe, M.L. (2005).Occurrence of aquatic microphytes in relation to biotic and abiotic factors in a medium size tropical Lake in the Nigerian savanna. In: Obadaet al., (eds). *Proceedings of the 11<sup>th</sup> World Lakes Conference Nairobi, Kenya*, 1:330-335.
- Bako, S.P., Mordi, I.L.andOniye, S.J. (2005). Aquatic microphytes infestation in relation to water quality status of a small tropical fish farm in the Nigerian savanna ecosystem. In: Obadaet al., (eds). *Proceedings of the 11<sup>th</sup> World Lakes Conference Nairobi, Kenya*, 1:137-144.
- Balarabe, M.L. (1989). Limnology and Zooplankton Distribution of Makwaye (Ahmadu Bello University Farm) Lake, Samaru, Zaria, Nigeria.Unpoblshed M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, pp 20-41.
- Balarabe, M.L. (2000). Effects of Zooplankton composition and distribution in Dumbi and Kwangila ponds, Zaria, Nigeria. (Unpublished) PhD Thesis, Department of Biological Sciences, A.B.U., Zaria.
- Balarabe, M.L. and Abubakar, M.M. (2007).Contribution to some elemental accumulation in Nguru Lake, North-Eastern Nigeria.*International Journal of Pure and Applied Science*, 1(1):26-29.

- Balogun, J.K. (1981). Impact of predation by the Nile perch, *Latesniloticus* (Linn) on the fisheries of Kainji Lake (Nigeria) In: Ayeni, J.S. and Olatunde, A.A. (eds). *Proceedings of the National Conference on two Decades of Research on Lake Kainji*, New Bussa, Nigeria, pp 110-116.
- Balogun, J.K. (2005). Fish Distribution in Zaria Reservoir: A Typical Small and Shallow African Domestic Water Supply Reservoir. *Nigerian Journal of Scientific Research*, 1:27.
- Barnes, G.P. (2002). *Trends in the water quality of selected shallow lakes in the Waikato Region, 1995-2001*. Environment Waikato Technical Series, 2002/11.
- Bartram, J and Balance, R. (1996). *Water Quality Monitoring, A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes* (UNEP-WHO, 1996) pp 345-400.
- Bernadette, P., Methot, G., Lapierre, L. and Willsie, A. (1995). Macro-invertebrates community as a biological indicator of ecological and toxicological factors in Lake Saint Francois (Quebec). *Environmental Pollution*, 91(1): 44-65.
- Bierhuizen, J.F.H. and Prepas, E.E. (1985). Relationship between nutrients, dominate ions and phytoplankton standing crop in Praire saline Lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, 42:1588-1594.
- Boszormenyi, Z. and Imevbore, A.M.A. (1975). Pkosphate absorption as an index of Phytoplankton activity: The case of lakeKainji. In: Imevbore and Adegoke (eds). *The Ecology of lake Kainji, Transition from River to Lake*. University of Ife Press, Ile-Ife, pp 285-287.
- Bowling, L.C., Steane, M.S. and Tyler, P.A. (1986). The spectral distribution and alternuation of underwater irradiance in Tasmanisn inland water. *Journal of Freshwater Biology*, 761:313-335.
- Boyd, C.E. (1988). *Water Quality in Warm Water Fish Ponds*. Craft Master Publishing Company, New York, USA, pp 300-341.

- Boyd, P.W., Wong, R. and Lee, H. (2000). Ameso scale Phytoplankton bloom in the polar southern ocean stimulated by iron fertilization. *Nature*, 407:695-702.
- Brain Moses, T. (1989). *Ecology of Fishes in Fresh Water, Man and Medium*. Black Well Scientific Publication, London, pp 205-215.
- Brenner, F.J., Steiner, R.P. and Mandok, J.J. (1996). Groundwater-surface water interaction in an agricultural water shed. *Journal of the Pennsylvania Academy of Sciences*, 70:3-12.
- Carlton, R.G. and Wetzel, R.G. (1988). Differences in iron, manganese and phosphorus binding in fresh water sediment vegetated with *Littorella uniflora* and benthic microalgae. *Water, Air and Soil Pollution*, 99:265-273.
- Chapman, D. and Kimstach, V. (1996). Water Quality Assessments: A Guide to use of Boita, Sediments and Water in Environmental Monitoring (UNESCO-UNEP-WHO Publication), pp 450-650.
- Chapman, P and Shanon, L.V. (1985). The Benguela ecosystem. 2. Chemistry and related processes. In: Barnes, M. (ed) *Oceanography and Marine Biology. An Annual Review* 23. University Press, Aberdeen. pp 183-251.
- Clarke, N.V. (1978). Comparison of River Niger and Swashi. *Hydrobiologia*, 58:17-23.
- Cole, G.A. (1979). *Textbook on Limnology*. C.V. Mosby Publication, Ohio, USA, pp 426.
- Comin, B., Aloson, F.A., Lopez, M. and Comelles, P. (1983). Limnology and Gallocontalake, Aragon, Northern Spain. *Hydrobiologia*, 105:207-221.
- Copper, S.D. and Goldman, C.R. (1980). Opossum shrimp (*Mysis relicta*) predation on zooplankton. *Canadian Journal of Fisheries and Aquatic Sciences*, 37:909-919.
- Deas, M. and Orlob, G.J. (1999). Assessment of alternatives for flow and water quality control in the Klamath River, below Ivoa Gate Dam. *University of California Daris Center for Environmental and Water Resources Engineering Report*, 99(4):236.

- Downing, J.A. (1991). The effect of habitat structure on the spatial distribution of freshwater invertebrates. *Freshwater Biology*, 20:365-374.
- Dugan, P.P. (2004). Biodiversity, culture and importance of Tilapias in West Africa. In Abban, B. and Falk, S.T. (eds), *Biodiversity Management and Utilization of West African Fishes*. Proceedings of the World Fish Centre Conference, Cairo, Egypt, 1-5 September, pp50-63.
- Egborge, A.B.M. (1977). The hydrology and Plankton of the Asejire Lake, Unpublished Ph.D Thesis. University of Ibadan, Nigeria, pp278.
- El-Otify, A.M. (1999). Characteristics of Phytoplankton communities in fish pond in Aswan. *Egypt Journal Union Arab Biology*, 7:93-116.
- Enplane LTD, (1997). Sabke Dam, Irrigation and Water Supply Project. Nigerian Petroleum Special Trust Fund Design Review Document, 5:67-109.
- Ezealor, A.U., Gbem, T.T., Kwande, W.S., Auta, J. and Bako, S.P. (1999). Sedimentation: A threat to man-made reservoirs in the savanna (A case study of Kubani reservoir, Zaria, Nigeria). A paper presented at the International Seminar on the Performance of Large and small-scale Irrigation Schemes in Africa, Abuja, Nigeria, pp18-31.
- Ezra, A.G. and Abdul-Hameed, A. (1997). Studies on the algae from four ponds in Zaria. In: *Proceedings of the International Conference on Biotechnology for Development in Africa, Enugu, Nigeria*, pp18-31.
- Ezra, A.G. and Nwankwo, D.I. (2001). Composition of Phytoplankton algae in Gumbi reservoir, Bauchi. *Nigerian Journal of Aquatic Sciences*, 16(2):115-118.
- Fanfhauser, H.B. (1983). Abundance, dynamic and succession of Phytoplankton, fortifiers in Lake Biel, Switzerland. *Hydrobiologia*, 104:349-352.
- Farrell, I.O., Lumbardo, J.R., Pinto, P. and Carolina, L. (2002). The assessment of water quality in the lower Lujan River (Buenos Aires, Argentina): Phytoplankton and Bioassay. *Environmental Pollution*, 120:201-218.

- Gibbons, W.M. and Funk, T. (1982). Seasonal patterns in the Zooplankton community of a eutrophic lake in Eastern Washington prior to multiphase restoration. *Journal of Fresh Water Ecology*, 1:615-628.
- Goldman, C.R. and Horne, A.J. (1987). *Limnology*. McGraw Hill Publication, New York, pp 31-464.
- Havens, M.D. (1985) Response of zooplankton, benthos and fish to acidification: An overview. *Water, Air and Soil Pollution*, 85:51-62.
- Ibe, P.A. (1993). A general review of pollution dynamics of aquatic macro-invertebrates of the tropical freshwater system. Unpublished M.Sc. Thesis, University of Jos, Nigeria, pp65-88.
- Idodo-Umeh, G. (2003). *Freshwater Fishes in Nigeria*, (Taxonomy, ecological notes, diet and utilization). Idodo-Umeh Publishers Limited, Benin City, Nigeria, pp230.
- Ita, E.O. (1993). Inland fishery resources in Nigeria. *Food and Agricultural Organization, Occasional Paper*, 20:91-120.
- James, M.D. (2002). Present application and future needs of meteorological and climatological data in inland fisheries and agriculture. *Agricultural and Forest Meteorology*, 103:109-117.
- John, D.M. (1986). The inland waters of Tropical West Africa. *Hydrobiology*, 23:67-69.
- Jonasson, P.M., Lindegaard, C. and Hamburger, K. (1990). Energy budget of Lake Esform, Denmark. *Veterinaria Limnology*, 25:12-31.
- Karabin, A. (1985). Palagic zooplankton (*Rotararia crustacean*) variation. *Polish Archives of Hydrobiologia*, 33(4):567-616.
- Kaunzinger, C.M.K. and Morin, T. (1998). Productivity controls food-chain properties of microbial communities. *Nature*, 395:495-497.

- Kemdirim, E.C. (1987). Limnology and trace element studies in an upland and lowland impoundment in Plateau State, Nigeria. Unpublished Ph.D. Thesis, University of Jos, Nigeria, pp484.
- Kemdirim, E.C. (1990). Periodicity and succession of phytoplankton in an upland and lowland impoundment in Plateau (Nigeria) in relation to nutrient level and physical characteristics. *Journal of Aquatic Sciences*, 5:43-52.
- Kennedy, R.H. and Hains, J.J. (2002). Limnological Assessment of VerkhneViiskii reservoir, Russian Federation. *Journal of Environmental Quality*, 31:2111-2115.
- Kigamba, J.N. (2005). Significance of land use changes in African Lakes. In: Odada E.O. *et al.*, (eds) *Proceedings of the 11<sup>th</sup> World Lakes Conference*, Nairobi, Kenya, 2:427-432.
- Kolo, R.J. and Oladimeji, A.A. (2001). Water quality and some nutrient levels in Shiroro Lake, Niger State, Nigeria. *Journal of Aquatic Sciences*, 19(2):99.
- Lalonde, S. and Downing, J.A. (1992). Phytofauna of eleven microphyte beds differing trophic status, depth and composition. *Canadian Journal of Fisheries and Aquatic Sciences*, 49:992-1000.
- Lamara, V.A. (1980). Digestive activities of carp as a major contributor to nutrient loading in Lakes. *Verhandlungen der Internationale Vereinigung Limnologie*, 19:2461-2462.
- Leopold, L.B. (1974). *Water*. Primer Freeman Publication, San Francisco, USA, pp16-54.
- Lind, O.T. (1979). *A handbook of Limnology Methods*. C.V. Mosby Co. St. New York, pp199.
- Lind, O.T., Doyle, K., Vodopich, D.S., Trotter, B.G., Limon, J.G. and Davalos-Lind, L. (1992). Clay turbidity, regulation of phytoplankton production in large, nutrient rich tropical lake. *Limnology and Oceanography*, 37:349-565.
- Lowe-McConnell, R.H. (1975). *Fish Community in Tropical Freshwater: Their Distribution, Ecology and Evolution*. Longman, New York, pp337.

- Luong-Van and Townsend, S.A. (1996). Retention time as a primary determinate of colour and light attenuation in two tropical Australian reservoir. *Russian Federation Freshwater Biology*, 36:57-69.
- Mackereth, F.J.H. (1963). *Some Methods for Freshwater Analysis for Limnologist*. Freshwater Biological Association Scientific Publications, USA, pp21-71.
- Miranda, L.E. (1999). A review of guidance and criteria for managing reservoirs and associated river environment to benefit fish and fisheries. In: Marmulla, G. (ed) *Dams, Fish and Fisheries: Opportunities, Challenges and Conflict Resolution*, FAO Technical Paper, 419:2001-2067.
- Moreau, T.E. and Da Silva, B. (1991). Predictive fish yield models for lakes and reservoirs of the Philipines, Sri-Lanka and Thailand. *FAO Fisheries Technical Paper*, 319:68-77.
- Needham, J.G. and Needham, P.R. (1975). *A Guide to Study of Freshwater Biology*. Holden-day Incorporated Publication, San Francisco, pp108.
- Odnri, C.S. (1989). *Nigeria, Profile of Agricultural Potential*. National Resources Institute Overseas Development Publication, United Kingdom, pp612.
- Olaniya, C.I.O. (1968). *An Intoduction to West African Animal Ecology*. Heinemann Educational Books, London, UK, pp170.
- Onuma, Y.J., Takahashi, J., Suzuki, K. and Huzitomi, M. (1984). Study on production of benthic animals in Lake Kasumigara. *Res. Rep. Natn. Inst. Envir. Stud.* 53:61-71.
- Orchutt, J.D. and Porter, G. (1983). Dial vertical migration by zooplankton constant fluctuating temperature effect on the life history parameter of *Daphnia*. *Limnology and Oceanography*, 28:720-730.
- Osborne, A.E., Broker, M.P. and Edmando, R.W. (1980). The chemistry of River Wye. *Hydrobiologia*, 45:233-252.

- Owili, M.A. (1999). Zooplankton-fish interaction in the littoral zone of Nyanza Gulf, lake Victoria. *Hydrobiologia*, 25:65-90.
- Pennak, R.W. (1978). *Freshwater Invertebrates of the United States*. John Willey Publication (2<sup>nd</sup>ed), Florida, USA, pp803.
- Peterjohn, W.T. and Correll, D.L. (1984) Nutrient dynamics in an agricultural water shed: observation on the role of a Riparian Forest. *Ecology*, 65:1466-1475.
- Petriere, D.A. (1996). The influence of dams on river fisheries. In: Marmulla, G. (ed) *Dams, Fish and Fisheries: Opportunities, Challenges and Conflict Resolution*. FAO Fisheries Technical paper, 417:47-121.
- Rasaussen, J.B. (1988). Littoral zoobenthic biomass in lakes and its relationship to physical, chemical and tropical factors. *Canadian Journal of Fisheries and Aquatic Sciences*, 45:1436-1437.
- Reid, G.K. (1961). *Ecology of Inland Waters and Estuaries*. Blackwell Scientific Publication, New York, USA, pp376.
- Robbins, J.A., Keilty, T.J., White, D.S. and Edgington, D.N. (1989). Relationship between tubified abundances, sediment composition and accumulation rates in Lake Erie. *Canadian Journal of Fisheries and Aquatic Sciences*, 46:223-231.
- Ruel, J.J. and Ayres, M.P. (1999). Jensen's inequality predicts effects of environmental variation. *Ecology and Evolution*, 14:361-366.
- Saki, H. (1982). *Organic Materials in Aquatic Ecosystem*. CRC Press Publication, Philadelphia, USA, pp210.
- Stephen, T.T. (1994). Benthic-Pelagic interactions in shallow water columns: An experimenter's perspective. *Hydrobiologia*, 275(276):293-300.
- Thomas, R., Meybeek, M. and Beim, A. (1996). Lakes. In: Chapman, D. (ed). *Water Assessment, A guide to use Biota, Sediments and Water in Environmental Monitoring*. (UNESCO-UNEP-WHO, 1996), pp97-104.

- Ufodike, E.B.C., Kwanasie, A.S. and Chude, L.A. (2001). On-set of rain and its de-stabilizing effect on aquatic physico-chemical parameters. *Journal of Aquatic Sciences*, 16(2):91-94.
- Vijverberg, J. and Richter, A.F. (1982). Population dynamics and production of *Daphnia hyaline* and *Daphnia cucullata* (Surs). In: Tjeukemeer. *Hydrobiologia*, 95:235-239.
- Vollenweider, R.A. (1974). In: A manual on methods for measuring primary production in aquatic environment. IBP handbook No12, Blackwell Scientific Publications, Oxford.
- Wade, J.W. (1985) Limnology and trace element studies in relation to primary production in two mine lakes. Unpublished M.Sc. Thesis, Department of Zoology, University of Jos, pp205.
- Wade, J.W. and Anadu (1987). Observation on Sediment water pH conditions and morpho-edaphic index on disuse mining lakes and potentials for fish production. *Nigerian Journal of Applied Fisheries and Hydrobiology*, 2:11-17.
- Wetzel, R.G and Likens, G.E. (1979). *Limnological Analysis*. W.B. Saunders, Philadelphia, pp357.
- Wetzel, R.G. (1975). *Limnology*. W.B. Saunders Company Philadelphia, pp743.
- Wetzel, R.G. (1983). *Limnology*, Second Edition. W.B. Saunders, Philadelphia, pp767.
- Wetzel, R.G. (2001). *Limnology Lake and River ecosystem* (3<sup>rd</sup> edn). Academic Press, San Francisco.

## APPENDICES

### Appendix I: Table showing ANOVA for Physico-Chemical Parameters

Sources of	Degree of	Temperature	Water	pH	Transparency
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<b>variation</b>	<b>freedom</b>	<b>depth</b>			
Station	4	0.062ns	5.36*	0.349ns	0.134ns
Season	1	127.42*	3.46ns	0.894ns	6.159*
Station by Season	4	0.175ns	0.215ns	0.150ns	0.076ns

**Appendix II: Table showing ANOVA for Physico-Chemical Parameters**

<b>Sources of variation</b>	<b>Degree of freedom</b>	<b>Conductivity</b>	<b>Water hardness</b>	<b>BOD</b>	<b>DO</b>	<b>Nitrate-nitrite</b>	<b>Alkalinity</b>
Station	4	0.082ns	0.917ns	9.640*	0.777ns	0.286ns	0.271ns
Season	1	0.019ns	0.203ns	1.949ns	29.845*	0.007ns	1.842ns

Station by Season	4	0.076ns	0.832ns	1.304ns	0.950ns	0.549ns	0.274ns
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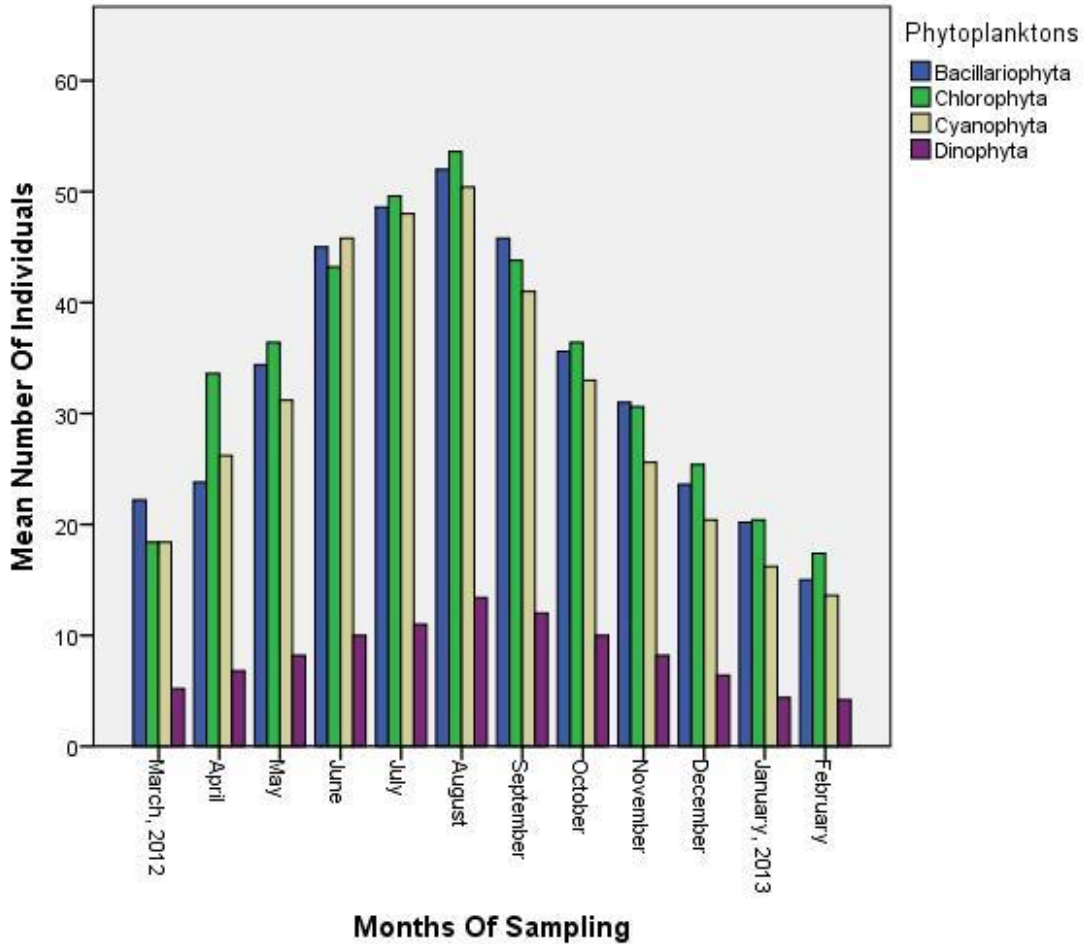
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**Appendix III: Table showing ANOVA for Phytoplankton Parameters**

Sources of variation	Degree of freedom	Chlorophyta	Cyanophyta	Bacillariophyta	Dinophyta
Station	4	11.219**	14.741**	10.246**	14.08**
Season	1	51.496**	59.817**	40.174**	28.688**

Station by 4                      0.529ns                      2.631ns                      2.235ns                      0.965ns  
 Season

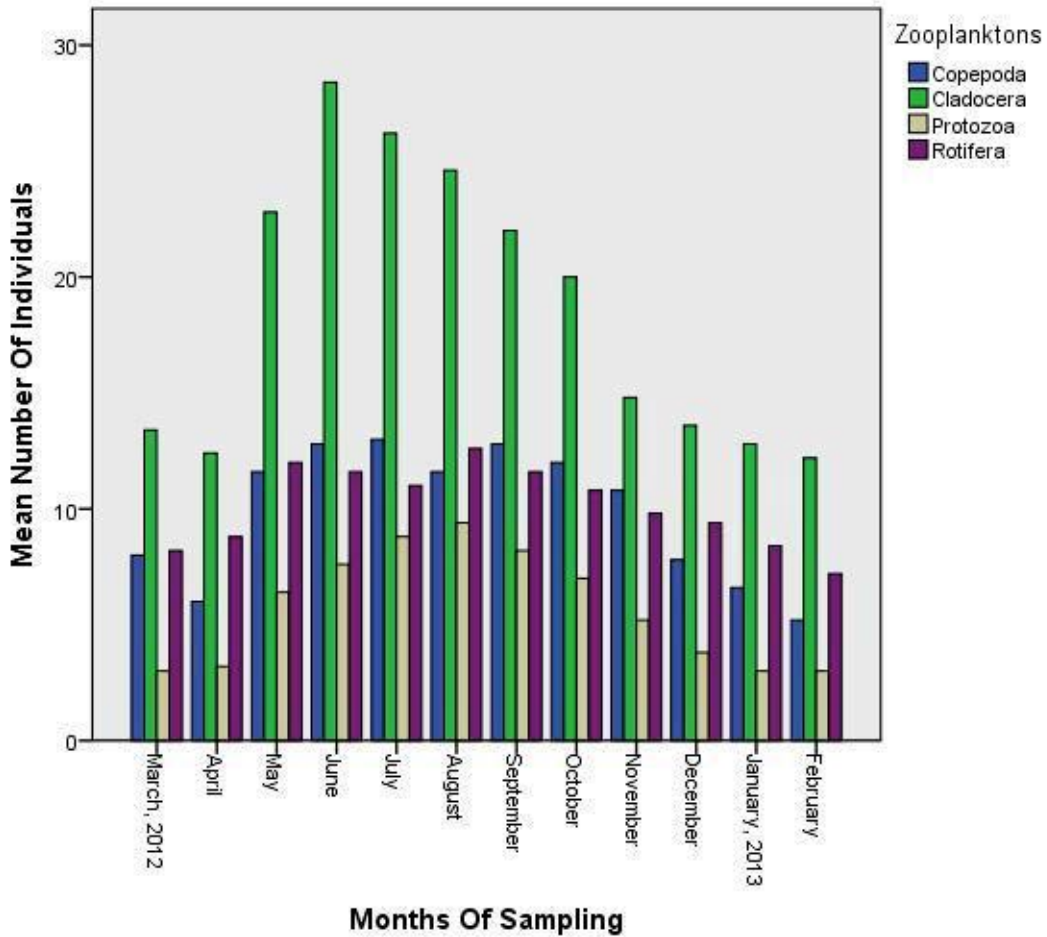
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**Appendix IV: Table showing ANOVA for Zoo Planktons**

Sources of variation	Degree of freedom	Protozoa	Cladocera	Copepoda	Rotifera
Station	4	2.725*	24.678**	18.446**	29.706**
Season	1	28.772**	28.39**	6.347*	11.584**

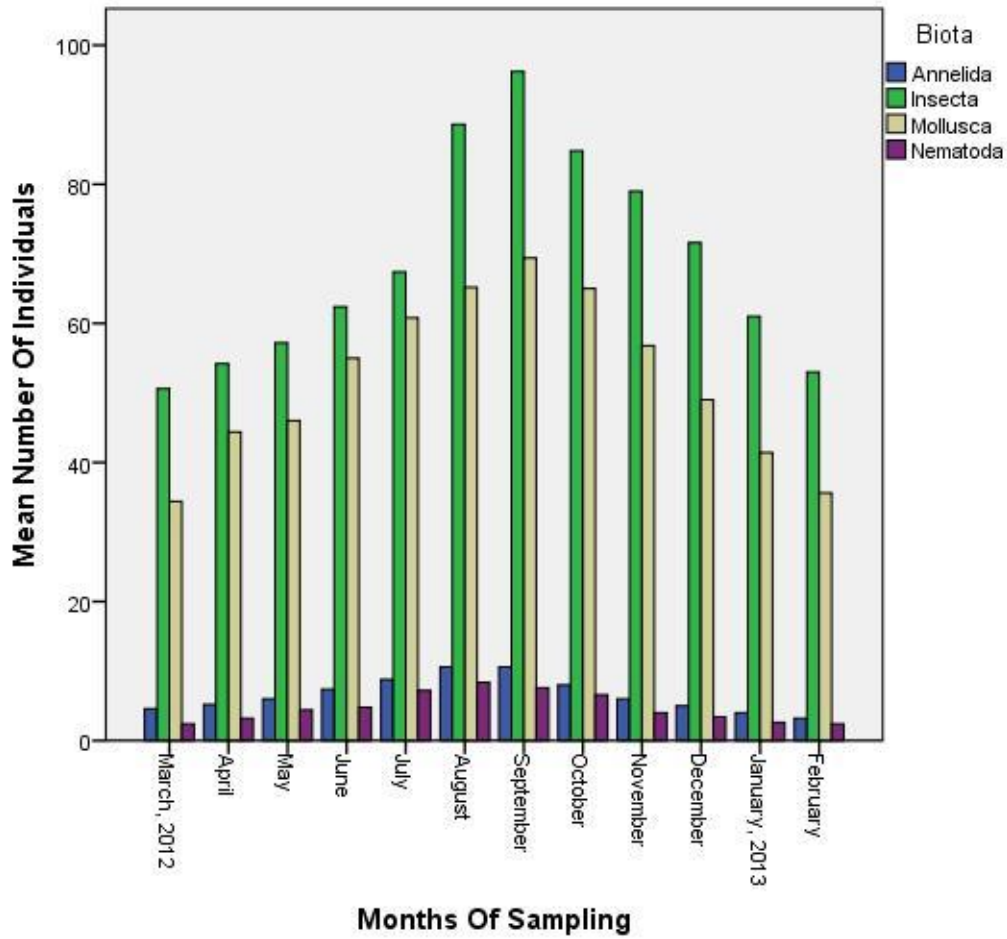
Station by Season	4	1.444ns	2.782*	2.655*	2.934*
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**Appendix V: Table showing ANOVA for Benthic Organisms**

Sources of variation	Degree of freedom	Mollusca	Annelida	Nematoda
Station	4	24.481**	41.342**	18.447**

Season	1	9.139**	21.373**	19.403**
Station by Season	4	0.583ns	0.401ns	0.995ns



**Appendix VI: Pearson's correlation coefficient table for physicochemical parameters.**

	Temp	H <sub>2</sub> O depth	pH	Trans p	Cond H <sub>2</sub> O hardness	BOD	DO	Cl	Ca	Fe	Mg	N	P	Alk
Temp	1													
H <sub>2</sub> O depth		1												
			.293											
			*											

pH	.059	-.105	1																	
Transparen	-.266	-.353	.141	1																
cy																				
Conductivit	.142	.487*	-	-.53**	1															
y		*	.321																	
			*																	
H <sub>2</sub> O	-.142	-	-	.204	-.152	1														
hardness		.279*	.017																	
BOD	.080	-.125	.258	.220	-	.101	1													
			*		.45**															
DO	-	-.187	.130	.479*	-	.270*	.124	1												
	.44*		*		.311*															
	*																			
Cl	.237	-.014	.277	-.285*	-.016	-.180	.072	-	1											
			*					.266												
								*												
Ca	-.030	-.479	.117	.610*	-.67*	.232	.347*	.186	.156	1										
			*				*													
Fe	.036	-.072	-	-.187	.403*	-.109	-	-	-.087	-.186	1									
				.329	*		.303*	.274												
			*				*													
Mg	-.123	-.189	-	.272*	-.072	.180	-.089	.044	.010	.478*	.345*	1								
				.265						*	*									
			*																	
N	.251	.308*	.040	-.36**	.510*	-.025	-.185	-	0.67	-	.354*	-	1							
				*				.162		.47**	*	.16								
P	-.093	-.185	.168	-.016	-	-.008	-.143	-	.260*	.176	-.180	.16	-	1						
					.36**			.004				.09	.20							
												.09								
Alkalinity	-.202	-.146	.042	-.180	-.142	-.069	-.066	-	.507*	.043	-.026	.13	-	.558*	1					
								.146	*			.06	.00	*						

**Appendix VII: Pearson's correlation coefficient table for biological parameters**

	Chlorophyta	Cyanophyta	Bacillariophyta	Dinophyta	Protozoa	Cladocera	Copepoda	Rotifera	Insecta	Annelida	Nematoda
<b>Chlorophyta</b>	1										
<b>Cyanophyta</b>	.681**	1									
<b>Bacillariophyta</b>	.906**	.761**	1								
<b>Dinophyta</b>	.789**	.846**	.844**	1							
<b>Protozoa</b>	.692**	.770**	.793**	.755**	1						
<b>Cladocera</b>	.584**	.618**	.604**	.671**	.700**	1					
<b>Copepoda</b>	.488**	.630**	.556**	.667**	.622**	.847**	1				
<b>Rotifera</b>	.570**	.659**	.617**	.737**	.476**	.571**	.755**	1			
<b>Insecta</b>	.581**	.431**	.596**	.680**	.430**	.475**	.437**	.581*	1		
								*			
<b>Annelida</b>	.618**	.766**	.673**	.895**	.597**	.711**	.743**	.772*	.738*	1	
								*	*		
<b>Nematoda</b>	.643**	.700**	.706**	.834**	.755**	.777**	.770**	.675*	.718*	.870**	1
								*	*		

**Appendix VIII: Monthly mean values of physic-chemical parameters of Sabuwa reservoir**

<b>MONTH</b>	<b>Temp</b>	<b>W. depth</b>	<b>pH</b>	<b>Transp</b>	<b>Conduc</b>	<b>W. hardness</b>	<b>BOD</b>
<b>MARCH, 2012</b>	<b>24.6c</b>	<b>153.6df</b>	<b>7.40a</b>	<b>54.8ab</b>	<b>13.0de</b>	<b>1.7b</b>	<b>4.02a</b>
<b>APRIL</b>	<b>26.6b</b>	<b>171.8df</b>	<b>7.26a</b>	<b>46.8bcd</b>	<b>11.6e</b>	<b>3.5a</b>	<b>4.01a</b>
<b>MAY</b>	<b>28.4a</b>	<b>215.0cde</b>	<b>7.78a</b>	<b>56.6a</b>	<b>13.6de</b>	<b>1.1b</b>	<b>3.89ab</b>
<b>JUNE</b>	<b>28.4a</b>	<b>244.8c</b>	<b>7.85a</b>	<b>36.2ef</b>	<b>18.1cde</b>	<b>1.1b</b>	<b>3.80ab</b>
<b>JULY</b>	<b>29.0a</b>	<b>251.8c</b>	<b>8.00a</b>	<b>41.3de</b>	<b>21.6cd</b>	<b>1.0b</b>	<b>4.08a</b>
<b>AUGUST</b>	<b>28.4a</b>	<b>329.0b</b>	<b>7.61a</b>	<b>20.4g</b>	<b>74.4b</b>	<b>1.2b</b>	<b>3.93a</b>
<b>SEPTEMBER</b>	<b>26.6b</b>	<b>400.6a</b>	<b>6.58b</b>	<b>28.8f</b>	<b>83.0a</b>	<b>1.1b</b>	<b>3.18c</b>
<b>OCTOBER</b>	<b>26.4b</b>	<b>375.6ab</b>	<b>7.74a</b>	<b>39.8de</b>	<b>76.0ab</b>	<b>1.5b</b>	<b>3.21c</b>
<b>NOVEMBER</b>	<b>24.4c</b>	<b>252.6c</b>	<b>7.50a</b>	<b>46.0cd</b>	<b>73.2b</b>	<b>1.8b</b>	<b>3.49bc</b>
<b>DECEMBER</b>	<b>23.2d</b>	<b>225.0cd</b>	<b>7.77a</b>	<b>51.4abc</b>	<b>13.6de</b>	<b>1.7b</b>	<b>3.78ab</b>
<b>JANUARY, 2013</b>	<b>22.4e</b>	<b>203.0cde</b>	<b>7.60a</b>	<b>43.4cde</b>	<b>23.4c</b>	<b>1.4b</b>	<b>3.78ab</b>
<b>FEBRUARY</b>	<b>23.2d</b>	<b>133.8f</b>	<b>7.96a</b>	<b>39.2de</b>	<b>16.2cde</b>	<b>1.6b</b>	<b>3.78ab</b>

Means with the letters within a column are not significantly different using DMRT at 5% level of probability

**Appendix IX: Monthly mean values of physic-chemical parameters of Sabuwa reservoir**

<b>MONTH</b>	<b>DO</b>	<b>Cl</b>	<b>Ca</b>	<b>Fe</b>	<b>Mg</b>	<b>N</b>	<b>P</b>
<b>MARCH, 2012</b>	45.67a	1.96d	24.88c	0.31b	8.39a	0.20c	0.19ab
<b>APRIL</b>	42.14b	2.26d	30.94b	0.29b	9.08a	0.21bc	0.17ab
<b>MAY</b>	40.18cde	5.16ab	38.95a	0.36b	9.30a	0.18c	0.16ab
<b>JUNE</b>	40.13cde	4.76abc	16.23fg	0.26b	5.78bc	0.27bc	0.21ab
<b>JULY</b>	39.67de	3.06bcd	18.02ef	0.27b	6.22b	0.27bc	0.21ab
<b>AUGUST</b>	39.20e	5.72a	15.20g	0.37b	6.12b	0.31b	0.15b
<b>SEPTEMBER</b>	39.10e	2.42cd	10.41h	4.65a	9.34a	0.24bc	0.13b
<b>OCTOBER</b>	42.49b	2.66cd	11.03h	0.27b	5.52bc	0.42a	0.14b
<b>NOVEMBER</b>	41.65b	3.30bcd	18.62e	0.27b	8.54a	0.25bc	0.14b
<b>DECEMBER</b>	42.31b	1.66d	22.00d	0.28b	8.68a	0.20c	0.24ab
<b>JANUARY, 2013</b>	41.49bc	2.00d	18.80e	0.34b	4.40bc	0.18c	0.19ab
<b>FEBRUARY</b>	40.98bcd	6.72a	25.62c	0.28b	9.03a	0.24bc	0.30a

Means with the letters within a column are not significantly different using DMRT at 5% level of probability

**Appendix X: Table showing monthly mean value of biological parameters of Sabuwa reservoir**

<b>MONTH</b>	<b>Chloro</b>	<b>Cyano</b>	<b>Bacilla</b>	<b>Dino</b>	<b>Protozoa</b>	<b>Cladocera</b>	<b>Copepoda</b>
<b>MARCH, 2012</b>	18.4f	18.4ef	22.2cd	5.2ef	3.0f	13.4cd	8.0abc
<b>APRIL</b>	33.6cde	26.2de	23.8cd	6.8de	3.2f	12.4cd	6.0bc
<b>MAY</b>	36.4cd	31.2d	34.4b	8.2cd	6.4cd	22.8ab	11.6abc
<b>JUNE</b>	43.2bc	45.8ab	45.0a	10.0bc	7.6abc	28.4a	12.8a
<b>JULY</b>	49.6ab	48.0ab	48.6a	11.0b	8.8ab	26.2ab	13.0a
<b>AUGUST</b>	53.6a	50.4a	52.0a	13.4a	9.4a	24.6ab	11.6abc
<b>SEPTEMBER</b>	43.8abc	41.0bc	45.8a	12.0ab	8.2abc	22.0ab	12.8a
<b>OCTOBER</b>	36.4cd	33.0cd	35.6b	10.0bc	7.0bcd	20.0bc	12.0ab
<b>NOVEMBER</b>	30.6de	25.6de	31.0bc	8.2cd	5.2de	14.8cd	10.8abc
<b>DECEMBER</b>	25.4ef	20.4ef	23.6cd	6.4def	3.8ef	13.6cd	7.8abc
<b>JANUARY, 2013</b>	20.4f	16.2f	20.2d	4.4ef	3.0f	12.8cd	6.6abc
<b>FEBRUARY</b>	17.4f	13.6f	15.0d	4.2f	3.0f	12.2d	5.2c

Means with the letters within a column are not significantly different using DMRT at 5% level of probability