



Seasonal Variation in Physicochemical Parameters of River Saye, Zaria, Kaduna State, Nigeria

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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 physicochemical parameters and the phytoplankton assemblage of River Saye, Zaria, Kaduna state were investigated for a period of one year between April 2017 and March 2018 from five sampling stations. The study was aimed at establishing the physical, chemical and phytoplankton parameters of the river. The phytoplanktons were collected using silk plankton net of 25 cm diameter of 70 μm meshes attached to a bottle of fifty (50 ml) capacity at the base, preserved in 4% formalin and stained 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 physicochemical parameters were temperature ($27.62 \pm 0.16^\circ\text{C}$), pH (8.56 ± 0.20), electrical conductivity (EC) ($121.80 \pm 49 \mu\text{s/cm}$), total dissolved solid (TDS) ($64.43 \pm 2.52 \text{mg/l}$), dissolved oxygen (DO) ($4.18 \pm 0.14 \text{mg/l}$) biochemical oxygen demand (BOD) ($3.02 \pm 0.16 \text{mg/l}$), hardness ($213.30 \pm 6.46 \text{mg/l}$), alkalinity ($42.43 \pm 1.37 \text{mg/l}$) and chloride ($38.84 \pm 1.25 \text{mg/l}$). Phosphate ($0.20 \pm 0.01 \text{mg/l}$) 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 phytoplankton in River Saye were recorded namely; Bacillariophyta with (25 genera), Chlorophyta (18 genera) Cyanophyta (9 genera), Euglenophyta (3 genera). Bacillariophyta dominated numerically (47.50%), followed by Chlorophyta (36.16%) then Cyanophyta (12.98%) and Euglenophyta the (3.36%) least. The distribution of phytoplankton between the Stations showed that stations 1, 2, 4 and 5 had higher phytoplankton than station 3.

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INTRODUCTION

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

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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 Yilidis 2001). 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; Odele 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 (13,000km²) 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 *et-al*, 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 macro invertebrates 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 concise 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.

Aim of Study

Was to assess the seasonal variation in physicochemical parameters of the Saye River (wet and dry season).

MATERIALS AND METHODS

Study Area

River saye is lotic water which involved many activities such as mining, washing of cloths, molding blocks, irrigation farming, cattle rears River Saye is in Zaria Local Government Area which is located on latitude $11^{\circ} 7.9^{\prime}N$ and longitude $7^{\circ} 45.59^{\prime}E$. (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 seasons: 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.

Sampling Procedures

Five sampling stations were chosen within the river as follows;

1. Station 1 and 2 are located at the longest arm of the River where mining and moulding of blocks were taking place.

2. Station 3 and 4 are located at the lower point before the bridge where irrigation farming were taking place
3. 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 October 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 sterilized plastic sampling bottle and slid

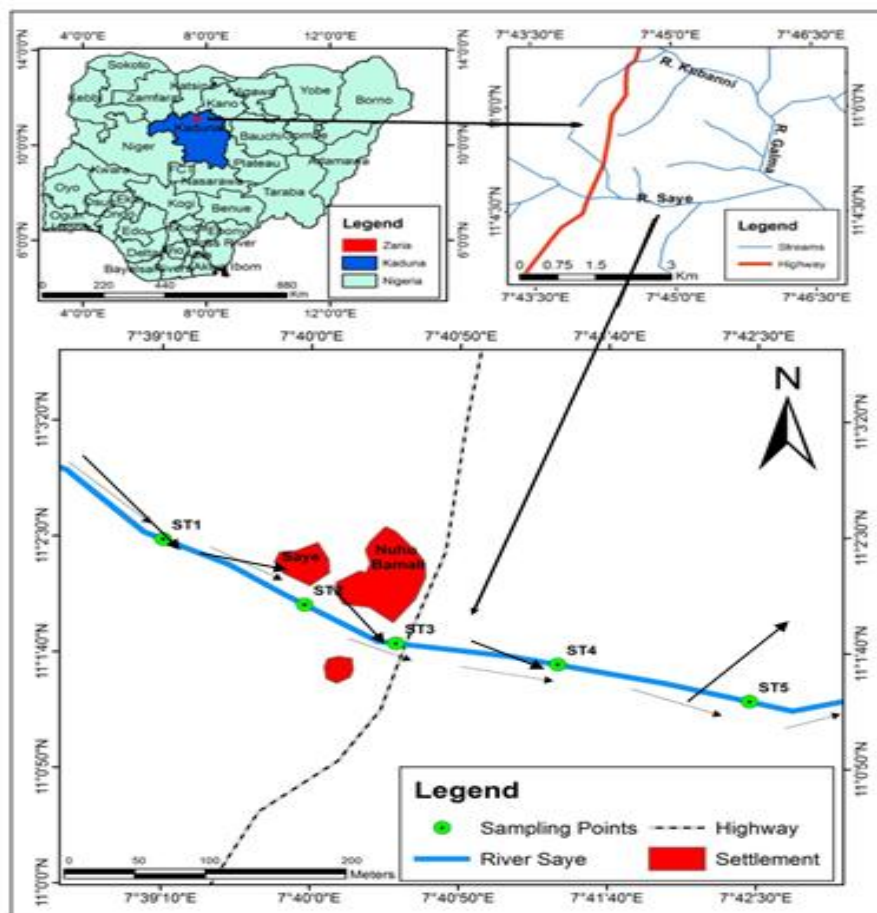


Figure 3.1: Map of River Saye Showing Sampling Stations



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.

Determination of Physico-Chemical Parameters of the River

Determination of Temperature, pH, electrical conductivity, total dissolved Solids. These were determined using the Hanna instrument of model (H198129).

Determination of Dissolved Oxygen and Biological Oxygen Demand

Two milliliters of magnesium-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 2ml. Concentrated sulphuric acid (H_2SO_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($Na_2S_2O_3 \cdot 5H_2O$) 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 $mg/l = DO_1 - DO_5$

DETERMINATION OF HARDNESS

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 16.9g of ammonium chloride in 100 ml in volumetric flask with 1.179 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.

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.

Calculation

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

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)



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 alkalinity in $CaCO_3$ mg/l=titer value $\times 10$

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 is then titrated against silver nitrate solution until dirty reddish precipitate was obtained. $Clmg/l = \text{volume of } AgNO_3 \times 10$ (ALPHA, 2005)

Determination of phosphate-phosphorus

This was determined using the Denniges method one mile (1ml) of Denniges reagent and 1 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 read from the calibration curve. (APHA, 2005). $Mg PO_4/L = mg PO_4 \text{ in vol. flask} \times 1000/ml \text{ of sample used}$.

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. Setting the

spectrophotometer at the wave length 430nm, absorbance of the sample treated was obtained, using water as blank. The concentration of nitrate- nitrogen was obtained from the calibration curve in mg/l (APHA, 2005).

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 70 μ m 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 sample which was then mounted on a compound microscope for identification using text book key and Robert perry guide line or key.

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.



RESULTS

Physico-chemical parameters in relation to seasons and station in River saye

Table 4.2: Seasonal Variation of Physico-chemical Parameters of River Saye near 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

Temperature

The lowest temperature value (27.12±0.20 °C) was recorded in wet season while highest in dry (28.12 ± 0.22 °C) Variation was highly significant between the seasons ($P \leq 0.01$) (Table 4.2). Station 5 and 4 had the highest value of temperature (27.73 ± 0.36 °C) across the stations, lowest in station 3 (27.38 ± 0.40 °C) which was significant ($P \geq 0.05$) Figure 4.1.

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).

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 ($P \leq 0.05$) (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).

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 ($P \leq 0.01$) (Table 4.2). Station two had the highest value ($72.08 \mu\text{s/cm}$) lowest in station 5 ($59.6 \mu\text{s/cm}$) (figure 4.1)

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 (4.38 mg/l) minimum in station 1 2.78 mg/l (figure 4.1).

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 (3.50 mg/l) low in station 1 (2.78 mg/l) which was non-significant (figure 4.1).

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)

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).

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 ($P \geq 0.01$) (Table 4.2). Station 5 was highest among the stations (43.67 mg/l) and low in station 1 (38.21 mg/l) (Figure 4.1).

Phosphate- Phosphorus

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

Nitrate- Nitrogen

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

DISCUSSION

Physio-chemical Parameters

The lowest temperature observed in December (26.08 ± 0.06 °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°C to 31°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 crassipes*). 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.

The highest pH value recorded in June (10.78 ± 0.06) (dry season) table 4.1 might 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.

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 reported higher 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 concentration of nutrient loaded which enhanced the growth of cyanophyta Ibrahim, 2009.

The highest TDS obtained in dry season December (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.

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 rains elicited increased turbidity and decreased oxygen concentration during rainy season (Oniye *et al.*, 2002). Similar observation was made by Saksena *et al.*, 2011 wet 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.

Biological oxygen demands (BOD) values was recorded to be highest in wet season (4.10 ± 2.48 mg/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 be 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).

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 ± 7.29 mg/L)

The higher alkalinity observed in dry season (45.43 ± 1.46 mg/L) was recorded indicated 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 Wetzelet *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 alg Similar observation made by (Saksena, 2011)

Higher value of chloride (42.27 ± 2.16 mg/L) was recorded in dry season, due to increase 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 *et al.*, (2006)

Higher wet season mean value (0.22 ± 0.01 mg/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.

Highest value of nitrate (0.20 ± 0.01 mg/L) in wet season was recorded could be attributed to the buildup 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 concentration of nitrates in river saye. The positive correlation between 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.

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.

CONCLUSION

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°C) and low in wet season (27.12°C), electrical conductivity EC was significant in dry season ($133.73\mu\text{s/cm}$) low in wet season ($109.87\mu\text{s/cm}$), 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.

RECOMMENDATIONS

The following recommendation were 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 surveillance this River studies should be conducted to identify the zooplankton and Macro-benthic 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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