ASPECTS OF PHYSICO-CHEMICAL PARAMETERS AND PHYTOPLANKTON ASSEMBLAGE OF RIVER SAYE, ZARIA, KADUNA STATE, NIGERIA

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARDOF MASTER OF SCIENCE DEGREE IN EDUCATIONALBIOLOGY

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DEDICATION

This dissertation is dedicated to my father, Alhaji Salisu Abdullahi Bichi, who bestowed upon me the wisdom, strength and courage throughout this program and to all my siblings.

DECLARATION

I hereby declare that the work in this dissertation entitled **ASPECTS OF PHYSICO-CHEMICAL PARAMETERS AND PHYTOPLANKTON ASSEMBLAGE OF SAYE RIVER, ZARIA, KADUNA STATE, NIGERIA**was carriedoutme in the Department of Biological Sciences. The information derived from the literaturer has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another in thisor another institution. I take exclusive responsibility for all errors and over sights in this write-up.

Abubakar Salisu ________________________ ___________________

Signature **Date**

CERTIFICATION

This dissertationentitled “ASPECTS OF PHYSICO-CHEMICAL PARAMETERS AND PHYTOPLANKTON ASSEMBLAGE OF RIVER SAYE”by Abubakar Salisu meets the regulations governing the award of the degree of masters of Science (M.Sc.) of the Ahmadu Bello University Zaria and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Water quality is important to man because it is directly associated to human health. The presence of phytoplanktons in water bodies has led contamination. In this study, selected physico-chemical parameters andthe phytoplankton assemblage of River Saye, Zaria, Kaduna state were investigated for a period of one year between April 2014 and March 2015 from five sampling stations. The study was aimedat establishing the physical, chemical and phytoplankton parameters of the river. The phytoplanktons were collected using using silk plankton net of 25 cm diameter of 70 µm meshes attached to a bottle of fiffty (50 ml) capacity at the base,preserved in 4% formalin and stanined with Lugol's iodine solution. It was then mounted on a compound microscope for identification using text book key and Robert perry guide line or key.The physicochemical were determined using standard methods. The mean values of the physico-chemical parameters were temperature (27.62±0.16°C), pH (8.56±0.20), electrical conductivity (EC) (121.80±49µs/cm), total dissolved solid (TDS) (64.43±2.52mg/l),dissolved oxygen (DO) (4.18±0.14mg/l) biochemical oxygen demand (BOD) (3.02±0.16mg/l), hardness (213.30±6.46mg/l), alkalinity (42.43±1.37mg/l) and chloride (38.84±1.25mg/l). Phosphate (0.20±0.01mg/l) which exceed the acceptable level of 0.10mg/l for natural water bodies and nitrate (0.20 ± 0.01). The means of all the measured physio-chemical parameters were highly significant ($P<0.01$). The phytoplanktons were more prevalent during dry season and there were variations in their composition and abundance along the river. Four groups of phytoplanktonin River Saye were recorded namely; Bacillariophyta with (25 genera), Chlorophyta (18 genera) Cyanophyta (9genera), Euglenophyta (3 genera). Bacillariophyta dominated numerically (47.50%), followed by Chlorophyta (36.16%) then Cyanophyta (12.98%) and Euglenophyta the (3.36%)learst. The distribution of phytoplankton between

the Stations showed that stations 1, 2, 4 and 5 had higher phytoplankton than station 3. The presence of Navicula, Synedra, Anabaena, And Euglena indicate high level of phosphate pollution (synifying organic pollution). While the presence of Melosira, Scenedesmus, Oscillataria and Anabaena indicates nutrient enrichment of the river. And the presence of harmful plankton species like Coscinodiscus, Melosira, Navicula, Nitzschia, Pleurosigma, Synedra, Nodularia, Anabaena and Oscillatoria indicates that the river is highly disturbed. Generally, the phytoplankton community composition of the river indicated that the river is moderately polluted.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Water sustains life. The quality of water is of vital concern to mankind because it is directly linked with human health. Presently, the menace of water borne diseases and epidemics is becoming serious both in developed and developing countries, due to the dumping of human and animal wastes into the aquatic environment and pollution from other sources, thereby making it unsuitable and unsafe for domestic, especially drinking purposes (WHO, 2002). Water serves different functions ranging from serving as solvent for most chemicals to serving as habitat to many organisms. For instance, some insects and amphibians use water as their breeding sites while it serves as an agent of dispersal for many plant seeds and fruits. The biological diversity of aquatic areas is neglected world- wide, needs protection from human excesses of pollution and over exploitation (Ajuzie, 2012).Limnology (Limne'lake' and logos, 'knowledge') often regarded as a division of ecology or environmental science. That covers the physical, chemical, biological and other attributes of all inland waters (running and standing waters, fresh and saline, natural or man-made). This includes the study of lakes, ponds, rivers, springs, streams and wetlands with all the factors that influence living populations within those water bodies(Gupta *et al.*, 2006).They are the main primary producers and they condition the structure and density of consumers as well as hydrochemical properties of water and the community varies widely in respect to taxonomic composition and cell size and their density increase with increasing nutrient status or trophic state (Harold *et al.*, 2007).

Phytoplankton are very suitable organisms for the determination of the impact of toxic substances on the aquatic environment, when encountered in water body they reflect the average ecological condition and therefore, they may be used as indicator of water quality (Akbulut and Yilidis2001). Knowledge of phytoplankton population dynamics is relevant because temporal and spatial fluctuations in composition and biomass may be efficient indicators of natural or anthropogenic alteration in the aquatic ecosystems. Phytoplankton is the chief primary producer of the aquatic environment which fixes solar energy by the process of photosynthesis, assimilating carbon dioxide and water to produce carbohydrates. Phytoplanktonic species have different physiological requirements and thus show diverse responses to physical and chemical parameters such as light, temperature and nutrient regime, their sensitivity and variations in species composition are often a reflection of significant alteration in ambient condition within an ecosystem (Prescot; 2004; Olele and Ekelemu, 2008).

Nigeria is richly blessed with a vast area of inland waters. The total surface area of water bodies in Nigeria is estimated to be 550,000 hectares (13,000km^2) and this constitutes about 15.9% of the total area of Nigeria (Ekiye, 2010). These include both natural and man-made lakes, reservoirs, Floodplains and cattle ponds, rivers and streams; but exclude deltas, estuarine and miscellaneous wetlands suitable for rice cultivation. The composition and density of aquatic organisms depends on the geographical and water quality of the aquatic .which habitat can be adversely affected by human activities (Oben, 2000; Atobatele and Ugwumba, 2008).

Rivers are considered favourable environments to the development of plankton communities, which may establish diverse assemblages in relatively short periods of time after impoundment (Rocha *et al.,* 1999). Several factors usually contribute to the establishment of plankton communities in a reservoir, among which are good water quality, presence of nutrients, physicochemical factors of water, hydrological characteristics of the reservoirs and reservoir ageing. Phytoplankton are usually at the base of aquatic food web and are the most important factor for production of organic matter in aquatic ecosystem. Most reservoirs will require significant amount of plankton to have productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are structured by these factors. Thus any perturbations in these factors may affect their assemblage which could have a significant impact on water quality and fishes in reservoirs (Mustapha,2011). Phytoplankton are microscopic aquatic plants, occurring as unicellular, colonial or filamentous forms, without any resistance to currents and are free-floating or suspended in the open water (Hassan and Saadi, 2001). They are important water quality indicators because of their short life cycles, and ability to respond to environmental changes, hence, their standing crop and species composition indicate the quality of water (Abagai and Tiseer,2011). The change in abundance species diversity and community composition of Phytoplankton indicates environmental changes like pH, temperature, nitrate, phosphate total dissolved salt, nutrient levels, and alkalinity are sensitive indicators of pollution in comparison with phytoplankton (Abagai, 2011).

Freshwater phytoplankton communities are important sentinel of environmental changes. Since they integrate the effects of increased nutrient loads, and they can be more sensitive to the combined impacts of stressors than a single stressor(Sagert *etal.*, 2008). In the coastal zone, the water quality and its biological communities are subjected to enormous spatio-temporal variations caused by natural factors and anthropogenic activities. Identifying the key variables cannot be easily achieved by traditional ecology method. In contrast, multivariate statistical analysis through clustering and ranking base on species and environment data could successfully identify the key factors from the environmental variable in the marine environment and other aquatic ecological research.

Reservoir communities of phytoplankton constitute the basis of the aquatic food chain. This is because they are primary producers which sustain populations of primary consumers that include zooplankton, some macroinvertebrates and fishes. The composition and abundance of plankton communities may provide a hint on the health status of a reservoir (Watson, 2004). Presently, our knowledge on the phytoplankton communities of River Saye is limited because of none availability of information on the present coencies composition, diversity, abundance and distribution of these organisms in the reservoir.The monitoring of physico-chemical characteristics of a water body is vital for both long term and short analyses (Wood, 1995). Distribution and productivity levels of organisms in any water body are largely determined by physicochemical factors which also have direct effect on productive potentials of fish species (Adakole, 2002). Highlightsthe factors influencing the distribution, the survival and abundance of diverse species of organisms in water.

1.2 Statement of the Research Problem

Phytoplankton have been reported to contaminate several water bodies and has been associated with certain diseases (Chia and Oniye, 2013).The anthropogenic inputs from neighboring communities such as run-offs from agricultural farms containing manures and fertilizers are the of several river systems. These inputs can cause serious effect on the water quality and subsequently affect the biodiversity of organismswithin the river. The role of nutrients, in controlling seasonal succession of phytoplankton composition and diversity, in the River has not been documented (Mustapha, 2010).

There is little information available on the physico-chemical parameters and phytoplankton assemblagein River Saye.

1.3 Justification

This study on the physico-chemical parameters and phytoplankton community of River Saye was initiated in order to provide baseline information on the quality of the water and to propose best management practice that will enhance the productivity of the water. Plankton are very sensitive to the environment they live, any alteration in the environment leads to the change in the plankton communities in terms of tolerance,diversity distribution, and dominance in the habitat. The species composition, distribution, diversity and relative abundance of phytoplankton of River Saye could have significant impact on fisheries and public health of the river and its users (Mustapha a, 2010). Therefore, plankton population observation may be used as a reliable tool for bio monitoring studies to assess the pollution status of aquatic bodies. Also the results of the study will be used to enlighten the community within the vicinity of River Saye on the effects of their activities on this water body.

1.4 Aim of The Study

The aim of the research was to study the Physico-chemical characteristics and diversity of phytoplankton assemblage of River Saye, Zaria.

1.5 Objectives of the Study

The specific objectives are to;

i. Determine the monthly seasonal spatially variation of the physico-chemical parameters of River Saye
ii. Assess the Species composition, diversity, abundance and distribution of phytoplankton community of River Saye.
iii. Determine the relationship between the physico-chemical Parameters and phytoplankton community of River Saye.

1.6 Hypotheses of the Study

There is no significant difference in;

i. Physico-chemical characteristics between the month, seasons and sampling stations.
ii. Abundance of phytoplankton between months, seasons and sampling stations.
iii. Between the physico-chemical parameters and phytoplankton community of River Saye.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water

Water is an elixir of life. It governs the evolution and function of the universe on the earth and most available water on the earth is saline in nature; only small quantity is freshwater. Freshwater has become a scare commodity due to over exploitation and pollution (Singh and Mathur, 2005). Pollution is caused when a change in the physical, chemical or biological condition of the environment is altered and affected quality of human life including other (Okoye*et al.,* 2002). Industrial, sewage and municipal wastes have been continuously added to water bodies hence affect the physiochemical quality of water making them unfit for use of livestock and other organisms (Dwivedi and Pandey, 2002). Water resources are of critical importance to both natural ecosystem and human development.It is essential for agriculture, industry and human existence. The healthy aquatic ecosystem is dependent on the physicochemical and biological characteristics (Ventatesharaju *et al*., 2010). The quality of water in any ecosystem provides significant information about, the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physic-chemicaland biological characteristics. Monitoring of these parameters are essential to identify the magnitude and source of any pollution load. These characteristics can identify certain condition for ecology of living organism and suggest appropriate conservation and management strategies. Many researches are being carried out till present day: seasonal influence of limnological variables on plankton dynamics of a small, shallow, tropical African reservoir Mustapha b (2010).Survey of phytoplankton and evaluation of some physicochemical properties of Challawa River Kano State Nigeria, (Ibrahim 2009) Physicochemical characteristics and phytoplankton abundance of lower Niger River, Kogi State, physico-chemical factors and their influence on fish species composition in Asa Lake, Ilorin.(Araoge, 2008).

2.2 Temperature

Temperature is one of the most important and essential parameters of aquatic habitats because almost all the physical. Chemical and biological properties are governed by it. Temperature influences the oxygen contents of water, quantity and quality of heterotrophs.Temperature affects the rate of photosynthesis directly and indirectly affects the carbon dioxide and oxygen production and utilization. The temperature of water varies throughout the year and with seasonal changes in air temperature, day length, and solar radiations. Animals are stressed when temperature changes rapidly, because there is no enough time for physiological adaptation (Boyd, 2000). The significance of bright sunlight and temperature helped in production of green algae.Temperature is one of the most important factors in the aquatic environment (Singh and Mathur, 2005). The temperature plays a crucial and biological behaviour of aquatic system. Temperature has no direct effect on aquatic life up to 39°C in the river, while observed that Solubility of Oxygen in the water increased when water temperature decreases. The water level correlates negatively with core depth. During the rainy season (Adakole *et al.,* 2009).

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

2.3 pH

The pH expresses the acidity or alkalinity of water which is determined by means of hydrogen ion (H) and the hydroxyl ion concentrations in water. Water of around pH 7 is, neutral below this value,water is acidic and above is alkaline. During daylight, aquatic plants usually remove the carbondioxed(CO_2) from the water quickly and pH increases. At night, carbondioxed(CO_2) accumulates and pH declines (Mahar, 2003). pH value is very important for plant growth. (Umavathi *etal.*,2007).

Differences in water pHimpacts on phytoplankton occurrence and diversity. The productivity of water bodies in Nigeria with respect to fish catch and other aquatic animals have been affected also by changes in pH. Water with pH of 6.5 to 9.0 have been considered suitable for aquaculture (Boyd and Lichkoppler, 1979).The toxicity of trace metals in aquatic environments are influenced by changing pH values which negatively affects aquatic diversity (Kemdirim, 1987).Sudden changes in pH can stress orkill aquatic animals even when thosechanges occur within a pH range theynormally tolerate (Tucker and Abramo, 2008).

pH ranged 5 to 8.5 is best for plankton growth. Decrease in pH may probably be due to the stirring effect of the incoming flood from the rivers and streams that converged towards the lake resulting in the mixing of the poorly alkaline or acidic bottom water with alkaline surface water to reduce pH Also, the decrease in pH of surface watermay arise from decomposition of the inundated terrestrial vegetation of the littoral zone following increased water levels. Decomposition reduced the amount of oxygen, while increasing the amount of carbon dioxide in the affected environment.This accounted for the positive correlation between pH and dissolved oxygen (Araoye, 2009).

2.4 Electrical Conductivity

Conductivity of natural water is a measure of its ability to convey an electric current. Specific conductivity can be utilized as a rapid measurement of dissolved solids and is useful in monitoring waste streams and conducting field water quality studies (Fatoki *et al.,* 2003). The level of conductivity in water gives a good indication of the amount of joinable substances dissolved in it, such as phosphate, nitrate and nitrites. Different ions vary in their ability to conduct electricity, but generally, conductivity of the natural water is directly proportional to the concentration of ions. Distilled water has a conductivity of about 1 ions/cm, while natural water normally has conductivity of 20- 1500 µs/cm (Fatoki and Gogivane 2003).

The source of electrical conductivity of any water is due to the abundance or dissolved salts, minerals from rain water, runoff, or other discharges. Electrical conductivity is also the measure of a materials ability to allow the transport of an electrical charge. Total Dissolved Solids (TDS) or salinity. At about 0.3 µs/cm is the point as which the health of some crops and fresh water aquatic organisms will to be affected by the salinity.

Salinity refers to the presence of dissolved inorganic ions such as magnism ion(Mg^{++}), calcium ion ($Ca)^{++}$, potassium ion(K^{+}), sodium ion (Na^{+}), carbon and fluoride ion (CF^{-}), sulphate ion($S0_2^{4-}$), Hydrocarbonate ($HC0_3$) and carbonate ion CO_3^{2-} in the aqueous solution or soil matrix. The salinity is quantified as the total concentration of soluble salts and is expressed in terms of electrical conductivity. There exists no in-situ salinity probe (based on electrical conductivity alone) that can distinguish between the different ions that may be present (Boyd, 2000). When salts such as sodium chloride are in their solid form, they exist as crystals. Within the salt crystal, the sodium and the chlorine atoms are joined together in what is called an ionic chemical bond. An ionic chemical bond holds the atoms tightly together because the sodium atom will give up an electron to the chlorine thus ionizing the atoms. If an atom like sodium gives up an electron, it is said to be a positively charged ion (also called a cation). If an atom such as chlorine receives an electron, it is said to be a negatively charged ion (also called an anion and is given the suffix' ide,' like chloride). The sodium and the chloride ions comfortably arrange themselves into a stacked like configuration called a crystal lattice. The sodium chloride crystal lattice has a zero net charge(Singh and Mathur, 2005). Water will dissolve the sodium chloride crystal lattice and physically separate the two ions. Once in solution, the sodium ion and the chloride ion will float around in the solution separately and randomly. This is generally true for all inorganic salts. Once in a solution, the ions will float apart and become two separate species dissolved in the water. Typical, charged ions exist separately in a solution. If the water dries up, the cations and the anions will find each other and fuse back into a crystal lattice with a zero net charge.

2.5 Total Dissolved Solids (TDS)

Total dissolved solids indicate organic and inorganic matter in a sample. It is aggregated amount of the entire floating suspended solids present in water sample. The solids may be organic or inorganic in nature depending upon volatility of the substances. A high of dissolved solids increases the density of water affects osmo-regulation of fresh water organisms, reduces solubility of gases and utility of water for drinking, irrigational and industrial purposes (Garg *et al*., 2006). According to Rao *et al*. (2003). TDS has great implication in the control of biological and physical waste water treatment processes.

2.6 Hardness

Hard water contains high concentrations of alkaline earth metals while soft water has low concentrations of such meals. Hardness usually includes only calcium ion(Ca^{2+}) and magnisum ion (Mg^{2+}) expressed in the terms of equivalent calcium carbonate C_aCO_3. Total hardness of 15ppm or above are satisfactory for the growth of fish and do not require liming but water having less than 11lppm require liming for higher production of fish. Water having hardness less than 5ppm calcium carbonate $CaCO_3$ equivalent cause low growth, distress and eventually death of fish Total hardness value, which is the sum of calcium and magnesium hardness concentrations, was found to be significantly higher in the wet season; this was the same for calcium and magnesium ions (Mustapha, 2009).

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

2.7 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) has primary importance in natural water as limiting factor because most organisms other than anaerobic microbes diminish rapidly when oxygen levels in water falls to zero, of all dissolved gases, oxygen plays the most important role in determining the potential biological quality of water. It is essential for respiration, helps the breakdown of organic detritus and enables completion of biochemical pathways (Indabawa, 2010). In general, the concentration of dissolved oxygen will be the result of biological activity. Photosynthesis of some aquatic plants will increase the dissolved oxygen during day light hours and the dissolved oxygen levels will fall during the night time hours. In natural water, man-made contamination, or natural organic material will be consumed by micro-organisms. As this microbial activity increases, oxygen will be consumed out of the water by the organisms to facilitate their metabolic digestion process. The water that is near the sediment will be depleted of oxygen for this reason. In waters contaminated with fertilizers, suspended material, or petroleum waste, microorganisms such as bacteria will break down the contaminants. The oxygen will be consumed and the water will become anaerobic. Typically dissolved oxygen levels less than 2 mg/Lwill kill fish (Indabawa, 2010).

Oniye *et al.* (2012) reported that, the cool harmattan wind which increases wave action and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season, while the torrential rains, created increased turbidity and decreased oxygen concentration during rainy season. Ibrahim *et al.* (2009) reported that.The cool harmattan wind which increases wave action, and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season. Decomposition reduced the amount of oxygen, while increasing the amount of carbon dioxide in the affected environment. This accounted for the positive correlation between pH and dissolved oxygen distribution followed a similar annual cycle with the pH. The high oxygen concentration recorded during the dry season was due to an enhanced photosynthetic activity and reduced turbidity during the dry season. The drop in dissolved oxygen concentration in October /December was as a result of the vertical mixing due to low surface water temperatures that accompanied the harmattan season (Rao. 2005). Rani *et al.* (2004) also reported lower values of dissolved oxygen in summer season due to higher rate of decomposition of organic matter and limited flow of water in low holding environment due to high temperature.

2.8 Phosphate-Phosphorus ($P0_4$)

Phosphorus is one of the most important major nutrients that are required by living organisms, although needed in small amount it is one of more common phytoplankton growth elements (Bade *et al.*, 2004). Phosphorus enters lakes as inorganic phosphate ions, inorganic polymer and organic phosphorus compounds in living micro-organisms and dead detritus. Some organic forms of phosphorus are relatively unreactive and would not be detected by analyses for phosphates. Organic phosphorus can dramatically affect the algal growth; therefore, it may he more appropriate to evaluate total phosphorus as opposed to the reactive phosphates. Some microorganisms will uptake only inorganic phosphates; in this case, measurement of reactive phosphates may be a better indicator of water quality than total phosphorus. Ideally, phosphates and total phosphorus should both be evaluated when assessing a water system Rani *et al.*, (2004).

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

2.9 Nitrate-Nitrogen (NO_3^-)

Nitrate-nitrogen is required in aquatic and terrestrial ecosystem in a moderate quantity. Nitrate ion NO_3^-) is the common form of nitrogen in natural waters. Nitrite ($N0_2^-$) will oxidize into nitrate after entering an aerobic regime. The amount of nitrate in solution at a given time is determined by metabolic processes in water; that is production and decomposition of organic matter (Balarabe. 2001). Kigamba (2005) reported the increased level of nitrates leached into African lakes from the excessive use of nitrogen fertilizers. The most highly oxidized form of nitrogen compounds is commonly present in surface and ground water because it is the end product of aerobic decomposition of organic nitrogenous matter. Unpolluted natural waters usually contain only minute amounts of nitrate (Jaji *et al.*, 2007). In the environment, nitrate will become toxic to fish at about 30 mg/L. Nitrate pollution will cause eutrophication of a stream where algae and aquatic plant growth will consume the oxygen and increase the total dissolved solid of thewater. Eutrophication is usually the result of nitrate and phosphate contamination and is a significant reduction of water quality. Nitrate can exist naturally in groundwater but can increase dramatically on irrigated lands if the irrigation operation is not managed properly. Groundwater contaminated with nitrate can contaminate sources of drinking water in wells, and will contaminate the surface water as the ground water recharges streams and lakes. As more land is converted into agricultural land and as urban areas expand; nitrate monitoring is an important tool in accessing locating and mitigating man made sources of nitrate (Jaji*etal*., 2007).

2.10 Biological Oxygen Demand (BOD)

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

Biological oxygen demand (BOD) is a measure of the oxygen used by micro-organisms to decompose waste. There is a large quantity of organic waste in water supply, there will also be a lot of bacteria present working to decompose waste. In case, the demand for oxygen will be high, the BOD level will be high. As the waste is consumed or dispersed through the water, biochemical oxygen demand levels will begin to decline. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level. When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in water is being consumed by bacteria, since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive (Thirupathacah, 2012).

2.11 Alkalinity

Alkalinity refers to the capability of water to neutralize acids. This is really an expression of buffering capacity. A buffer is a solution to which an acid can be added without changing the concentration of available Hydrogen ion(H^+) appreciably. It is essentially absorbs the excess H^+ and protects the water body from fluctuations in pH (Lindsery, 2010). Generally, the basic species responsible for alkalinity in water are bicarbonate ion, carbonate ion and hydroxyl ion (Manahan, 1993). The presence of calcium carbonate or other compounds such as magnesium carbonate contribute to the buffering system, minor contributors to alkalinity are ammonia and conjugate bases of phosphoric. silicic, boric and organic acids (Lindsery., 2010).

Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks (lime stone) which are mostly $CaCO_3$. Since hard water contains metal carbonate (mostly $CaCO_3$) it is high in alkalinity, conversely, unless carbonate is associated with sodium or potassium which do not contribute to hardness. Soft water usually has low alkalinity and little buffering capacity. So generally, soft water is much more susceptible to fluctuations in pH from acid rains or acid contamination (Lipkowaska *et al.*, 2006). It is important to distinguish between high basicity manifested by an elevated pH and high alkalinity and the capacity to accept Hydroden(H), whereas pH is an intensity factor, alkalinity is a capacity factor. Alkalinity is important for chlorophyta and aquatic life because it protects or buffers against rapid pH changes. Living organisms especially aquatic life function best in a pH range of 6.0 to 9.0.

2.12 Chloride (Cl^-)

Chloride is generally present in all natural surface waters, from as low concentration as Ctl3n of mg/l to thousand mg/dm^3. Chlorides are present in natural waters due to high solubility of salts of muriatic acid. They are also commonly found in the environment. The lowest concentrations of chlorides arc in rain water, mountain streams and rivers, while the highest concentration of the salt is found in marine waters. However, high concentrations may also be found in ground water because of naturally high levels of chloride in soils in some areas (Hujare, 2008).

Generally, chlorides penetrate into natural water from soil, natural layer of salt municipal and industrial sewage and waste of animal origin. Chlorides are not removed in typical sewage treatment processes and they entirely pass into surface water deteriorating their quality. In case of determination of chloride content in water it is necessary to define their origin, if natural or pollution. In case of water pollution together with chloride high concentration of nitrogen compounds and increase in quantity of bacteria occurs (Gupta *et al.,* 2006). There is no evidence that ingestion of chloride is harmful to humans. High chlorides concentration increase corrosive properties of water (Umavathi *et al.,* 2007).

2.13 Studies on Phytoplankton

Phytoplankton are the autotrophic (self-feeding) components of the plankton community and a key part of oceans, seas and freshwater basin ecosystems. The name comes from the Greek word phyton, meaning "wanderer" or "drifter". Most phytoplankton are too small to be individually seen with the unaided eye. However, when present in high enough numbers, some varieties may be noticeable as colored patches on the water surface due to the presence of chlorophyll within their cells and accessory pigments (Roger, 2009). Phytoplankton are responsible for 50 percent of all photosynthetic activity on earth. They can be divided into two division which include phototrophic bacteria (which is made up of purple sulphur bacteria and green sulphur bacteria) and algae (which are made up of Bacillariophyta, Euglenophyta, Cyanophyta, Chlorophyta, Chrysophyta, Phaecophyta and Purrophyta). Their composition and abundance is highly dependent on the availability of sunlight, carbondioxide and nutrients such as nitrate, phosphate and silicate, these factors influence their density and distribution throughout the water column. Phytoplankton is very important because they form the base with which the aquatic ecosystem is culminating (Regnolds, 2010). They are a source of food to almost all aquatic life either directly or indirectly. In aquaculture, they serve as a food stock for zooplankton which are in turn fed to fish larvae reared in fish hatcheries (Moncheva and Parr, 2010). According to Lindsey and Scott(2010) reported data that as beneficial as phytoplankton are, they could also be harmful-under certain condition such as pollution of water body with sewage and human excreta, certain harmful phytoplankton predominate, and produce bio-toxins which affect the taste and cause disease there by causing massive fish kills, example of such harmful phytoplankton include: (cyanophyta cyanobacteria or blue-green algae) which produce geosmin which is a toxin that impacts a bad flavour on fish especially bottom dwellers (such as catfish and carp), Rhodophyta which causes red tides following massive fish kill. Since phytoplankton are the primary producers forming the first tropic level of food chain in aquatic, investigation of the phytoplankton community of great importance for monitoring them.

Algae, like higher plants, obtain energy by photosynthesizing; especially producing their food by capturing the energy from the sun. Many algae store energy in the form of starch. Other algae use other compounds and distinction between some alga groups is based upon which compound that they use to store energy. For example, Rhodophyta (red algae) store energy in the form of floridean starch, whereas the Phaeophyceae (brown algae) store their energy in the form of laminarin. The green color of algae derives from the dominance of chlorophyll as a photosynthetic pigment. The other colors of many algae do not mean that they lack chlorophyll but that the chlorophyll is masked. These algae have necessary photosynthetic pigments which conceal the green color of chlorophyll. Rhodophyta contains the pigment phycobin, giving it a red color, while the group Chrysophaeceae contains the pigment fucoxanthin which gives them a golden color. All phytoplankton are members of the Kingdom Protista, which have eukaryotic cells (with a true nucleus) with the exception of the Cyanobacteria or Cyanophyta, which belong to the Kingdom Monera, and prokaryotic cells (without a true nucleus) (Mageed, 2015).

Phytoplankton, have long been used as indicator for water quality. Because of their short life span and quick responses to environmental changes thancrop plants, their species composition indicate the quality of water in which they are found (Mercado, 2003). Clean water supports a great diversity of organisms, whereas, very few organisms survive in polluted water with one or two dominant forms (Saladia, 1997). Phytoplankton constitutes the basis of nutrients cycle of an ecosystem hence play an important role in maintaining equilibrium between living organisms and biotic factors (Wetzel, 2001).

2.13.1 Bacillariophyta

Bacillariophyceae are very abundant and are commonly known as Diatoms**.** The word "Diatom" comes from the Greek *Dia*, = across, and *tom*, = to cut. This refers to the fact that diatoms are enclosed within two glass silicate oxzide (SiO_2) shells which split across the middle and separate from each other during reproduction. One shell is older (the epitheca) is slightly larger than the other, younger shell (the hypotheca). Under the microscope most diatoms will appear green or golden green, and their frustules are as clear as the glass which makes them. When diatoms are exceptionally abundant in the surface water, the ocean will appear very green. Some species like *Coscinodiscus* are solitary, while others like *Chaetoceros* form long chains. They occur in oceans, freshwater, on damp rocks or in the soil. The majority of the ocean's phytoplankton consists of diatoms and they are usually abundant in the very nutrient-rich areas of the ocean (Guiry 2009). Diatoms are one of the most important groups of producer organisms in the marine ecosystem. They inhabit the illuminated upper 200 meters of most oceans and help form the base of the food chain using photosynthesis to convert solar energy into chemical bond energy. Diatom species are both solitary and free, attached to a substratum by gelatinous extrusions, or joined to each other in chains of varying length. Many diatoms convert the carbohydrates that are produced during photosynthesis into oils. These oils are less dense than the surrounding seawater and, thus, help buoy the diatoms upward into the illuminated photic zone to form long chains in the ocean. Some chain-forming diatomspecies prevent sinking through the growth of spiny extensions (the setae or chaetae). During population explosions or "blooms" of these spiny diatoms they may damage the sensitive gills of fish and other animals (Robert,2003). A small handful of diatom species are also toxic to marine animals and humans. Species such as *Pseudo- nitzschia* produce a poisonous chemical known as Domoic Acid (DA). DA is known to cause Amnesic Shellfish Poisoning (ASP) a neurological disorder that affects pelicans, sea lions, and other marine animals including humans. DA builds up inside the tissues of filter-feeding invertebrates such as mussels and clams, which, if eaten during periods of high concentrations of DA, can cause death in humans (Robert, 2003).

Importance of Bacillariophyceae

1. The paper industry uses white kieselgur for absorbing ink without discoloring; the insulation industry can use any type of purity while the chemical industry uses only the highest grades.
2. Other major industrial uses of diatoms include isolation and filtration. The extremely high surface area and porosity make diatomite an excellent filtering material and the wine and beer industries uses it in their filtration processes (Maberly 2008).

2.13.2 Chlorophyta

The Phylum Chlorophyta are known as the green algae. Most of them live in freshwater, but there are many marine species. Green algae occur in a brand range of habitats. They attach themselves to rocks or plants on the benthos, or form free floating mats or balls of filaments. Some green algae form large plant-like structures called seaweeds, while others thrive in snow banks. Green algae store their food in the form of starch within their chloroplasts (Mageed, 2015).

Some species of green algae are unicellular and microscopic, but most are larger. Other green algae form plate-like colonies, thread-like filaments, net-like tubes, or hollow balls.

Their chlorophylls (*a* and*b*) and other pigments are very similar to those of higher plants. Their green color results from the green chlorophyll in the chloroplasts which are not masked by accessory pigments (Mageed, 2015).

(a) Some species of green algae, like *chlorella species;* are very easy to culture and it can be used in investigations into photosynthesis and respiration.

(b) *Chlorella species* contains most of the vitamins needed for human nutrition except vitamin C, so since it is so easy to culture it may become an important food source(Robert, 2003).

2.13.3 Cyanophyta

Cyanobacteria are also known as Cyanophyta, blue-green algae or blue-green bacteria. Most species live in freshwater but, some are marine and a few can even be found in very inhospitable places like damp soil, glaciers and hot springs. Blue-green algae can be found in slow moving or still freshwater and dense populations of them will form after spring when the water becomes stratified. (Perry, 2003).Among the Cyanobacteria some are unicellular, colonial and filamentous forms. As in other bacteria there are no membrane bound organelles such as a nucleus or mitochondria. The cells are generally blue-green to violet in color, but sometimes red or green. Most species of cyanobacteria appear blue because the green of the chlorophyll is masked by the blue of the accessory pigment, phycocyanin (Guiry, 2009).

Blue green bacteria play an important role in the fixation of molecular nitrogen.

Due to their nutritional requirements and position at the bottom of food webs, blue-green provide information about the ecosystem conditions as they respond rapidly and predictably to a wide variety of pollutants (Mageed,2015).

2.13.4 Euglenophyta

Some members of this group are marine, but most are freshwater and tend to grow in small pools which have been enriched by organic compounds, like manure from farmers' field. Euglenophyta form blooms in polluted waters as well as green films on the mud and sand flats of estuaries. The cells of euglenoids are spindle-shaped, lack a rigid cell wall, and hence change shape as the organisms moves along. There are fine strips, just below the plasma membrane that spiral around the cell parallel to one another. These strips are free of cellulose and together are called the pellicle. These strips are elastic and their movement helps to provide locomotion and is called euglenoid movement (Mageed, 2015).

Importance of Euglynophyta

1. Some species of Euglenophyta are heterotrophic and can live in the dark if the proper food and vitamins are present.
2. As long as a suitable environment is provided these cells can survive indefinitely (Maberly 2008).

2.13.5 Rhodophyta

Rhodophyta or red algae, is a small phylum of predominantly marine organisms but a few are fresh water. Red algae are generally found in warmer waters and are restricted to narrow coastal fringes living attached to rocks. They can also be found attached to sea walls, eel grass and on shells. They are a common sight in intertidal zones covering the rocks in a carpet of red. Some red algae are unicellular but most are multicellular filaments, with leaf-like or feathery structures. Red algae lack flagellates stages at any point in their life cycle. The red color of these algae is produced by the accessory pigment, phycobilin, which is located in their chloroplasts. This pigment masks the green color of chlorophyll a. Thylakoids are not stacked and lie equidistant and singly within the chloroplasts. Red algae store their food in a unique substance called Floridean starch.

Importance of Rhodophyta

1. The part of red algae cell wall is made of a mucilaginous material that can be extracted from the cell wall with hot water. These materials are used on a large scale for the production of gels.

2. Agar gel is of great importance to the microbiology industry as it contains nutrients and provides a media for the growth of fungi and bacteria.

3. The gel itself is resistant to degradation by these organisms and it sis non-toxic, making it an excellent substrate.

4. The colloidal properties of these substances are also used to make ice cream, jams, soups, sauces and toothpaste. (Maberly 2008).

2.13.6 Dinophyta

Dinophyta called Dinoflagellates live in the surface waters of freshwater and brackish water. In marine, they are more abundant near shore where nutrients are rich. Members of the Protist Phylum Dinoflagellata (aka Dinophyta or Pyrrophyta) are very common in coastal plankton samples. The name comes from the greek word "*Dinos*" which means "to spin," and "flagellate" which means to have flagella. Flagella are whip-like "tails" that act like propellers and cause these single celled organisms to rotate through the water. When observed immediately after capture, under a microscope, dinoflagellates move in a wonderful spiral pattern. Large species are caught with a microplankton net, and smaller species require a nanoplankton net. (Robert, 2003). Dinoflagellates appear reddish-brown, or greenish-brown under the microscope. Many dinoflagellates have red or brown accessory pigments along with chlorophyll to carry out photosynthesis. Hence, when very abundant in the water, the phenomenon is called a "red tide." Red tides are localized patches of discolored water from dinoflagellate population explosions. (Robert,2003). Every unit of poison found naturally in a dinoflagellate will magnify ten-fold in the next trophic level, a hundred times in the next level and so forth. Species such as *Alexandrium* and *Gymnodinium* are known to cause PSP (Paralytic Shellfish Poisoning) in humans. PSP results when humans eat shellfish such as mussels, clams or oysters that are suspension feeders which have, in turn, have consumed these dinoflagellates. Symptoms of PSP include nausea, dizziness, a tingling numbness, respiratory failure and even death. It is not wise to consume these shellfish during periods of the year when toxic dinoflagellates are blooming (Robert, 2003).

Importance of Dinoflagellates

Large aquatic animals have also been poisoned by Dinoflagellate toxins accumulated from their food.

2.13.7 Phaeophyta

The Phaeophyta (family Phaeopyhceae) are the brown algae and most of them are found in marine habitat and can be found attached to rocks or mollusks. Only sixteen genera of brown algae occur in freshwater. All species of brown algae are multicellular although their structure varies from microscopic branched filaments to foliose plants many meters long. Brown algae owe their color to the accessory photosynthetic pigment fucoxanthin, which is contained in the chloroplasts which are discoidal or ribbon-like shape (Roven 2008).

Importance of Phaephyceae

The cell walls of brown algae contain alginic acid which is used as a thickening agent in ice cream. Sodium alginate swells in the stomach so it is also used in slimming foods to make dieters feel full. Alginates are also used in the manufacture of building materials, dyes, glue and paper (Wynne, 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

River saye is lotic water which involved many activities such as mining, washing of cloths, moulding blocks, irrigation ferming, cattle rearsRiver Saye is in Zaria Local Government Area which is located on latitude 11^0 7.9^1N and longitude 7^0 45.59 ^{1}E. (Figure 3.1)**.** The river catchment lies within the tropical wet and dry climatic zone, characterized by strong seasonality in rainfall and temperature distribution. It has two distinct season the dry season (October to March) and wet season (April to September). The area has a single maximum rainfall regime with average annual total ranging from 1050mm to 250mm.

3.2 Sampling Procedures

Five sampling stations were chosen within the river as follows;

- Station 1 and 2 are located at the longest arm of the Rsiver where mining and moulding of blocks were taking placed
- Station 3 and 4 are located at the lower point before the bridge where irrigation ferming were taking place
- Station 5 located where anthropogenic and human activities are taking place such as washing of cloths and bathing.

Samples were collected for a period of twelve months from Octorber to March 2014 in dry season to April to September 2015 in wet season. Water samples were collected from five sampling stations between the hours of 8:00 am to 1:00 pm. In this method, water was sampled at surface level by dipping 1 litre steriloed plastic sampling bottle and slided

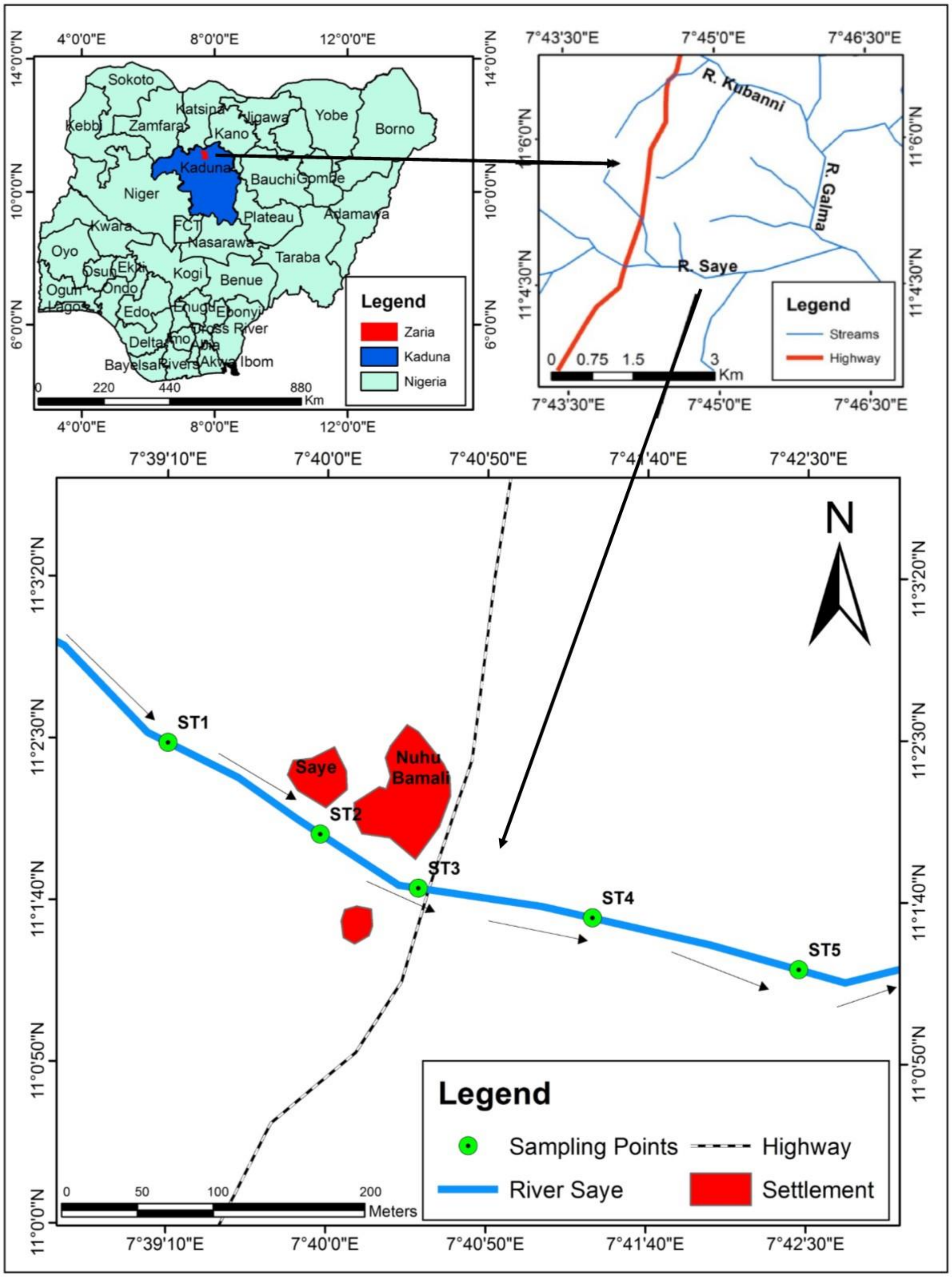

Figure:3.1 Map of River Saye Showing Sampling Stations

Source; Fieldwork/Administrative Map of Zaria L.G.A, Kaduna State

over the most upper surface of water with their mouth against passage of the water into the bottle (APHA,2005).

Some parameters were determined in-situ using Hanan Instrument (model HI 98129) such as the Temperature, pH, Electrical conductivity and Total dissolved solids while others were transported to the laboratory for the analysis of physico-chemical parameters.

3.3 Determination Of Physico-Chemical Parameters Of The River

3.3.1 Determination of Temperature, pH, electrical conductivity, total dissolved Solids

Thesre were determined using the Hanna instrument of model (H198129).

3.3.2 Determination of Dissolved Oxygen and Biological Oxygen Demand

Two milliliters of magnisum sulphate ($MnSO_4$) was added to collected water sample at the sampling stations before being taken to the Hydrobiology Laboratory, Department of Biology, Ahmadu Bello University. Water sample was then poured into a 300 ml bottle of BOD and 2ml of alkali-iodide azide reagent was added then corked with care to exude air bubbles. It was then mixed gently by inverting the bottle a number of times until a clear supernatant was obtained. It was then allowed to settle for two minutes after which 2rnl. Concentrated sulphuric acid (H_2S0_4) was added by allowing the acid run down the neck of the bottle. It was stopped again and mixed by gentle inversion until dissolution was complete. One hundred(100ml) of the prepared solution was transferred into a conical flask and then titrated with 0.0125N of sodium thiosulphate($Na_2S_2O_3.5H_20$) solution to a pale straw yellow colour.Two milliliters of freshly prepared starch solution was added and the colour changed to blue Titration was continued by adding the thio-sulphate, drop wise, until the blue colour disappeared.

For biological oxygen demand, sampled water was incubated for five days in cupboard and Dissolved oxygen was also tested. The difference between the initial value of dissolved oxygen and the value after incubation gave the value of the biological oxygen demand in the water sample (Mahar, 2003).

$(BOD)_5$ in mg/l=DO_1-DO_5

3.3.3 Determination of hardness

a. Chemicals

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

Buffer solution was prepared by dissolving I 6.9g of ammonium chloride in l•1 ml in volumetric flask withl.179 g of magnesium carbonate, 12.61420 in 50 ml distilled water. These two reagents were mixed to make 250 ml as a final volume of buffer solution, Erichrome black-T dye was used as indicator.

b. Procedure

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

c. Calculation

$$\text{Hardness (mg/L)} \quad s = \frac{N x M x 50{,}000}{V}$$

Where:

N = Normality of titrate 0.1 N

M = Mean of three titra value readings

V = Volume of water sample

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

3.3.4 Determination of Total alkalinity

One hundred (100) ml of water sample was transferred into a conical flask and two (2) drops of bromo-cresol green and two (2) drops of methyl red were added respectively the mixture was swirled and titrated with solution of H_2SO_4 until color changed.

Total alkality in $CaCO_3$ mg/l=titer value × 10

3.3.5 Determination of chloride

One hundred (100) ml of water sample was transferred into a conical flask and two (2) of potassium chromate was added and the content was then swirled for few minutes. It eas then titrated against silver nitrate solution until dirty reddish precipitate was obtained. Clmg/l=volume of $AgNo_3$× 10 (ALPHA,2005)

3.3.6 Determination of phosphate-phosphorus

This was determined using the Denniges method one mile (1ml) of Denniges reagent and I drop of stannous chloride was added to one hundred mile(100ml) water sample. Absorbance at 690nm was measured with spectrophotometer (Model S 101) using distilled water as the blank. The phosphate concentration of water sample was red from the calibration curve. (APHA, 2005). Mg PO4/L=mg PO4 in vol. flask × 1000/ml of saple used.

3.3.7 Determination of nitrate-nitrogen

One hundred (100) ml of water sample was poured into a crucible and evaporated to dryness and cooled. Two (2) ml of phenol disulphonic acid was added and smeared around the crucible, after 10 minute.One hundred mile(100ml) of distilled water was added followed by five(5ml) strong ammonia solution. Settingthe spectrophotometer at the wave length 430nm, absorbance of the sample treated was obtained, using water as blank. The concentration of nitrate- nitrogen was obtained from the calibration curve in mg/1 (APHA, 2005).

3.4 Phytoplankton sampling and Analyses

Five sampling points were selected which were 50m from the succeeding points. Phytoplankton samples were collected with silk plankton net of 25cm diameter of 70µm meshes attached to a bottle of fifty (50ml) capacity at the base. The net was sunk just below the surface and then towed through a distance of 10m horizontally. The content of the collected vial was then poured into plastic bottle of fifty mile (50ml) capacity and preserved in 4% formalin.and then 2-3 drop of Lugol's iodine solution was added to stain the samples and enhanced proper identification of phytoplankton species based on morphological features. Counting was done by shaking the preserved samples and pipetting one mile (1ml) of water samplewhich was then mounted on a compound microscope for identification using text book key and Robert perry guide line or key.

3.5 Data Analysis

The results obtained were subjected to analysis of variance (ANOVA) to test for significance at probability level of 0.05 between the physico-chemical factors months, season and stations. The distribution and abundance of the phytoplankton community in the river were also assessed.Principal Components Analysis (PCA) analysis was used to test for relationships between physico-chemical parameters and phytoplankton.

CHAPTER FOUR

4.0 RESULTS

4.1 Physico-chemical parameters in relation to month in River Saye

4.1.1 Temperature

Temperature ranged between 27.12±0.07^{0}C (July)and (30. 04± 0.02^{0}C) with mean value 27.62±0.16^{O}C (Table 4.1). There was hghly significant at $P \leq 0.001$.

4.1.2 pH

The lowest pH values (6.94±0.02) was recorded in August and highest (10.78± 0.62) in junuary 2014. Monthly distribution of pH was significant at $P < 0.01$.

4.1.3 Electrical conductivity (EC).

There was significant electrical conductivity P < (0.01) range from 75.80±1389 μs/cm (July 2014) to 159.20± 10.02 μs/cm (June 2014).

4.1.4 Total dissolved solids

Total dissolved solid (TDS) July 2014 was recorded the lowest TDS value (39.60 ± 6.62 mg/L) while June 2014 had the highest value (86.00 ± 1.76 mg/L). Monthly fluctuations of TDS were significant ($P < 0.01$).

4.1.5 Dissolved oxygen

Dissolved oxygen (DO). The lowest value of DO was recoded (2.45 ± 0.08 mg/L) in November and highest (6.48 ± 0.08 mg/L) in Octorber 2014. There was significant at $P < 0.01$ with mean value 3.02 ± 0.16 mg/L.

4.1.6 Biological oxygen demand

Biological oxygen demand was recoded lowest (1.47 ± 0.08 mg/L) in Novermber while highest value in October (6.13 ± 0.15 mg/L) there was significant at $P < (0.01)$.

4.1.7 Hardness

Hardness was recorded lowest (98.00±4.70 mg/L) $CaCO_3$ in November while highest in octorber with the value of (296.40 ± 5.57) there was significant $P < 0.01$ with mean value 213.30 ± 6.46 mg/L

4.1.8 Alkalinity

Alkalinity was recorded lowest in Octorber (25.00±1.97 mg/L) and highest (56.50 ± 1.66 mg/L) which was significant at $P < 0.01$ the mean value of Alkalinity of River Saye 42.43 ± 1.37.

4.1.9 Chloride

Chloride lowest value was recorded in November (25.30 ± 1.48 mg/L) while highest in April (57.90 ± 3.55 mg/L) there were significant at $P < 0.01$ with mean value 38.84 ± 1.25

4.1.10 Phosphate

Phosphate was recorded lowest in November (0.13 ± 0.03 mg/L) and December (0.13 ± 0.03 mg/L) while highest in July (0.32 ± 0.05 mg/L) which was significant at $P < 0.01$with mean value 0.20 ± 0.01

4.1.11 Nitrate

Nitrate was recorded lowest in March and April (0.28 ± 0.00 mg/L) and highest in November (0.06 ± 0.02 mg/L) and December (0.06 ± 0.02 mg/L).

Table 4.1: Mean monthly variation of physico-chemical parameters of River Saye

Months	Temp ºC	pH	ECµs/cm	TDS mg/L	DO mg/L	BOD mg/L	Hardness $caco_3$mg/L	Alkalinity mg/L	Chloride mg/L	Phosphate mg/L	Nitrate mg/L
October, 2014	28.12 ± 0.06^{ab}	8.64 ± 0.45^{ab}	113.40 ± 6.73^{bc}	62.20 ± 5.05^{bcd}	6.48 ± 0.08^{a}	6.13 ± 0.15^{a}	296.40 ± 5.54^{a}	25.00 ± 1.97^{e}	33.00 ± 0.86^{cd}	0.14 ± 0.00^{c}	0.25 ± 0.01^{a}
November, 2014	28.14 ± 0.05^{ab}	8.66 ± 0.43^{ab}	114.40 ± 6.54^{bc}	62.60 ± 5.25^{bcd}	2.45 ± 0.08^{f}	1.47 ± 0.08^{d}	98.00 ± 4.70^{g}	32.60 ± 1.78^{de}	25.30 ± 1.48^{d}	0.13 ± 0.03^{c}	0.06 ± 0.02^{d}
December, 2014	26.08 ± 0.06^{e}	8.56 ± 0.40^{ab}	112.80 ± 7.30^{bc}	63.80 ± 5.44^{bcd}	2.46 ± 0.09^{f}	1.52 ± 0.08^{d}	101.20 ± 4.13^{g}	33.10 ± 1.97^{de}	25.90 ± 1.35^{d}	0.13 ± 0.03^{c}	0.06 ± 0.02^{d}
January, 2015	30.04 ± 0.02^{a}	7.98 ± 0.36^{ab}	108.40 ± 5.70^{c}	60.80 ± 5.21^{bcd}	2.51 ± 0.12^{f}	1.80 ± 0.09^{cd}	160.40 ± 13.96^{f}	43.30 ± 1.73^{c}	34.30 ± 0.99^{c}	0.22 ± 0.01^{bc}	0.24 ± 0.01^{a}
February, 2015	27.76 ± 0.07^{cd}	8.72 ± 0.94^{ab}	$153.60\pm5.20.77^{ab}$	76.60 ± 10.35^{abc}	4.04 ± 0.15^{d}	2.20 ± 0.21^{cd}	242.80 ± 5.96^{bcd}	52.90 ± 1.99^{abc}	56.00 ± 4.23^{a}	0.17 ± 0.03^{cd}	0.28 ± 0.00^{a}
March, 2015	27.88 ± 0.07^{c}	8.75 ± 0.93^{ab}	155.40 ± 20.37^{a}	79.60 ± 9.36^{ab}	4.07 ± 0.15^{d}	2.25 ± 0.21^{cd}	256.00 ± 4.69^{bc}	54.20 ± 1.59^{ab}	54.20 ± 3.87^{a}	0.17 ± 0.03^{cd}	0.28 ± 0.00^{a}
April, 2015	28.82 ± 0.09^{a}	9.72 ± 0.94^{ab}	157.80 ± 20.21^{a}	81.40 ± 8.93^{ab}	4.15 ± 0.17^{d}	2.39 ± 0.25^{c}	259.20 ± 5.43^{b}	56.50 ± 1.66^{a}	57.90 ± 3.55^{a}	0.17 ± 0.03^{cd}	0.28 ± 0.00^{a}
May, 2015	27.06 ± 0.46^{d}	8.45 ± 1.35^{ab}	113.40 ± 15.65^{bc}	62.00 ± 10.07^{bcd}	4.99 ± 0.61^{c}	4.06 ± 0.66^{b}	224.80 ± 22.05^{cd}	42.50 ± 7.75^{cd}	32.90 ± 0.81^{cd}	0.20 ± 0.02^{cd}	0.19 ± 0.03^{b}
June, 2015	28.24 ± 0.67^{ab}	10.78 ± 0.62^{a}	159.20 ± 10.02^{a}	86.00 ± 1.76^{a}	3.59 ± 0.36^{de}	1.97 ± 0.11^{cd}	226.80 ± 19.91^{bcd}	54.10 ± 3.88^{ab}	45.80 ± 3.62^{b}	0.29 ± 0.02^{ab}	0.25 ± 0.02^{a}
July, 2015	26.06 ± 0.07^{e}	7.68 ± 0.34^{c}	75.80 ± 13.89^{c}	39.60 ± 6.62^{e}	5.72 ± 0.24^{b}	2.11 ± 0.08^{cd}	216.40 ± 4.90^{de}	45.80 ± 4.32^{bc}	35.60 ± 2.76^{c}	0.32 ± 0.05^{a}	0.12 ± 0.00^{c}
August, 2015	26.08 ± 0.04^{e}	6.94 ± 0.02^{c}	85.20 ± 1.62^{c}	42.60 ± 0.51^{de}	3.24 ± 0.11^{e}	4.24 ± 0.27^{b}	188.00 ± 9.94^{ef}	45.60 ± 4.25^{bc}	34.10 ± 2.97^{c}	0.26 ± 0.01^{abc}	0.12 ± 0.00^{c}
September, 2015	27.16 ± 0.05^{d}	7.83 ± 0.08^{ab}	112.20 ± 6.69^{bc}	56.00 ± 3.77^{cde}	6.43 ± 0.08^{a}	6.10 ± 0.15^{a}	289.60 ± 5.00^{a}	23.60 ± 1.61^{e}	31.10 ± 0.80^{cd}	0.14 ± 0.01^{c}	0.25 ± 0.01^{a}
Mean	**27.62±0.16**	**8.56±0.20**	**121.80±4.89**	**64.43±2.52**	**4.18±0.14**	**3.02±0.16**	**213.30±6.46**	**42.43±1.37**	**38.84±1.25**	**0.20=0.01**	**0.20±0.01**
P value	**0.000****	**0.007****	**0.000****	**0.000****	**0.000****	**0.000****	**0.000****	**0.000****	**0.000****	**0.000****	**0.000****

KEY; Means of different alphabets in the same column are significantly different, L- Lowest and H- highest
**** highly significant at $p \leq 0.01$: KEY:** Temp= temperature, pH=Hydrogen ion concentration, EC= Electrical conductivity, TDS=Total dissolved solids, BOD= Biological Oxygen Demand,

4.2 Physico-chemical parameters in relation to season and station in River saye

4.2.1 Temperature

The lowest temperature value (27.12±0.20 ^{O}C) was recorded in wet season while highest in dry (28.12 ± 0.22 ^{o}C) Variation was highly significante between the seasons ($P\leq0.01$) (Table 4.2). Station 5 and 4 had the highest value of temperature (27.73 ± 0.36 ^{o}C) across the stations, lowest in station 3 (27.38 ± 0.40 ^{O}C) which was significan ($P \geq 0.05$) Figure 4.1.

4.2.2 pH

Wet season (8.39 ± 0.27) recorded the lowest pH value was observed while highest in dry season (8.73 mg/l). Fluctuation was non-significant between the seasons ($P\geq 0.05$) (Table 4.2). Station 1 recorded the highest value (9.45 ± 0.50) and lowest in station 3 (7.86 ± 0.35) (figure 4.1).

4.2.3 Electrical Conductivity (EC)

The lowest EC value 109.87 ± 6.23µs/cm was observed in wet season (133.73 µS/cm)while the highest value was in dry season (133.73 ± 6.96 µs/cm) seasonal fluctuation was significant ($P\leq0.05$) (Table 4.2) Station 1 and 2 had the highest value (130.92 µS/cm) and low in station 4 (108.33µS/cm) (figure 4.1).

4.2.4 Total Dissolved Solids (TDS)

Wet season TDS value (58.07 ± 3.52 mg/L) was lowest than dry season value (70.80 ± 3.28 mg/L) which was highly significant between the seasons ($P\leq0.01$) (Table 4.2). Station two had the highest value (72.08 µs/cm) lowest in station 5 (59.6 µ/cm) (figure 4.1)

4.2.5 Dissolved Oxygen (DO)

Dry season DO value (3.28 ± 0.21 mg/l) was lowest than dry season value (5.08 ± 0.21 mg/L) which was highly significant variation from dry season ($P \leq 0.01$) (Table 4.2).Station 4 was recorded to have the highest value for D.O (4.38mg/l) minimum in station 1 2.78mg/l (figure 4.1).

4.2.6 Biological Oxygen Demand (BOD)

Dry season BOD value (1.94 ± 0.08 mg/L) was recorded the lowest while highest value in wet season (4.10 ± 2.48 mg/L) which was highly significant between the seasons ($P \leq 0.01$) (Table 4.2). Station 4 was recorded to have the highest value (3.50mg/l) low in station 1 (2.78mg/l) which was non significant (figure 4.1).

4.2.7 Hardness

Dry season value (186.27 ± 9.50 mg/L) was recorded the lowest and highest value in wet season (240.33 ± 7.30 mg/L) and highest in dry season (240.33 ± 7.30 mg/L) which was highly significant between the seasons ($P \leq 0.01$) (Table 4.2). Stations 2 and 3 were observed to have the highest across the stations (Figure 4.1)

4.2.8 Alkalinity

Analysis of Variance revealed the value wet season had the lowest (39.43 ± 2.27 mg/L) while highest in dry season (45.43 ± 1.46 mg/L) which were significant between the season ($P \geq 0.05$) (Table 4.2). Station 1 was highest across the stations (48.83 mg/l) (figure 4.1).

4.2.9 Chloride

Results showed that chloride was observed to be lowest in wet season (35.42 ± 1.09 mg/L) and highest in dry season (42.27 ± 2.16 mg/L) which was highly significant from both seasons (P≥0.01) (Table 4.2).Station 5 was highest among the stations (43.67 mg/l) and low in station 1 (38.21mg/l)(Figure 4.1).

4.2.10 Phosphate- Phosphorus

Result shows that Phosphate-Phosphorus was observed to be lowest in season (0.17 ± 0.01mg/L) while highest value in wet season (0.22 ± 0.01 mg/L) which was higly significant from both seasons. (P≥0.01) (Table 4.2). Station 1 had the highest value (0.24mg/l) which was highly significant from other stations (figure 4.1).

4.2.11 Nitrate- Nitrogen

The concentration of Nitrate- nitrogen was equal for both wet and dry season (0.22 mg/l) which was non significant (P≥0.05) from both seasons (Table 4.2)While stations one and 4 had the highest values across the stations (0.20mg/l) low in station 2 (0.17mg/l) (figure 4.1).

Table 4.2: Seasonal Variation of Physico-chemical Parameters of River Sayenear Zaria

Physico-Chemical Parameters	Wet	Dry	Mean Total	P value
Temp (°C)	27.12±0.20[b]	28.12±0.22[a]	27.62±0.16	0.002**
pH	8.39±0.27	8.73±0.28	8.56±0.20	0.383ns
EC (µS/cm)	109.87±6.23[b]	133.73±6.96[a]	121.80±4.89	0.013*
TDS (mg/L)	58.07±3.52[b]	70.80±3.28[a]	64.43±2.52	0.010**
DO (mg/L)	5.08±0.21[a]	3.28±0.12[b]	4.18±0.14	0.000**
BOD (mg/L)	4.10±2.48[a]	1.94±0.08[b]	3.02±0.16	0.000**
Hardness (mg/L.$CaCO_3$)	240.33±7.30[a]	186.27±9.50[b]	213.30±6.46	0.000**
Alkalinity (mg/L)	39.43±2.27[b]	45.43±1.46[a]	42.43±1.37	0.028*
Chloride (mg/L)	35.42±1.09[b]	42.27±2.16[a]	38.84±1.25	0.005**
Phosphate (mg/L)	0.22±0.01[a]	0.17±0.01[b]	0.20±0.01	0.002**
Nitrate (mg/L)	0.20±0.01	0.20±0.01	0.20±0.01	0.832ns

**** highly significant at p<0.01, * significant at p<0.05, ns significant at p>0.05,**

KEY; mean with different alphabets in the same row are highly significant

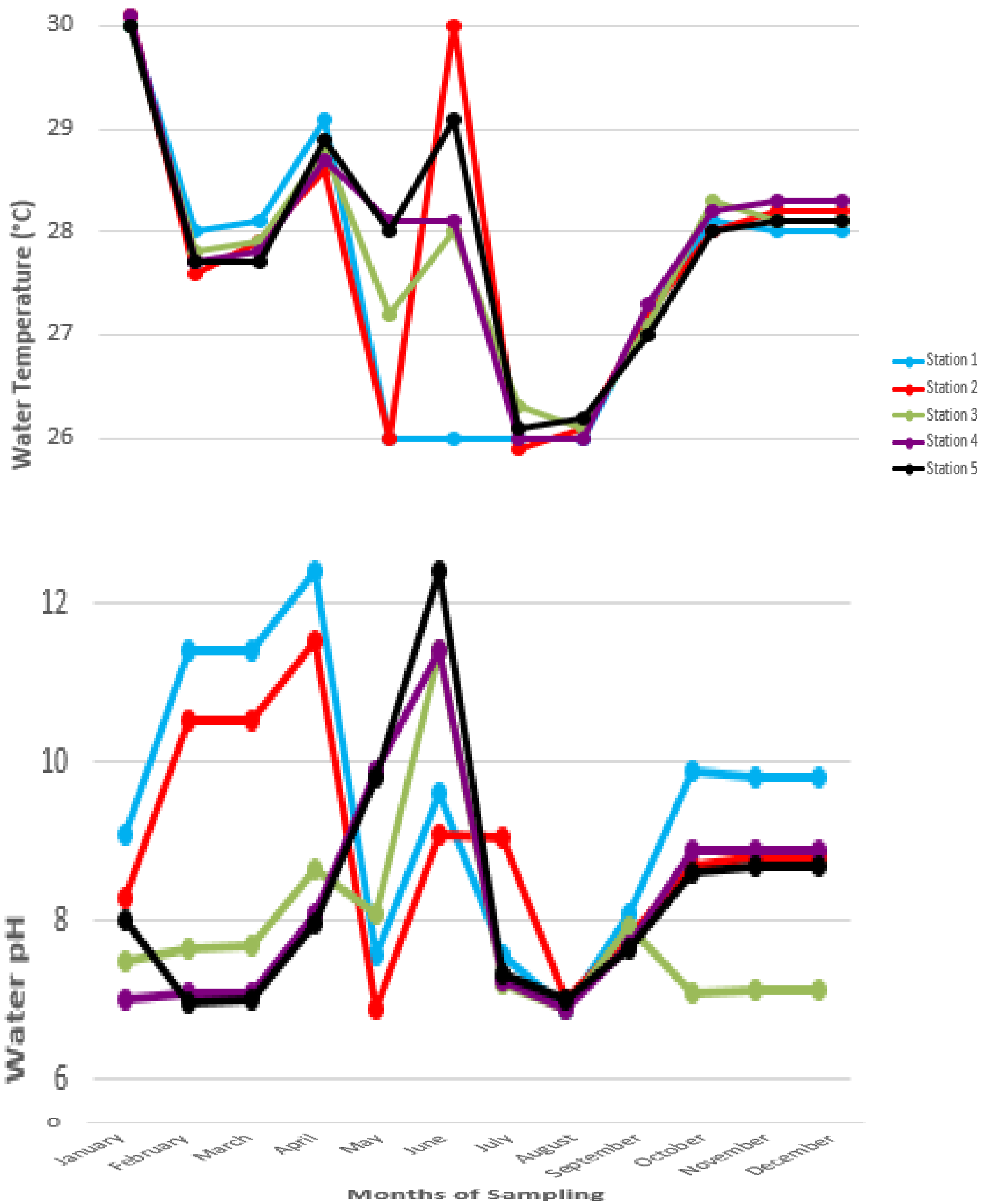

Figure 4.1: Mean monthly variation of Temperature and pH along asampling stations of River Saye.

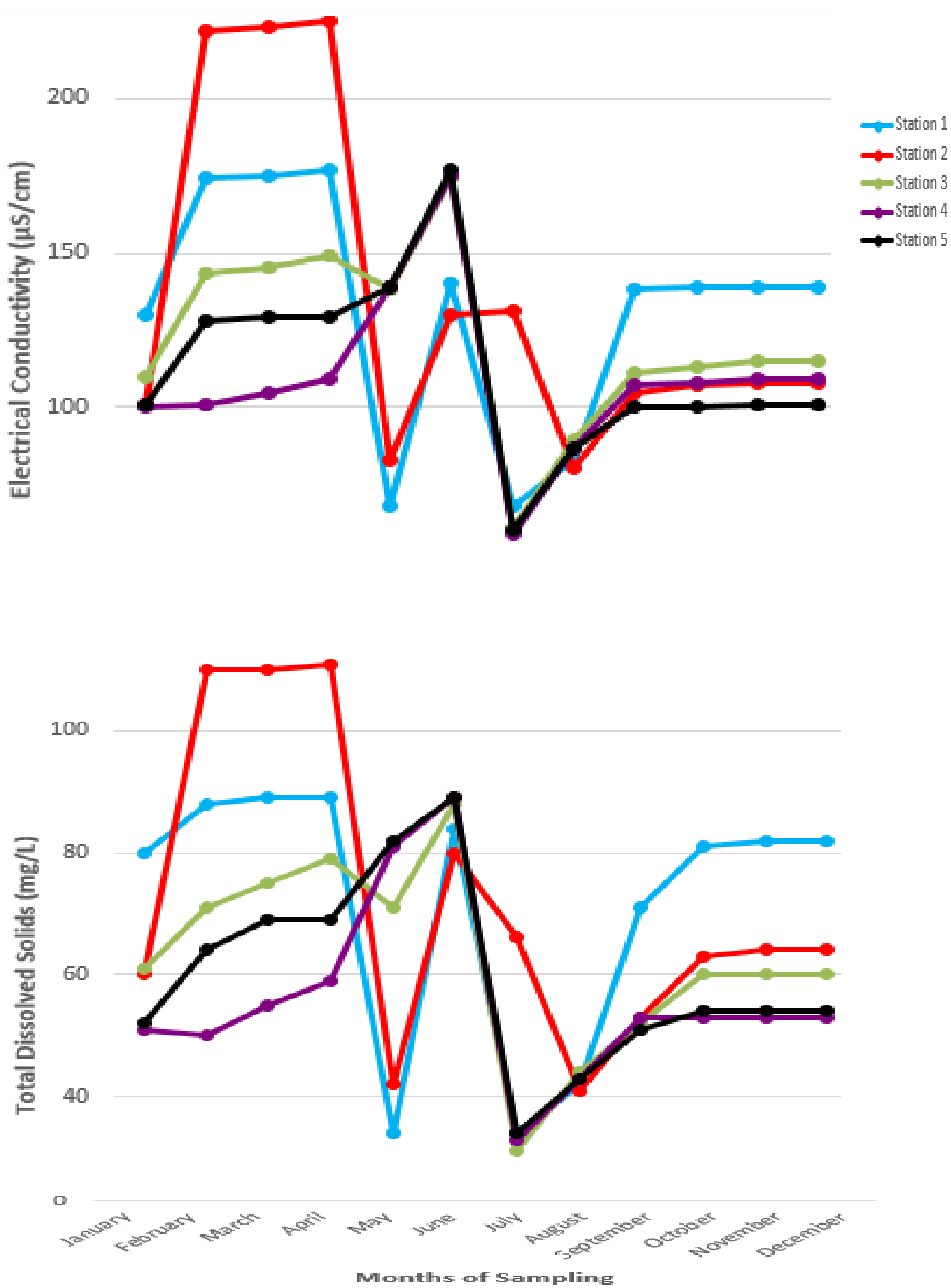

Figure 4.2: Mean monthly variation of Total Dissolved Solid and Electrical Conductivity along asampling stations of River Saye.

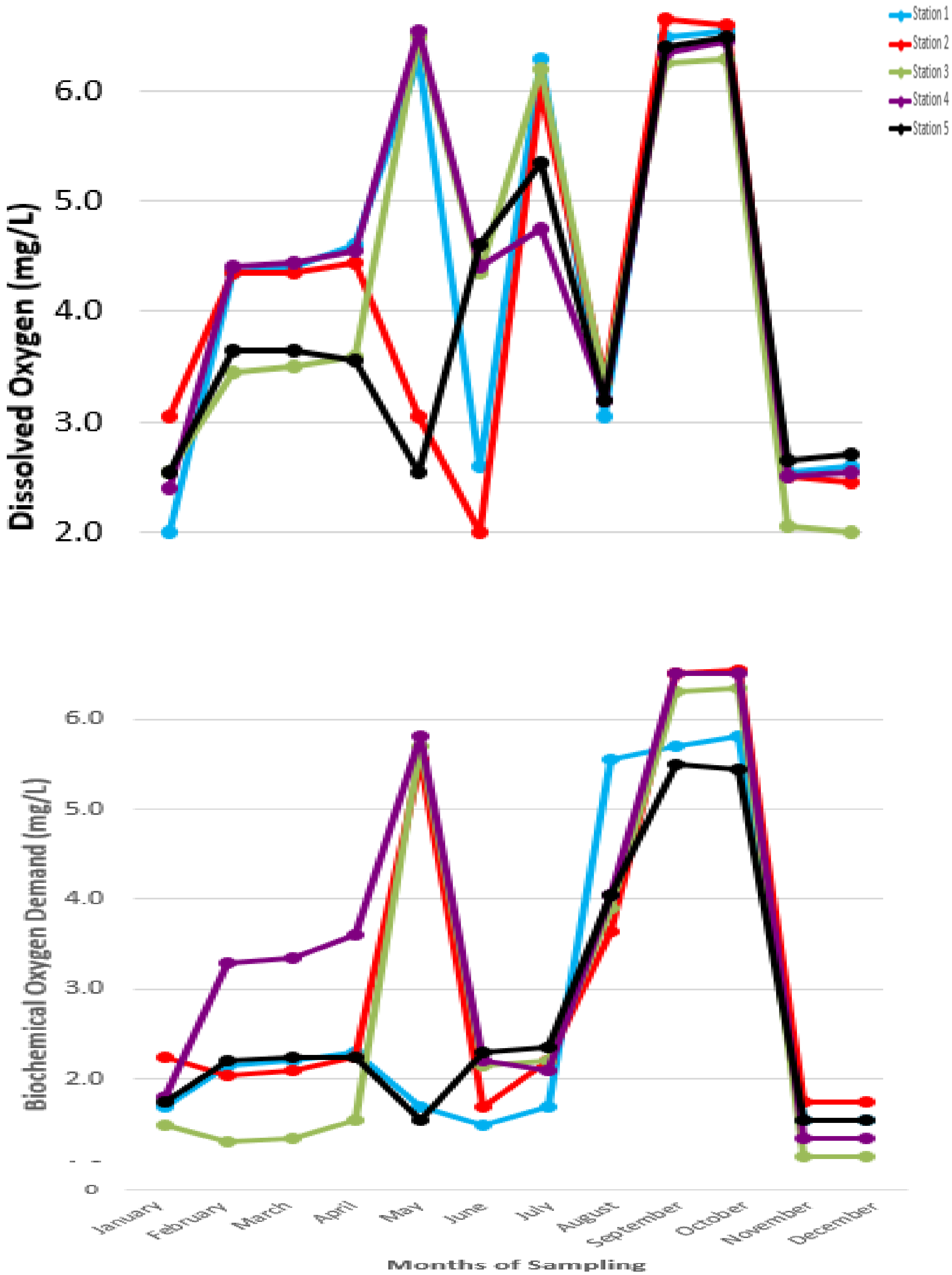

Figure 4.3: Mean monthly variation of Dissolved Oxygen and Biological Oxygen Demand along asampling stations of River Saye.

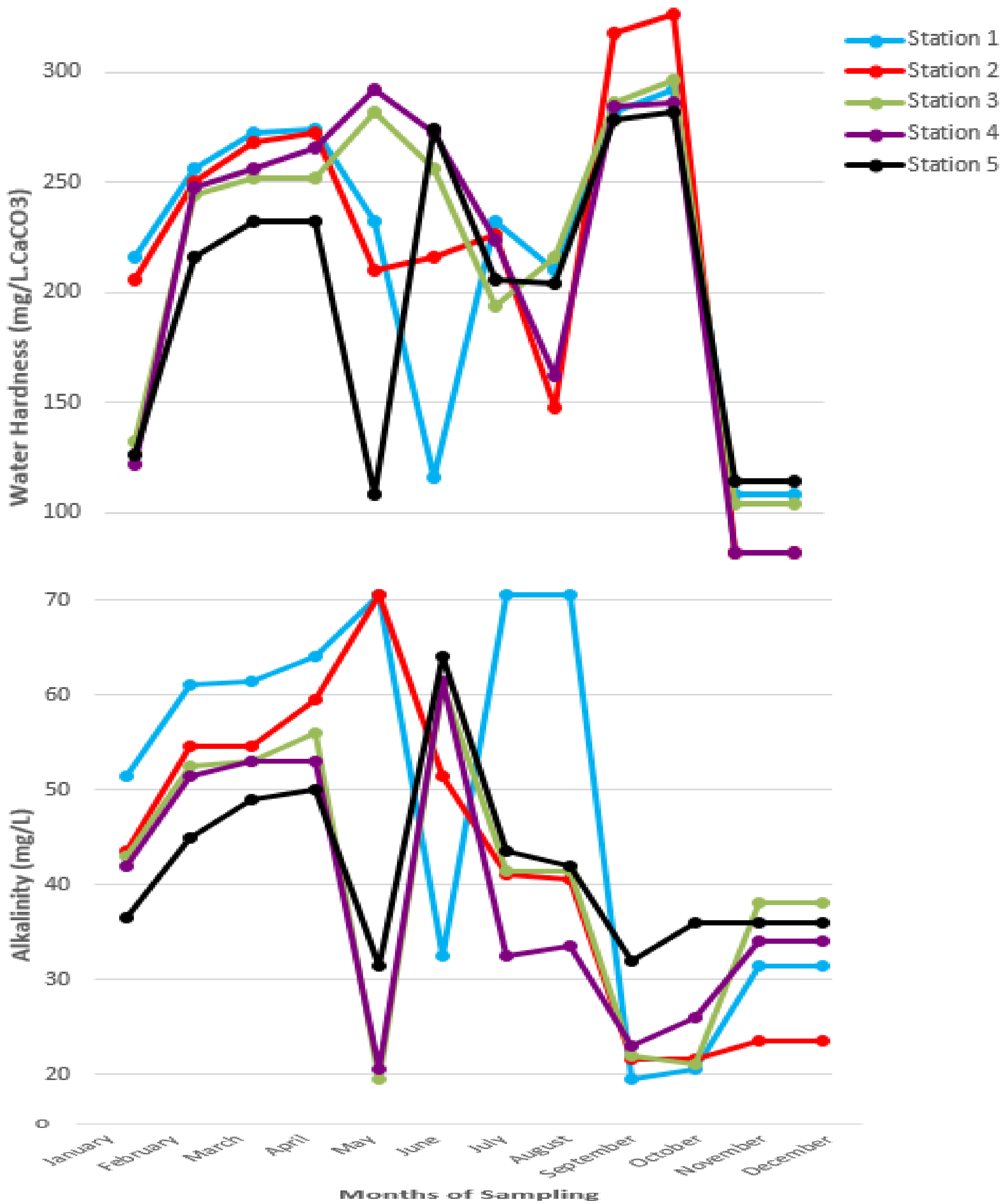

Figure 4.4 Mean monthly variation of Alkalinity and Hardness along asampling stations of River Saye.

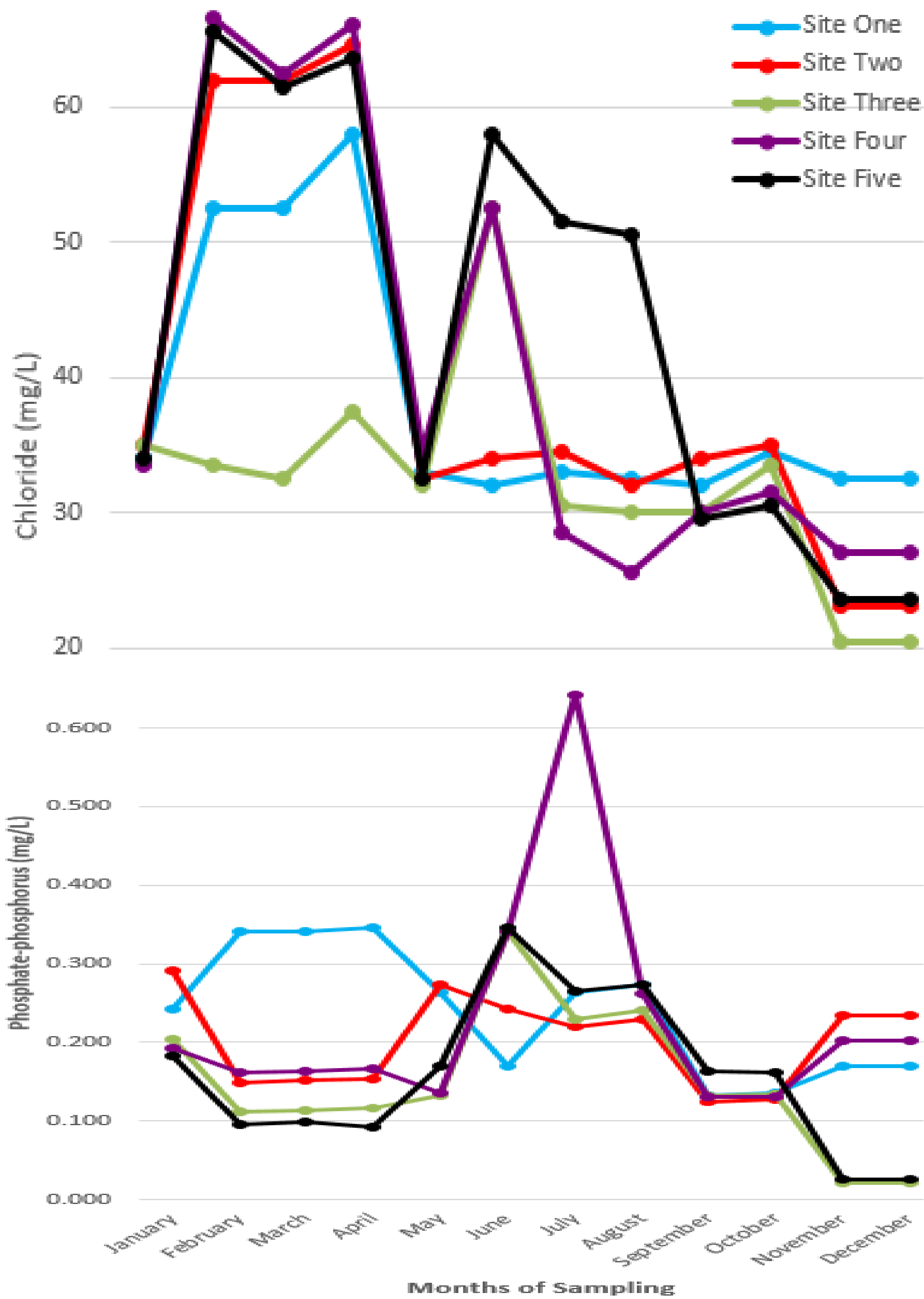

Figure 4.5 Mean monthly variation of phosphate (PO_4^-), and chloride (Cl^-) along asampling stations of River Saye.

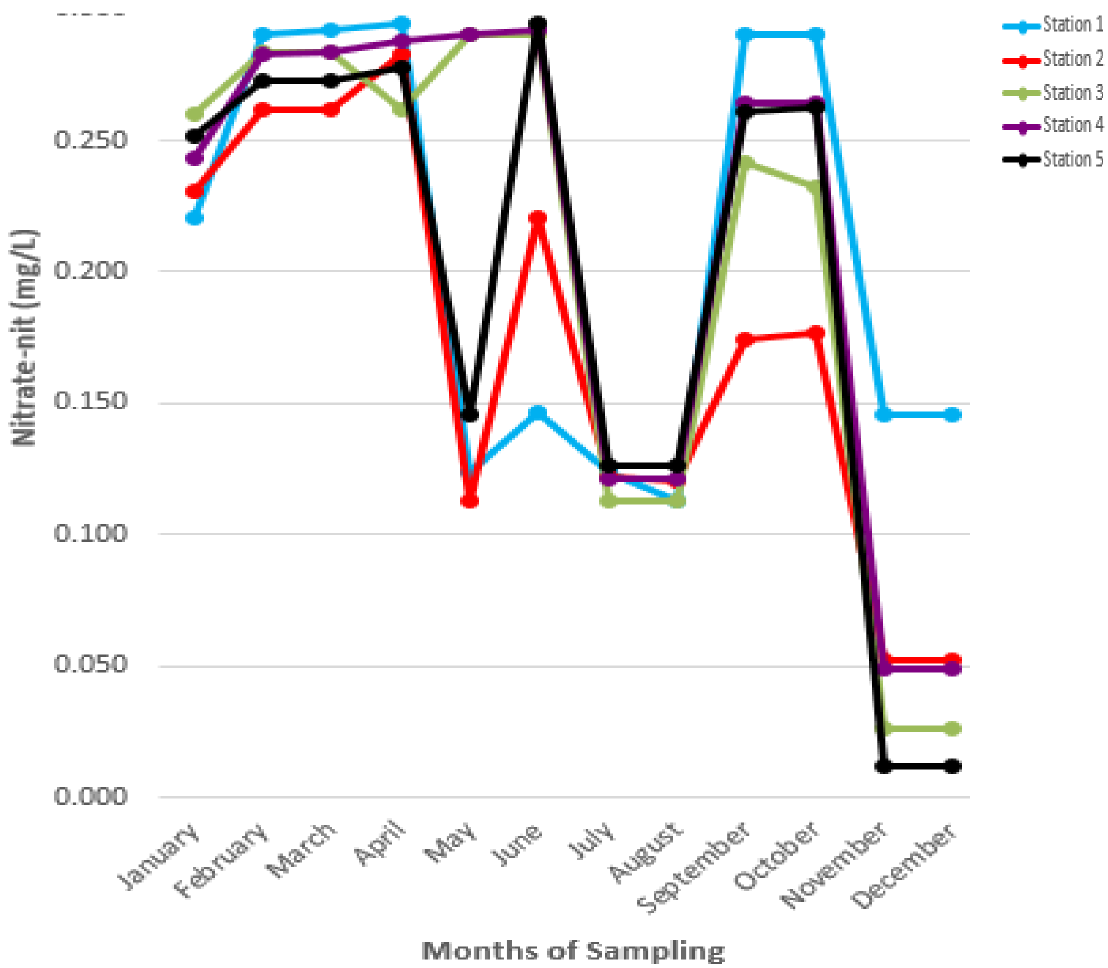

Figure 4.6 Mean monthly variation of Nitrate along asampling stations of River Saye.

4.3 Abundance of phytoplankton in relation to month in River Saye.

The total number of phytoplankton observed in this study was 1842 organisms with the family Bacillariophyta having the highest abundance (875 organisms, 47.50%) while the least abundant was recorded in the family of Euglenophyta (62 organisms, 3.37%). (Table 4.4).

Based on months, the family of Bacillariophyta had the highest abundance in January (79 organisms, 9%), February (63 organisms, 7%), March (73 organisms, 8%), April (80 organism, 9%), May (100 organisms, 11%), June (47 organisms, 5%), July (35 organisms, 4%) October (60 organisms, 6%), November (161 organisms, 18%) and December (71 organisms, 8%) respectively (Table 4.3).

4.4 Abundance of phytoplankton in relation to to season and station in river saye

Based on season, dry season (937 organisms 50.87 %) had the highest abundance of phytoplankton and least abundance (905 organisms 49.13%) was recorded in wet season (Table 4.4).

In dry season (875 organisms 47.50 %) the Bacillariolophyta had the highest number of organism (Table 4.4) for wet season, fallowed by chlorophyta (458 organisms 50.61 %) recorded the abundance while Euglenophyta (16 organisms, 1.77 %), the least.

Based on speces, the family of Bacillariophyta with genus of *Diatoma* had the highest abundance (205 organisms, 23%) among all the species.(table 4.5) The family of Chlorophyta with genus*Mougeota* (186 organisms, 28 %) has the highest among the species (table 4.6). The family of Cyanophyta with genus (67 organisms, 28%) was higher among the species (table 4.7). The family *Trichodesmium* of Euglenophyta with genus*Euglena* (33 organisms, 53%) has the highest abundance among the species (table 4.8).

The total number of phytoplankton observed in this study was (8410 organisms 42%) with the family Bacillariophyta having the highest abundance(3536 organism 45%) while the least abundant was family Euglenophyta(400 oganism 4.76%) comparism of the various families of organisms observed in all the stations (table 4.9 to 4.11).

Table 4.3: Abundance of phytoplankton in relation to month of River Saye

Phytoplankton	Bacillariophyta (org,%)	Chlorophyta (org, %)	Cyanophyta (org,%)	Euglenophyta (org,%)	Mean Total
January	79 (9.03)	15 (2.25)	5 (2.09)	3 (4.84)	**102 (5.54)**
February	63 (7.20)	47 (7.06)	24 (10.04)	10 (16.13)	**144 (7.82)**
March	73 (8.34)	49 (7.36)	39 (16.32)	12 (19.35)	**173 (9.39)**
April	80 (9.14)	49 (7.36)	36 (15.06)	10 (16.13)	**175 (9.50)**
May	100 (11.43)	30 (4.50)	16 (6.69)	9 (14.52)	**155 (8.41)**
June	47 (5.37)	22 (3.30)	38 (15.90)	3 (4.84)	**110 (5.97)**
July	35 (4.00)	27 (4.05)	12 (5.02)	1 (1.61)	**75 (4.07)**
August	32 (3.66)	224 (33.63)	1 (0.42)	0 (0.00)	**257 (13.95)**
September	74 (8.46)	112 (16.82)	12 (5.02)	0 (0.00)	**198 (10.75)**
October	60 (6.86)	43 (6.46)	4 (1.67)	3 (4.84)	**110 (5.97)**
November	161 (18.40)	29 (4.35)	21 (8.79)	5 (8.06)	**216 (11.73)**
December	71 (8.11)	19 (2.85)	31 (12.97)	6 (9.68)	**127 (6.89)**
Mean Total	**875 (47.50)**	**666 (36.16)**	**239 (12.98)**	**62 (3.37)**	**1842**

KEY=

% = percentage

Org = organism

Table 4.4: Seasonal Abundance of Phytoplankton in River Saye,Zaria

Phytoplankton	**Wet (%)**	**Dry (%)**	**Mean Total**
Bacillariophyta	348 (38.45)	527 (56.24)	**875 (47.50)**
Chlorophyta	458 (50.61)	208 (22.20)	**666 (36.16)**
Cyanophyta	83 (9.17)	156 (16.65)	**239 (12.98)**
Euglenophyta	16 (1.77)	46 (4.91)	**62 (3.37)**
Mean	**905 (49.13)**	**937 (50.87)**	**1842**

KEY = % percentage

Org = Ogernisms

Table 4.5: Seasonal Abundance of Bacillariophyta in River Saye

Family	**Genera/Species**	**Wet (%)**	**Dry(%)**	**Total (%)**
Bacillariophyta	*Anphora spp.*	0 (0.000)	15 (2.87)	15 (1.71)
	Actinella spp.	1 (0.29)	6 (1.15)	7 (0.80)
	Cocconeis spp.	5 (0.36)	5 (0.36)	13 (1.49)
	Coscinodiscus spp.	5 (1.45)	7 (1.34)	12 (1.37)
	Cymatoplenra spp.	5 (1.45)	8 (1.53)	13 (1.49)
	Diatom spp.	30 (8.72)	175 (33.52)	205 (23.43)
	Fraglaria spp.	5(1.44)	0 (0.00)	5 (0.57)
	Fagillanoph spp.	0 (0.000)	12 (2.30)	12 (1.37)
	Frustulia rhomboides	11 (3.20)	11 (2.11)	22 (2.51)
	Gyrosigma spp.	8 (2.33)	14 (2.68)	22 (2.51)
	Licmophora spp.	7 (2.03)	7 (1.34)	14 (1.60)
	Melosira spp.	26 (7.56)	6 ()1.15	32 (3.66)
	Meridian spp.	13 (3.78)	5 (0.96)	18 (2.06)
	Melosira spp.	23 (6.69)	0 (0.000)	23 (2.63)
	Navicula spp.	15 (4.07)	11 (2.11)	26 (2.37)
	Navicula petersonenii	52 (15.12)	23 (4.41)	75 (8.57)
	Nitzschia spp.	19 (5.53)	22 (4.21)	41 (4.69)
	Pinnularia spp.	33 (9.48)	15 (2.87)	48 (5.49)
	Pleurosigma spp.	21 (6.03)	45 (862)	66 (7.54)
	Rhizosolenia spp.	2 (0.58)	7 (1.34)	9 (1.03)
	Synedra spp.	8 (0.23)	14 (2.63)	22 (2.51)
	Surirella angusta	41 (11.34)	83 (15.30)	124 (14.17)
	Tetracyclus	10 (2.31)	11 (2.11)	21 (2.45)
	Terpsinoe	2 (0.58)	0 (0.000)	2 (0.23)
	Pleurosigma	7 (2.03)	20 (3.83)	27 (3.09)
	Seasonal Total	**348 (38.45)**	**527(38.45)**	**875 (47.50)**

Table 4.6: Seasonal Abundance of Chlorophyta in River Saye

Family	**Genera**	**Wet (%)**	**Dry(%)**	**Total**
Chlorophyta	*Actinastrus*	13 (0.46)	2 (0.06)	15 (9.75)
	Ankistrodesmus	6 (1.31)	10 (4.81)	16 (2.30)
	Arthroplesmus	0 (0.000)	2 (0.96)	2 (0.30)
	Binuclearia	0 (0.000)	19 (9.13)	19 (2.85)
	Coelastrum	0 (0.000)	13 (6.25)	13 (1.95)
	Cosmarium	5 (1.09)	7 (3.37)	12 (1.80)
	Closteriospsis	0 (0.000)	9 (4.33)	9 (1.35)
	Docidum	0 (0.000)	5 (2.40)	5 (0.75)
	Mougeota	161 (35.15)	25 (12.02)	186 (27.93)
	Mougeotiopsis	24 (5.24)	3 (1.44)	27 (4.05)
	Oetegonium	73 (15.94)	33 (15.8)	106 (15.92)
	Pediastrium	0 (0.000)	7 (3.37)	7 (1.05)
	Spyrogyra	3 (0.66)	0 (0.000)	3 (0.45)
	Scenedesmus	2 (0.44)	0 (0.000)	2 (0.30)
	Haematococcus	1 (0.22)	11(5.29)	12 (1.80)
	Ulothrix	121 (26.42)	7 (3.37)	128 (19.22)
	Volvex	30 (6.55)	23 (11.66)	53 (7.96)
	Stanrashtrum	9 (1.97)	18 (8.65)	27 (4.05)
	Seasonal Total	**458(50.61)**	**208(2.20)**	**666(36.16)**

Table 4.7: Seasonal Abundance of Cynophyta in River Saye

Family	**Genera/species**	**Wet(%)**	**Dry(%)**	**Total**
Cyanophyta	*Anabaena*	2 (2.47)	4 (2.58)	7 (2.93)
	Arthrospira	0 (0.000)	6 (3.67)	6 (2.51)
	Chrooccus	5 (6.17)	21 (13.55)	26 (10.8)
	Nodularia	10 (12.35)	20 (12.30)	32 (13.39)
	Merismophedia eleganism	3 (3.70)	7 (4.52)	10 (4.10)
	Oscillatoria	18 (22.22)	19 (12.26)	37 (15.48)
	Spirulina spp	6 (7.41)	10 (6.45)	17 (7.11)
	Spontylosium	14 (17.28)	24 (15.48)	38 (15.90)
	Trichodesmium	23 (28.40)	44 (28.39)	67 (28.03)
	Seasonal total	**83(9.17)**	**156(16.65)**	**239(12.98)**

Table 4.8: Seasonal Abundance of Euglenophyta in River Saye

Family	**Genera**	**Wet (%)**	**Dry (%)**	**Total (%)**
Euglenophyta	*Euglena*	10 (62.50)	23(50.00)	33(53.23)
	Phacus	3(18.75)	16(34.76)	19(30.65)
	Trachelomonos	3(18.75)	7(15.22)	10(16.13)
	Seasonal total	16(25.81)	46(74.19)	62(3.37)

Table 4.9: Spatial Abundance of Bacillariophyta in River Saye

Family	Genera	Stations					Total
		I	**II**	**III**	**IV**	**V**	
Bacillariophyta	*Amphora*	10(12.5)	10(12.5)	10(12.5)	0(0.0)	50(62.5)	**80(2.3)**
	Actinella	28(42.4)	0(0.00)	14(21.2)	14(21)	10(15)	**66(1.9)**
	Cocconeis	0(0.00)	41(34.4)	26(21.8)	16(13)	36(30.1)	**119(3.4)**
	Coscinodiscus	14(11.7)	34(28.3)	10(8.3)	38(32)	24(20)	**120(3.4)**
	Cymateplenra	20(16.8)	21(17.6)	1613.4)	36(30)	26(21.8)	**119(3.4)**
	Diatoma	35(17.2)	46(22.5)	41(20.1)	50(25)	32(16)	**204(5.8)**
	Fraglari	0(0.00)	0(0.00)	50(100)	0(.00)	0(0.00)	**50(1.4)**
	Fragillanops	0(0.00)	48(28.5)	24(14.3)	38(23)	58(34.5)	**168(4.8)**
	Frustulia	44(25.9)	0(0.00)	88(51.8)	28(17)	10(5.88)	**170(4.9)**
	Gyrosigma	0(0.00)	84(38.90	40(18.5)	48(22)	44(20.4)	**216(6.1)**
	Licomophora	0(0.00)	50(37.8)	28(21.2)	26(20)	28(21.2)	**132(3.7)**
	Melosira	12(5.88)	0(0.00)	64(31.4)	34(17)	94(46.1)	**204(5.8)**
	Meridian granuholta	40(19.1)	41(19.6)	0(.00)	82(39)	46(22.0)	**209(5.9)**
	Melosira granulate	26(13.7)	46(24.2)	16(8.42)	56(30)	46(24.2)	**190(5.4)**
	Navicula	10(13.3)	15(20)	20(26.7)	15(20)	15(20.0)	**75(2.1)**
	Nitzschia	80(40)	20(10)	0(0.00)	16(0.8)	84(42)	**200(5.7)**
	Pinnularia	96(31.4)	96(31.4)	0(0.00)	18(5.9)	96(31.4)	**306(8.7)**
	Pinnularia viridi	13(20)	16(24.6)	10(15.4)	13(20)	13(20)	**65(1.8)**
	Pleurosgima	10(16.7)	11(18.3)	0(0.00)	21(35)	18(30)	**60(1.7)**
	Pleurosigma	10(4.34)	58(25.2)	44(19.1)	64(29)	54(23.5)	**230(6.5)**
	Rhizosolenia	40(15.6)	84(32.8)	24(9.38)	64(25)	44(17.2)	**256(7.2)**
	Synedra	20(16.3)	28(22.8)	24(19.5)	25(20.3)	26(21.1)	**123(3.5)**
	Surirella angusta	0(0.00)	84(39.6)	42(19.8)	44(20.8 0	42(19.8)	**212(6.0)**
	Tetracyclus	0(0.00)	2(100)	0(0.00)	0(0.00)	0(0.00)	**2 (0.1)**
	Station Total	**468(13.2)**	**835(24)**	**591(17)**	**746(21)**	**896(25)**	
	TOTAL						**3536(42.05)**

Table 4.10: Spatial Abundance of Chlorophyta in River Saye

Family	Species	Stations					Total
		I	II	III	IV	V	
Chlorophyta	*Actinastrus*	10(20.0)	0(0.00)	40(80)	0(0.00)	0(0.00)	**50(2.44)**
	Ankistrodesmus	0(0.00)	64(39)	24(15)	42(26)	32(19.6)	**163(8.0)**
	Arthrodesmus	20(100)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	**20(0.9)**
	Binuclearia	10(10.0)	40(40)	20(20)	20(20)	10(10.0)	**100(4.9)**
	Coelastrum	0(0.00)	41(53)	26(33)	16(21)	36(46.2)	**78(3.8)**
	Cosmarium	20(16.1)	28(23)	0(0.00)	48(38)	28(23.0)	**124(6.1)**
	Closteriopsis	0(0.00)	90(100)	0(0.00)	0(0.0)	0(0.00)	**90(4.4)**
	Docidium	0(0.00)	50(100)	0(0.00)	0(0.0)	0(0.00)	**50(2.44)**
	Mougeotia scalaris	37(20.0)	30(16)	44(24)	30(16)	44(24.0)	**185(9.1)**
	Mougeotiopsis calopsora	10(6.9)	0(0.00)	58(40)	44(30)	33(22.8)	**145(7.1)**
	Oetegonium	25(23.8)	17(16)	21(20)	17(16)	25(23.8)	**105(5.1)**
	Pediastrum	30(42.9)	40(57)	0(0.00)	0(0.00)	0(0.00)	**70(3.4)**
	Spryrogyra	0(0.00)	0(0.00	0(0.000	0(0.00)	30(100)	**30(1.5)**
	Scenedesmus	0(0.00)	0(0.00)	20(100)	0(0.00)	0(0.00)	**20(0.9)**
	Stanrastrum	10(5.55)	50(28)	50(28)	0(0.00)	70(38.9)	**180(8.8)**
	Haematococcus	60(50.0)	30(25)	10(8.3)	20(17)	0(0.00)	**120(5.9)**
	Ulothrix	30(24.0)	20(16)	25(20)	30(20)	20(16)	**125(6.1)**
	Ulothrix closterium	0(0.00)	12(4.8)	80(32)	90(36)	68(10)	**250(12)**
	Volvox	10(7.3)	96(70)	11(8.0)	10(7.3)	10(10)	**137(6.7)**
	Station Total	**272(13.3)**	**608(30)**	**429(21)**	**367(18)**	**407(20)**	**2042(24.81)**

Table 4.11: Spatial Abundance of Cynophyta and Euglenophyta in River Saye

		Stations					**Total**
Family	**Genera/Species**	I	II	III	IV	V	
Cyanophyta	*Anabena*	20(28.6)	10(14.3)	40(57)	0(0.00)	0(0.00)	**70(2.9)**
	Arthrospira	0(0.00)	0(0.00)	10(17)	20(33)	30(50)	**60(2.5)**
	Chrooccus	60(24.8)	50(20.7)	0(0.00)	132(55)	50(20)	**242(9.9**
	Noduleria	90(25)	10(2.8)	120(33)	140(38)	0(0.00)	**360(15)**
	Merismopedia elegnus	20(20.0)	0(0.00)	40(40)	30(30)	10(10)	**100(4.1**
	Oscillatoria	100(27.0)	70(18.9)	100(27)	30(8.1)	70(18.9)	**370(15)**
	Spirulina	50(29.4)	20(11.8)	30(17)	40(23)	30(17.6)	**170(7.0**
	Spontylosium	80(20.5)	100(26)	100(26)	50(13)	60(15.4)	**390(16)**
	Trichodesmus	100(14.9)	200(30)	200(30)	170(25)	0(0.00)	**670(28)**
	Station Total	**520(21.4)**	**460(20)**	**640(26)**	**612(25)**	**250(10)**	2432(28.92)
Family							
Euglenophyta	*Euglena gracilus*	0(0.00)	10(16.7)	10(16.7)	30(50)	10(16.7)	**60(15.0)**
	Phacus	90(47.4)	50(26.3)	0(0.00)	0(0.00)	50(26.3)	**190(45.7)**
	Trachelomes	0(0.00)	0(0.00)	50(33)	50(33.3)	50(33.3)	**150(37.5)**
	Station Total	**90(22.5)**	**60(15)**	**60(15)**	**80(20)**	**100(25)**	400(4.75)

4.5 Correlation of Physico-Chemical Parameters and Phytoplanktons

The relationship between physico-chemical features Phytoplankton Composition of River Saye are presented in Figure 4.7 Chlorophyta is negatively correlated with phosphate, dissolved oxygen and biological oxygen demand. Positive correlation existed between Bacillariophyta, Cyanophyta, Euglynophyta, pH, temperature, alkalinity, total dissolved solids, electrical conductivity, chloride, nitrate and hardness.There was high significant positive correlation between the following families and physic-chemical parameters: TDS and Cyanophyta ($r = 0.81$), EC and Cyanopyta ($r = 0.88$), pH and Cyanophyta ($r = 0.77$) at $p<0.01$, while EC and euglynophyta ($r = 0.700$), TDS and Euglynophyta ($r = 0.69$) were highly significant at $p<0.05$. Significant negative correlation exised between Chlorophyta and chloride (Appendix II). The significant positive correlation observed between nutrient load and phytoplankton abundance might be due to the reason that increase in nutrient concentration leads to increase in phytoplankton abundance. The observed significant negative correlation between phosphate and some phytoplankton abundance could attributed to the reason that an increase in the phytoplankton abundance might lead to increased utilization of such nutrient by these phytoplankton species.

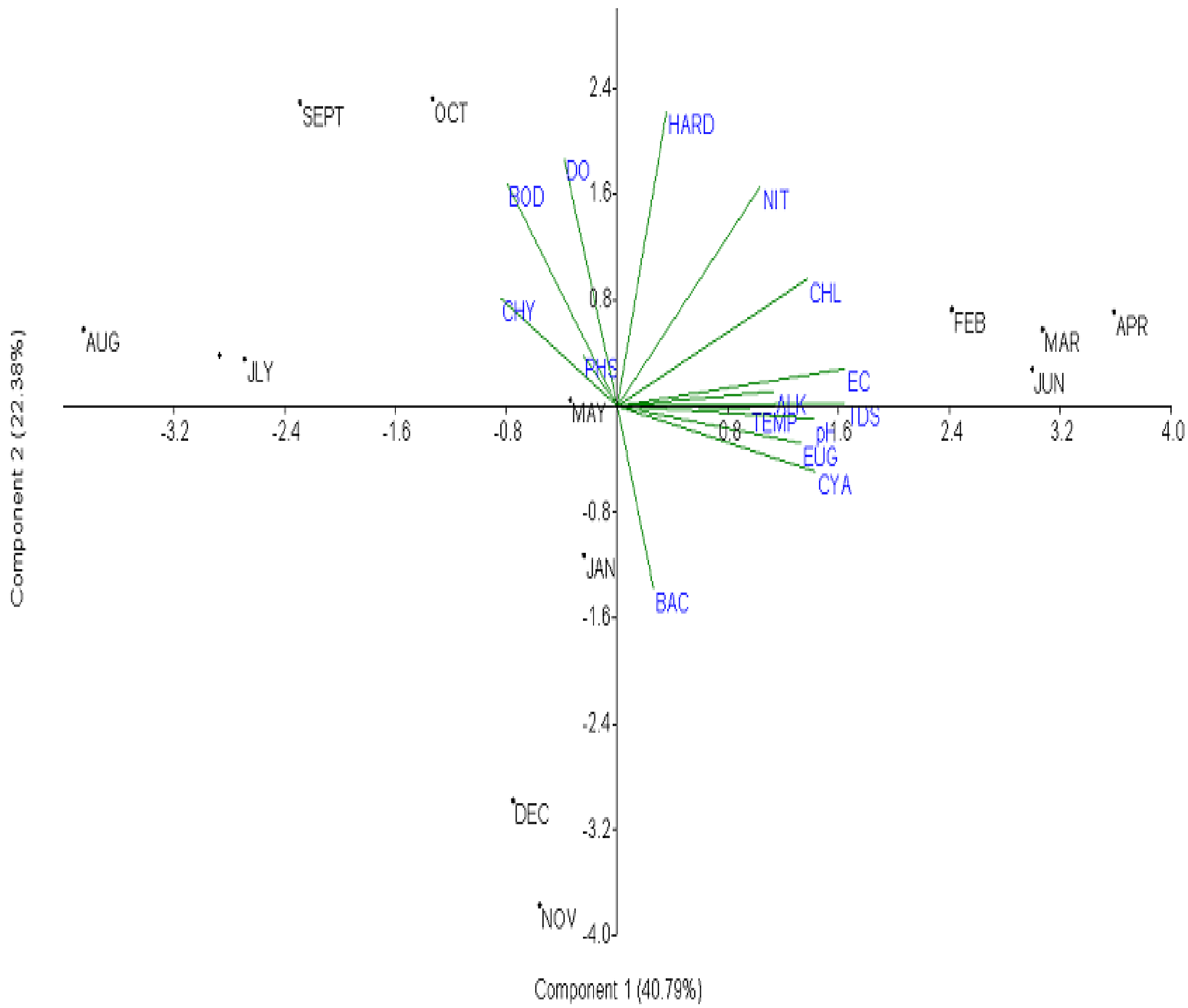

Figure 4.7: Principal component analysis biplot of physicochemical parameters and phytoplankton composition

NOTE: DO= dissolved oxygen, PHS= phosphate, NIT=nitrogen, Temp= temperature, EC= electrical conductivity, TDS= total dissolved solids, BAC= Bacillariophyta, CYA= Cyanophyta, EUG= Euglynophyta, CHL= Chlorine, CHL= Chlorophyta, BOD= Biological Oxygen demand, HARD= Hardness,

4.6 Principal component analysis biplot of physico-chemical parameters and phytoplankton composition

The observed positive correlation between EC, TDS and some species might be due to the fact that increase in conducting ions which include nutrients and essential elements are required for metabolic processes of phytoplankton. Tanimu, (2012) ($r = 0.76$) made similar observation on selected water bodies in Kaduna.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physio-chemical Parameters

5.1.1 Temperature

The lowest temperature observed in December (26.08 ± 0.06 ^{O}C) (early dry season) could be attributed to the hammatan period which is noted with decreased solar radiation and high wave action. Similar reports have been made by Oniye *et al.*(2002), Adakole and Annune, (2003). Dadi-Mahmud *et al.,* (2014) reported temperature range of 21^{O}C to31^{O}C in River Ndakostu which is similar to the present study. However water, temperature which was significantly lower in wet than dry season could be due to increased cloud cover, the extensive submerged macrophytes and water hyacinths (*Eichhonia erassipes*). The turbid nature of the river in wet season could have contributed to the reduction in temperature due to absorption of heat by the silts. This observation showed the preference of phytoplankton assemblage to low temperature in the river thus playing a vital role in the phytoplankton assemblage of the river.

5.1.2 pH

The highestpH value recorded in June (10.78 ± 0.06)(dry season) table 4.1might be due to high photosynthetic activities, which is associated with increased utilization of carbon (iv) oxide CO_2 thereby increasing the pH. The insignificant pH across the stations could be attributed to the uniformity in the chemical composition of the substratum. The present observation of pH fell within the recommended pH range (6.0-9.0) for aquatic life (Chapman and Kimstach, 2006). Also lowest pH in wet season than dry season might be(6.94 ±0.02) due to the presence of CO_2 in the water. Inuwa (2007) made similar observation.

5.1.3 Electrical conductivity (EC)

The highest EC values recorded during the dry seasons than wet season might be due to increase in evaporation thereby increasing the concentration of inorganic solutes in the water. Similar observation was made by Kibira *et al*. (2000) that preported higer EC values (162.13 ± 11.0 mg/L) in dry season. Oniye *et al.* (2002) observed that lower conductivity in wet season than dry season could be as a result of increase in dilution brought about by heavy rains. The positive correlation of electrical conductivity with cyanophyta as a result of increased in concerntration of nutrient loaded which enhanced the growth of cyanophyta Ibrahim, 2009.

5.1.4 Total dissolves solids (TDS)

The highest TDS obtained in dry seasonDecember (87.00 ± 1.76 mg/L) might be as a result of increased rate of evaporation thereby increasing the concentration of dissolved solutes in the water column (Samuel *et al.*, 2015). The lowest wet season TDS could be attributed to low wet season temperature, which promoted poor dissolution of solute in water and reduced evaporation rate temperature as well as low precipitation in the wet season. This study TDS value in dry season was similar to those of Ekpenyoung (2005) high TDS levels in the dry season when compared with the wet season. This possibly explains increase in solubility at high temperature.

5.1.5 Dissolved Oxygen (DO)

The cool harmattan wind which increases wave action and decrease surface water temperature might have contributed to the increased oxygen concentration during wet season, while the torrential rainselicited increased turbidity and decreased oxygen concentration during rainy season (Oniye *et al.*, 2002). Similar observation was made by Saksena *et al*., 2011wet season value was (6.08 ± 0.22 mg/L) in their research on ecological entomofauna of three water bodies at Gwalior, Mdhya dissolved oxygen positively correlated with biological oxygen demand this is due to the oxygen plays as an important regulator of metabolic activities of organisms and thus governs metabolism of the biological community as a whole and as used an indicator of tropic status of the water.Similar value for dissolved oxygen(DO) in wet season was also observed by Ibrahim *et al.* (2009) stating that, the cool harmattan wind which increase action and decrease surface water temperature might have contributed to the increase oxygen concentration during the wet season. The high oxygen value for wet season coincided with periods of low temperature increases the solubility of oxygen. The amount of dissolved oxygen in water has been reported not to be constant but fluctuates, depending on temperature depth and amount of biological activities such as degradation (Chindah and Braide, 2003). The lower DO value in dry season could be attributed to high biological activities such as decomposition of dead and decaying organic matters in the aquatic environment.

5.1.6 Biological oxygen Demand

Biological oxygen demands (BOD) values was recorded to be highest in wet season (4.10 ± 2.48mg/L) and lowest dry season (1.94 ± 0.08 mg/L). Due to high biological activities such as decomposition of dead and decaying organic matter, photosynthesis, etc. could beas a result of massive microbial population. The biodegrading, season hence oxygen will be consumed in the water and increases BOD (Abida and Harikrishna, 2008). Similar work conducted by Ahipathy and Puttaiah (2000) on ecological characteristics of Vrishabhavathy River Bangalore (India) and in their significant positive correlation between biological oxygen demand(r= 0.55) and water hardness with an indication of possibility of organic pollution effect on water in the area but negative correlation with alkalinity which could possibly decrease the demand of oxygen during the months of july (Kumar and Sharma, 2005).

5.1.7 Hardness

The possible reason for high value of hardness in wet season (240.33 ± 7.30 mg/L) might be attributed to increase in the concentrations of magnesium and calcium ion discharged into the river, either from eroded municipal wastes. The lower value of (186.27 ±9.50 mg/L)hardness observed could be as result of high dilution factor during the rainy season. The findings of Kolo and Oladimeji (2004) for shiroro Lake Utodike *et al.* (2001) for Dokowa Mine Lake is similar with the present observation as (240.12 ± 7.29mg/L)

5.1.8 Alkalinity

The higher alkalinity observed in dry season (45.43 ± 1.46 mg/L) was recordedindicated low carbonate bicarbonate ions in the water reflecting the absence of limestone in the water basin. This seasonal trend is in line with electrical conductivity and salinity suggesting limiting role of freshwater discharge into the water body (Chindah and Braide, 2003). Relative increase in alkalinity and electrical conductivity in dry season could be due to the extended dry season period, high evaporation and more intrusion of point source effluents (Michael *et al.*,2015) the finding is similar to the work of Wetzel*et al.*(2001)and the value was recorded(58.50 ± 1.67 mg/L)studies on limnology of lake and river ecosystems(New York; Elsevier press)the positive correlation between alkalinity and chloride could be due to the chloride contributes to the alkalinity of water which enhance the growth of algae. Similar observation made by (Saksena, 2011)

5.1.9 Chloride

Higher value of chloride (42.27 ± 2.16 mg/L) was recorded in dry season, due to increased in concentration of chloride in dry season to greater water evaporation in the dry season and no rain water discharge during the season accounted for higher dry season values and low wet season values (Ekpenyong, 2005). This observation also correlates with the findings of Farombi *et al*. (2014) on the study of variation of biotic conditions of water Quality of river Osun, Osun State Nigeria.Increase concentration of Chloride is always regarded as an indicator of eutrophication and pollution due to sewage and other organic materials. The high chloride content might be attributed to the presence of large amount of organic matter of both allochthonous and autochthonous origin. High chloride contents was obtained in the dry month and lower in wet which were due to increased temperature and consequent evaporation of water from the water body especially in wet runoff. Dunbi Water brought salt for catchment area in Saye River Similar reason have been given by Gupta *et al.* (2006). In Gundolva lake (Kishangarh Shinha and Biswas, 2011). In Kalyani lake and in Chando lake (Verma *et al.*, 2012). Similar observation was made by Toufeek and Korium (2009) in a study on the factor controlling the distribution major metals in Lake Nasser water. The significant correlation between chloride and nitrate suggested that calcium occurred as calcium chloride which enhanced the growth of algae Gupta *etal*.,(2006)

5.1.10 phosphate-phosphorus

Higher wet season mean value (0.22 ± 0.01mg/L) for phosphate phosphorus might be due to reduced photosynthetic activity by the phytoplankton.The relatively high value of phosphate recorded in this study could be attributed to discharged effluents and human activities such as washing, bathing soap, and fish farming. The recorded highest phosphate value in station1 might be due to the biodegradation of organic matter by bacteria Saksena, 2011.

5.1.11 Nitrate-Nitrogen

Highest value of nitrate (0.20 ± 0.01 mg/L) in wet season was recorded could be attributed to the build up of nitrate from extensive farming activities during the wet season. Lowest in dry season (0.20 ± 0.01 mg/L).The low rainy season nitrate could be due to high dilution caused by the rains.Similar observation was made by Thilaga *et al.* (2005) and Garg *et al.* (2009). Nitrate positively correlated with temperature, increased temperature favours the decomposition of plant and animal wastes which elicited the release of nitrogen into the river. Also, run-off water from agricultural farmland might have elevated the the concentration of nitrates in river saye. The positive correlation bewtween nutrient load (hardness, alkalinity, nitrate and phosphate) and phytoplankton abundance may be due to the reason that an increase in nutrient concentration may lead to a resultant increase in phytoplankton abundance.Chia and Oniye, (2013) reported that high nutrient load favoured the abundance of some microalgae in selected water sources.

5.2 Phytoplankton

The high abundance of phytoplankton in dry season might be attributed to the increase in photic depth due to solar radiation intensity as well as the reduction in input turbid materials from other tributaries of the river (Ewa et *al.*, 2013). The observed phytoplankton decreased with the progression of the rainy season might be attributable to the reduced water transparency photo period diminished nutrient content, cloud cover and dilution effects of rain. Plausible reason for the reduced phytoplankton diversity in the wet season might be linked to the flushing of planktonic algal forms towards the sea during rainy season by flood waters and to the low water clarity which reduced the amount of light available to the planktonic algal component for photosynthesis . The observation of abundance of phytoplankton on the Ijora creek by Oyema and Nwankwo (2006) was similar to the present observation.

5.2.1 Bacillariophyta

The dominance of Bacillariophyta is a common feature of both fresh and brackish water systems in Nigeria. The dominance of phytoplankton community by diatoma (Bacillariophyta) has been reported in previous studies of ecological areas (Oyema *et al.*, 2006)**.** The relative abundance of Bacillariophytais an indication that the water was fairly clean during this period, given that thisgroup of phytoplankton is usually associated with clean waters (APHA,2005).

Dominant of Bacillariophyta in Saye River could be linked to the increased water temperature which might be due to the presence of high concentration of silicate intrusion from the catchment area of the river hence an indication of pollution in the water system. Akpan (2006) noted that such pollution includes oxygen deficiencies leading to fish mortality, release of poisonous chemicals by toxic dinoflagellates leading to food poisoning through contaminated shellfish and reduction in aesthetic value of water. The predominance of diatoms is common feature of open lotic waters with fast flowing currents (Utta *et al.*,2008; Olele and Ekelemu, 2008).

The high diatom abundance recorded at most stations in the river during dry season and particularly at Station 4 might be due to available nutrients and other physical and chemical factors which promoted the growth of diatoms. While the lower abundance of Bacillariophyta species recorded in Station 1 could be attributed to the domestic discharge of effluents from run-off that empty into the river. This observation correspond to the work of Fikra *etal*.,(2008)in shatt AL-Hill on phytoplankton communities.Differences in the number of individual and species between sampling stations for each class of phytoplankton might be due to differences in temperature and pH as different species obtain nutrition at different temperature and pH based on the classification, Saye River is moderately polluted with Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta. A similar classification and less polluted with Euglenophyta similar observation was used by Sheha *etal.*,(2009). And Tanimu*etal.*, (2011). The findings were similar to the study of Vidakovic (2007) on biodiversity towards a unifying theme for river ecology in that study recorded significant negative correlation between Bacillariophyta and chloride. This might be due to gradual decrease in nitrogen concentration towards the edge of floodplain. (Vidakovic *etal.*, 2007) negatively correlated with pH he suggests that chloride occurred in the flood water as either calcium, magnesium, chloride and sodium which increase the acidity of the water (lowering the pH). The pH correlated with phosphate due to the mean monthly rainfall and ammonia suggesting that rainfall might have increased the supply of the nutrients for the phytoplankton via runoff, while ammonia increase formed by the decaying processes of plant and animal matters might also have raised the supply of nitrate needed by algae as nutrient.

5.2.2 Chlorophyta

The abundance of chlorophyta in wet season might be related to the acidic nature of the water, a reflection of the acid reported by Ewa *et al.*(2013). In addition, high light intensity characteristics of the tropics favors the development of Chlorophyta (Chukwu,2007).The dominant *Mougeotia scalaris*, in the River Saye agree with the fact that the species is the most widely and frequently recorded, planktonic species of the open water habitat in rivers.

The dominant*Mongeotia scalaris* might have arisen due to its body size which enable it to graze on large quantities and diver's forms of phytoplankton.The density and biomass of *Mougestra scalaris* were primary determined by food supply.Station 5 was characterized to have more abundance of green algae species than the other stations because it is at the point of anthropogenic and human activities is taking place, example washing, grazing and other domestic activities is carried out and it is also the point of human contact. The family of chlorophyta species *mougectia* spp *dociduim* spp *coelestrum* spp were abundant in station five (5), than any other station this may be due to the fact that they have large bodies and highly contributed to disturbance of human and other domestic activities while the lowest abundance were obtained in station 1 which is located at the largest arm of the river and have contact directly with the vegetation, the floral close the river has the ability of purifying the water in the river so much phytoplankton are not captured in the station II.

5.2.3 Cyanophyta

Cynophyta (also known a blue green algae, cyanobacteria and myxophycea). The abundance of cyanophyta observed in this study in dry season must have been caused by the polluted nature of the water due to the anthropogenic activities carried out around its stations five (5). The dominance of cyanophyta is a signal that the river is polluted consequently there is therefore need to regulate the amount of pollutants discharge in to the river so as to avoid total ecological collapse and extinction of the populace it is here by recommended that relevant laws in respect to sustainability of the river should be implemented (Dimowo,2013). The dominant of *Trichodsemium* species is to fix atmospheric nitrogen and the determining factor for the proliferation in various aquatic systems. (Oberholser, 2004). Similar finding have been made in Oyun and Ona rivers (Akin-Oriola 2003). The dominance of cynophyta (*Trichodesmium* spp) in Lake Victoria (Kakende *etal.*, 2004)and in Lake Cheohu (Ogata, 2007; Dimowo *etal.*, 2013) point to the possibility of content by cyanophyta in these water bodies.

Rainfall may have increased the supply of the nutrients for the phytoplankton via run off, while ammonia increase may also have raised the supply of nitrate needed by algae as nutrient.

5.2.4 Euglenophyta

Genus *Euglena gracilis* were the dominance of the Euglenophyta in dry season and low abundance in wet season in the river is good. This is because,Euglenophytaform a group related to contamination with organic matter, and a qualitatively well represented group in lentic environments; and they are subjected to the anthropogenic influence, revealing that they are good indicators of water quality. River Saye is not overloaded with much domestic discharge and organic matter as such it does not create a suitable medium for the growth of algae. Similar observation has been reported by Nweze and Domrufus(2006).

5.2.5 Influence of physico-ochemical parameters on phytoplankton abundance

The significant positive correlation observed between nutrient load and phytoplankton abundance may be due to the reason that increase in nutrient concentration leads to increase in phytoplankton abundance. The observed significant negative correlation between phosphate and some phytoplankton abundance may be due to the reason that an increase in the phytoplankton abundance may lead to increased utilization of such nutrient by these phytoplankton species. The observed positive correlation between EC, TDS and some species may be due to the fact that increase in conducting ions which include nutrients and essential elements are required for metabolic processes of phytoplankton. Tanimu, (2012) made similar observation on selected water bodies in Kaduna.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

The physico-chemical parameters of River Saye that were investigated were temperature,pH, Electrical conductivity, Total dissolved solids, Biochemical oxygen demand, Dissolved oxygen, alkalinity, chloride hardness, nitrate-nitrogen, and phosphate-phosphorus. All physico-chemical parameters revealed monthly seasonal variation and spatial which opposed the null hypotheses stated earlier, Bacillariophyta (56.24%), and was the dominant phytoplanktonof River Saye, which was higher in the dry season (38.45%) than Chlorophyta (2.2%) while Chlorophyte (50.61%) was in the wet season than Bacillariophyta (38.45%).

Bacillariophyta negatively correlated with phosphate(r= -0.66), chlorophyta negatively correlated with cyanophyta (r = -0.43), eglenophyta (r = - 0.40), alkalinity (r= - 0.06), nitrate (r = - 0.09), Tempreture (r = - 0.41), pH (r = -0.55), electrical conductivities (r= - 0.33) and total dissolved solid (r = - 0.44) cyanophyta negatively correlated with dissolved oxygen (r = - 0.28), biochemical oxygen demand (r = - 0.55), hardness (r = - 0.02), phosphate (r = - 0.14), euglenophyta negatively correlated with dissolved oxygen (r = - 0.19), biological oxygen demand (r = - 0.38), phosphate (r = -0.38). Dissolved oxygen negetivily correlated with alkalinity (r = - 0.32), tempreture (r = - 0.21), pH (r = - 0.13), electrical conductivity (r = - 0.14)whileChlorophyta positively correlated with chloride(r=0.63),Cyanophyta positively correlated with Euglenophyta(r=0.67), pH(r=0.77),electrical conductivity(r=0.88) and total dissolve solid(r=0.81).Euglenaphyta positively with chloride(r=0.63),electrical conductivity(r=0.70) and total dissolved solid(r=0.69). Biochemical oxygen demand correlated with dissolved solid (r=0.76), and water hardness(r=0.64).Water hadness positively correlated with nitrate(r=0.80). Alkalinlity positively correlated with chloride(r=0.80), chloride positively correlated with nitrate(r=0.74),electrical conductivity(r=0.77) and total dissolved solid(r=0.67).Nitrate positively correlated with temperature(r=0.58),electrical conductivity(r=0.65) and total dissolved solid(r=0.58), pH positively correlated with electrical conductivity(r=0.80) and total dissolved solid(r=0.8). Electrical conductivity positively correlated with total dissolvedsolid(r=0.98).

6.2 Conclusions

1. The study revealed significant differences in the physico-chemical parameters between the seasons, Temperature was highly significant in dry season with this value (28.12^{0}C) and low in wet season (27.12^{0}C), electrical conductivity EC was significant in dry season (133.73µs/cm)low in wet season (109.87µs/cm),total dissolve solid TDS high in dry season(70.80mg/l)than wet season (58.07mg/l), dissolve oxygen DO was highly significant in wet(5.08mg/l) while in dry season(3.28mg/l), biochemical oxygen demand BOD was high in wet season(4.10mg/l) and low in dry (1.94mg/l). Water hardness was high in wet season(240.33mg/l)than dry season(186.27mg/l), alkalinity was in dry season (45.43mg/l) was higher than wet season (39.43mg/l), chloride was high in dry season(42.27mg/l) and low in wet season(35.42mg/l), phosphate high in wet season (0.22mg/l) was higher than dry season(0.17mg/l);therefore, hypothesis one is rejected.

2. There were significant differences in the aboundance of phytoplankton between sampling stations, in station (v) Bacilariophyta had higher values 896(25%) in abundance and monthly with (875 organisms, 47.50%),Euglenaophyta was low in station (ii and iii) 60(15%)in of abundance and monthly (62 organisms, 3.37%).Therefore, hypothesis is also rejected.

3. The physico-chemical parameters had significant relationship with phytoplankton communities in River Saye. However,Bacillariophyta correlated negatively with phosphate(r=-0.66), Chlorophyta positively correlated with chloride(r=0.63),Cyanophyta positively correlated with Euglenophyta(r=0.67), pH(r=0.77),electrical conductivity(r=0.88) and total dissolved solid(r=0.81).Euglenaphyta positively with chloride(r=0.63),electrical conductivity(r=0.70) and total dissolved solid (r=0.69).The three null hypothesis three is rejected.

6.3 Recommendation

The following recommendationwere made at the end of study:-

1. People around the river should be enlightened on the effects of their activities on the body of water especially in dumping of organic wastes application of inorganic fertilizers, and the use of pesticides as well as their on consequences in aquatic organism.
2. There should be concerted environmental surveilliance this River studies should be conducted to identify the zooplankton and Macrobenthic organisms of River Saye.

3. Effects of organic and inorganic fertilizers on the zooplankton communities of River Saye is also should be determined.

4. Constant monitoring and evaluation of the quality of the water in River Saye should be done periodically.

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APPENDIX I

Physicochemical Parameters of River Saye, Zaria Based On the Stations

Stations	**Temp ^{o}c**	**Ph**	**ECμs/cm**	**TDS ppm**	**DO mg/l**	**BOD mg/l**	**Hardness mg/l caco$_3$**	**Alkalinity mg/l**	**Chloride mg/l**	**Phosphate mg/l**	**Nitrate mg/l**
Station One	27.38±0.40^{b}	9.45±0.50^{a}	130.92±11.18^{a}	71.50±6.25^{a}	4.32±0.35^{a}	2.78±0.35^{b}	217.17±13.59^{a}	48.83±4.02^{a}	38.21±2.01^{d}	0.24±0.02^{a}	0.21±0.02^{a}
Station Two	27.64±0.42^{b}	8.91±0.40^{b}	135.00±15.97^{a}	72.08±7.32^{a}	4.08±0.33^{c}	3.20±0.38^{a}	218.17±15.63^{a}	42.04±3.37^{a}	39.50±2.94^{b}	0.20±0.01^{b}	0.17±0.02^{d}
Station Three	27.64±0.3 ^{b}	7.86±0.35^{c}	122.00±8.66^{b}	62.75±4.51^{b}	4.18±0.35^{b}	2.89±0.42^{b}	218.17±13.98^{a}	40.63±2.80^{a}	32.58±1.61^{a}	0.15±0.02^{d}	0.20±0.02^{b}
Station Four	27.72±0.34^{a}	8.25±0.40^{b}	108.33±8.01^{c}	56.17±4.36^{d}	4.38±0.31^{a}	3.50**±3.78^{a}**	214.67±16.09^{a}	38.75±2.69^{c}	40.25±3.36^{b}	0.23±0.03^{a}	0.21±0.02^{a}
Station Five	27.73±0.36^{a}	8.33±0.45^{b}	112.75±8.59^{d}	59.67±4.53^{c}	3.95±0.29^{d}	2.74±0.29^{b}	198.33±13.56^{b}	41.92±1.89^{b}	43.67±3.27^{a}	0.16±0.02^{c}	0.19±0.02^{c}
Total Mean	**27.62±0.16**	**8.56±0.20**	**121.80±4.89**	**64.43±2.52**	**4.18±0.14**	**3.02±0.16**	**213.30±6.46**	**42.43±1.37**	**38.84±1.25**	**0.20±0.01**	**0.20±0.01**
P value	**0.963ns**	**0.086ns**	**0.367ns**	**0.173ns**	**0.880ns**	**0.544ns**	**0.852ns**	**0.185ns**	**0.075ns**	**0.004****	**0.600ns**

**** highly significant, ns – not significant at $p>0.05$.**

APPENDIX II

Correlation of physico-chemical parameters and phytoplankton in River Saye

	Bacilla	***Chloro***	***Cyano***	***Eugleno***	***DO***	***BOD***	***Hard***	***Alka***	***Cl***	***PO4-***	***N***	***Tep***	***pH***	***EC***	***TDS***
Bacilla	1.00														
Chloro	-0.36	1.00													
Cyano	0.15	-0.43	1.00												
Eugleno	0.33	-0.40	0.67*	1.00											
DO	-0.31	0.07	-0.28	-0.19	1.00										
BOD	0.21	0.49	-0.55	-0.38	0.76*	1.00									
Hard	-0.42	0.16	-0.02	0.08	0.8**	0.64*	1.00								
Alka	-0.28	-0.06	0.53	0.51	-0.32	-0.57	0.96	1.00							
Cl	-0.275	0.63*	0.57	0.63*	0.04	-0.23	0.52	0.8*	1.00						
PO_4^-	-0.60**	0.13	-0.14	-0.38	0.18	-0.21	0.03	0.50	0.11	1.00					
N	0.25	-0.09	0.21	0.35	0.39	0.27	0.8*	0.35	0.74**	-0.05	1.00				
Temp	0.34	-0.41	0.13	0.25	-0.21	-0.18	0.11	0.20	0.33	0.18	0.58*	1.00			
pH	0.13	-0.55	0.77**	0.43	-0.13	-0.33	-0.15	0.13	0.49	-0.04	0.39	0.46	1.00		
EC	0.13	-0.33	0.88**	0.70*	-0.14	-0.27	0.31	0.52	0.77**	-0.27	0.65*	0.50	0.8**	1.00	
TDS	0.19	-0.44	0.81**	0.69*	-0.25	-0.32	0.21	0.47	0.67*	-0.28	0.58*	0.55	0.8**	0.98**	1.0

* correlation is significant at $p<0.05$, ** correlation is highly significant at $p<0.01$

NOTE: DO= dissolved oxygen, Cl= chlorine, PO_4^-= Phosphate, N=nitrogen, Temp= temperature, EC= electrical conductivity, TDS= total dissolved solids

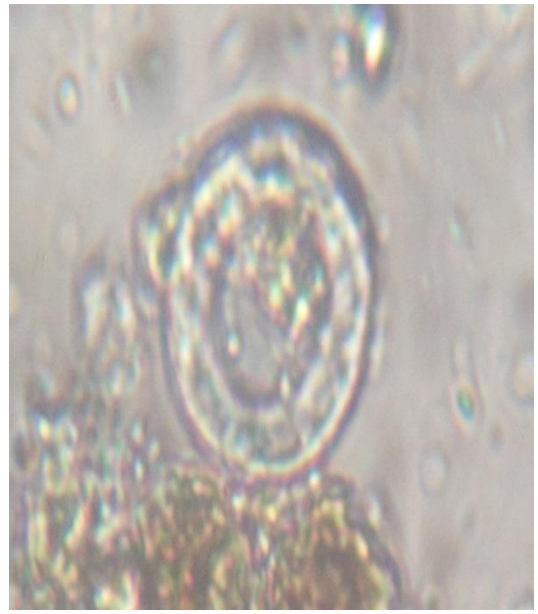
APPENDIX III

Phytoplanktons Diversity Indices

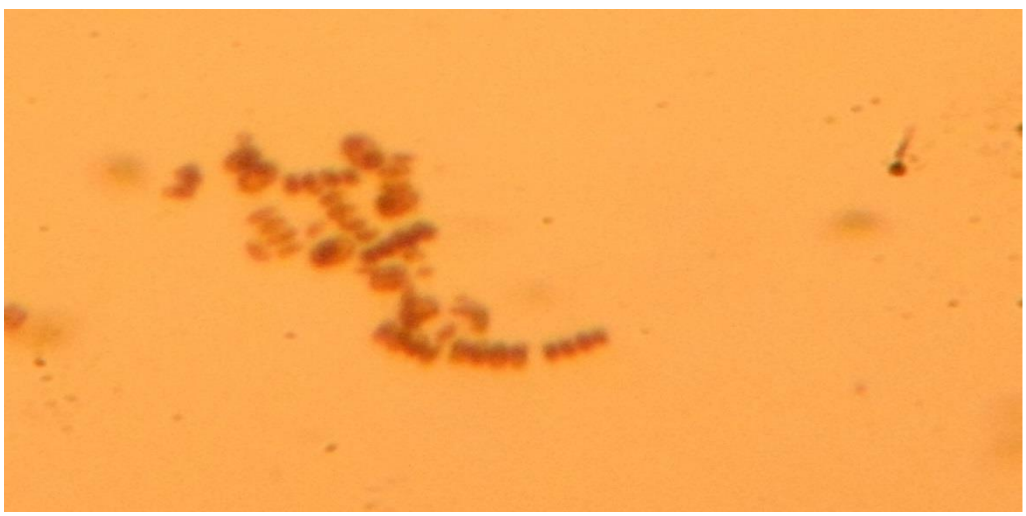
	Bacillariophyta	Chlorophyta	Cyanophyta	Euglenophyta
Dominance	0.09983	0.1694	0.1195	0.1337
Simpson	0.9002	0.8306	0.8805	0.8663
Shannon Index	2.395	2.12	2.236	2.122
Evenness	0.9141	0.6942	0.78	0.8346
Margalef	1.624	1.692	2.009	2.181

APPENDIX IV

A



B



C

KEY: A= *Scenedesmus caudata* (Chlorophyta), B= *Diatom* sp. (Bacillariophyta), C= *Anabaena* sp.

Plate showing *Scenedesmus caudata* (Chlorophyta), *Diatom* sp. (Bacillariophyta), *Anabaena* sp.