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Seasonal Distribution and Variations of Abundance of Phytoplankton Community in Ikere Gorge Dam, Oyo State, Southwest Nigeria

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ABSTRACT: Factors influencing the distribution and variations of abundance of phytoplankton of dams are yet to be accounted for in Southwest Nigeria. Therefore, the objective of this paper was to evaluate the seasonal distribution and variations of abundance of phytoplankton community in Ikere Gorge Dam, Oyo State, Southwest Nigeria using standard techniques. Data obtained show that a total of 494 microalgal taxa belonging to eight divisions were recorded. Zygnematophyceae comprised 360 taxa (64%), Bacillarophyceae 22 taxa (14%), Chlorophyceae 66 taxa (13%), Cyanophyceae 20 taxa (4%), Dinophyceae 8 taxa (1%), Trebouxiophyceae 13 taxa (2%), Ulvophyceae 3 taxa (0.02%), Xanthophyceae 2 taxa (0.01%). The observations and results confirm hypotheses that phytoplankton abundance varies more between season (wet and dry) than spatially in Ikere gorge dam. No single taxon or a combination of two or three taxa accounted for more than 80% of the phytoplankton abundance. Canonical correspondence analysis revealed DO, TDS, nitrate-nitrogen and water transparency as the major water quality variables driving variation in the composition of plankton communities in the dam. This study showed seasonality is the major factor influencing the diversity and abundance of phytoplankton community through changes in concentrations of DO, nitrates, and phosphate. Ikere Gorge dam showed a strong seasonal variation in physico-chemical water quality variables owing to the size of the dam that is not well-mixed, and with long water residence times. This study contributes to understanding the water quality, determinant factors, and drivers of biological communities in dams of tropical regions that are being influenced by anthropogenic activities.

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Dams serve a variety of uses in water-economic systems, such as providing industrial supplies, recreational and leisure needs, agricultural irrigation, and human water supply (Ziemińska-Stolarska, 2018; Bayhan *et al*., 2017; Simainga, 2006). In most circumstances, high-quality water is required for a dam to function as intended. The distribution and variations of abundance of phytoplankton of dams are yet difficult to account for except in vague and general terms. Since this microscopic floating plant is the primary producer of aquatic ecosystem, the inadequacy of our knowledge is reflected through the entire fields of fresh water and marine biology and limits the efficiency with which both fresh water and the sea can be exploited as sources of food (Zinat *et al*., 2021). According to Jachniak and Jaguś (2023), a trophic scale is displayed in aquatic systems by three basic variables working together. The first is the edaphic factor, which influences whether a dam is productive and rich or sterile. The morphological factors come next. The first two are geologic, third component is the climate, which is a meteorologic-geographic matter. Climates range from harsh to favorable for growth and productivity, with several meteorological implications. Mondal and Banerjee (2022) stated temperature differences, growing season

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duration, solar radiation, precipitation, evaporation locations, and wind are all factors. Thus, an oligotrophy is described as strikingly poor water; many dams fall midway between oligotrophy and eutrophy, with water rich in nutrients and high biotic productivity, and are the consequence of three three processes acting in concert (Kondowe *et al*., 2022). The evaluation of phytoplankton distribution, spatial structure is generally concentrated on experimental observations at scales ranging from more than 10 m to several kilometers, where inconsistency in phytoplankton distribution was empirically observed to be extremely variable in both space and time (Waters and Mitchell, 2002; Steele and Henderson, 1981). Many scholars have studied the seasonal variation of nutrients and the dynamics of plankton in aquatic systems during the last few decades, and mathematical models have been employed as a crucial tool for a better mathematical knowledge of these systems (Huisman *et al*., 2006; Edward and Brindley, 1996; Steele and Henderson, 1992). In both of these examples, the models are investigated at the mesoscale or greater scale, with only a few exceptions at the microscale. In contrast to large-scale investigations, there is little information on phytoplankton spatial optimization at ecologically relevant microscales. Phytoplankton species composition and population density are sensitive to environmental changes. Their recording in relation to a dynamic environment is an important feature of water quality. This study investigated diversity, composition, factors influencing the seasonal distribution and variations of abundance of phytoplankton community in Ikere gorge dam, a dam in Iseyin, Southwest Nigeria. The primary goal was to determine the primary factors impacting the seasonal distribution and variations of phytoplankton community, as well as their potential applications as bio-indicators of water quality. In addition to this, the dam's phytoplankton equilibrium status was evaluated (Sommer *et al*., 1993). Communities in Ikere gorge dam vary more over time because of its small size than in other lakes and reservoirs like Asejiri reservoir (Asibor and Adeniyi, 2022), Ufiobodo and Ebonyi River reservoirs (Nwonumara *et al*., 2022), Lekan-Are Lake (Ikenweiwe *et al*., 2011), Egbe reservoir (Edwards and Ugwumba, 2010), Awba reservoir (Akin-Oriola, 2002), African reservoirs and lakes (Madzivanzira *et al.*, 2023). According to several competition and predation theories, plankton will never reach equilibrium even in homogeneous and constant surroundings. Interactions between numerous species, on the other hand, may cause oscillations and chaos, with a continuous wax and wane of species within the community (Scheffer *et al*., 2003). Long-term laboratory tests back up this claim. When considered in depth, this chaotic behavior shows, among other things, that plankton dynamics are inherently unpredictable in the long run. On a higher aggregation level, however, metrics such as total algal biomass may exhibit highly regular patterns. Hence, the objective of this paper was to evaluate the seasonal distribution and variations of abundance of phytoplankton community in Ikere Gorge Dam, Oyo State, Southwest Nigeria

MATERIALS AND METHOD

Description of the Study Area: Ogun-Osun River Basin Development Authority (OORBDA) (2015) cited by Adeyemo (2016) stated that Ikere Gorge dam has a surface area of 47 km^2 and depth of 35.6 km, located in upper Ogun river, 8 km East of Ikere village and 40 km North East of Iseyin in Oyo State, Nigeria between longitude 8°10ˈN and 8°20ˈN and latitude 3°40ˈE and 3°50ˈE. The dam was formed by damming River Ogun (main source), River Owu, and River Amaka which are minor tributaries. River Ogun is part of the dense network of inland water course that flows southwards into Lagos Lagoon. The dam has a capacity of 690 m^3, Length of axis 660 m, Height at center 47.5 m, Volume of the earth fills 1.4 million cubic meters (MCM), Crest elevation 277.50 meters a.m.s.1. The reservoir was constructed by OORBDA in 1990. It was constructed primarily for the following purposes: Provide water to Iseyin, Okeho, and Iganna and environ, supplement out water supplies to Abeokuta and Lagos, provide irrigation water for 12,000 ha, to generate 6 megawatt of hydro-electricity. Also, about 90% of population comprising of people from seven villages around the dam have fishing as their primary occupation. Species *Chrysichthysnigro digitatus, Chrysichthysni grodigitatus, Tilapia guineensis* (Adeosun *et al*., 2009; Kareem *et al*., 2020) are the most dominant fish in Ikere gorge dam. Along the bank of the dam are distributed forest and savanna trees, aquatic grasses, and shrubs. There were several pieces of dead wood projecting out of the water. July and September are the period of heavy rainfall and November is the onset of dry season in the western part of Nigeria. Toward the southern part of the dam were hills primarily made of rock and gravels. The rivers that run down to the dam have gravels and sand as their major substrate (Adebisi, 1981).

The water bed comprised mainly of fine and coarse sand particles and gravels. The dam experienced frequent current as a result of wind that blows on it from time to time. Sometimes, the current results to wave action which frequently spread across the reservoir and sometimes, it could be violent particularly during the raining season.

Sampling sites: A total of seven stations were selected based on hydro-environmental gradients, ecological uniqueness, and anthropogenic activities using identifiable structures and a Global Positioning System (Germin nuvi 205w). These included stations in the littoral zone (Apata), open water (Amaka, Spillway, Dwelling quarters, Powerhouse, European quarters), and anthropogenic activities (Aquaculture) (Figure 1). The littoral and inflow zones had a depth range of 20 - 35.6 m during the dry season and 15-31.24–2.51 m during the wet season. The open water had a depth of 21.7 m during the wet season, while in the dry season, the depth was 24.9 m.

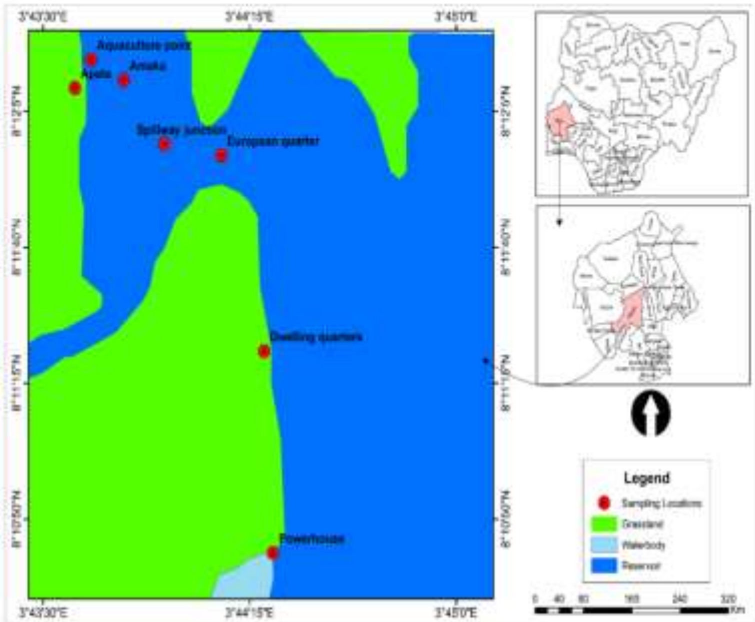

Fig 1: Map showing sampling sites in Ikere Gorge Dam for September 2017–February 2019 (ArcGIS 10.3.1)

Table 1: Average depth and geographical position of sampling stations on Ikere Gorge Dam, Oyo

Stations	Stations	Average depth (m)
1	Apata	16.62
2	Aquaculture point	19.90
3	Amaka	22.57
4	Spillway junction	23.92
5	European quarter	23.22
6	Dwelling quarters	23.86
7	Powerhouse	26.97

Sample Collection and Analysis: Samples were collected monthly for 18 months covering the dry (November-April) and wet (May-October) season. Surface water temperature, pH, Transparency, Depth, Electric conductivity (EC), Salinity, Total dissolved solids (TDS) were measured in-situ using a mercury-in glass thermometer (0° C -100° C), HACH HQ 40d multimeter. Triplicates water samples were collected in well labelled 1-L screw capped amber bottles and transported to the laboratory in an ice chest for water chemistry analysis (APHA, 1998). 500 mL of water was collected using 55 µm mesh size standard plankton net and fixed in situ using 4% unbuffered formalin before transport to the laboratory for analysis (Nwankwo, 1996a; 1996b). In the laboratory, biology oxygen demand (BOD), chemical oxygen demand (COD) was determined using closed reflux (SM 5220 D) method with COD reactor (Hanna HI839800), oil and grease and nutrient concentrations; reactive nitrogen (NO_3^-N), reactive phosphorous (PO_4^-P), silicate (SiO_2^-), sulphate were determined using standard methods for the examination of water and wastewater (APHA, 1998). Chlorophyll-a concentration was analyzed following pigment extraction from the thawed membrane filters using 5 Ml of 90% acetone (APHA, 2017) and centrifuged for 10 min at 4,000 rpm. Absorbance was read at 750 nm, 664 nm, and 665 nm against an acetone-solution blank and standards. Extract was acidified and absorbance read at 665 nm after which chlorophyll-*a* is calculated using the formula in equation 1. :

$$Chl_a(\mu/L) = \frac{26.7(664B - 6A) * V_1}{V_2 * L}$$

Where: Subscripts indicate absorbance before acid addition (B) and after acidification (A); V_1 is volume of solvent (mL); V_2 is volume of sample (mL); L is path length (cm) = 1.

Phytoplankton processing for identification and counting was done according to method of Lackey (1938). Replicate samples of 0.1 mL were pipetted to slide (covered with coverslip) and examined under Olympus microscope (88888) at x10 magnification to identify and count them. Phytoplankton identification to genus level was done using Whitford and Schumacher (1973), Coesel and Meesters (2013), Prescott (1982), David (2002). After enumeration, the phytoplankton abundances expressed as individuals identification to genus level.

Statistical analysis: The `vegan` package was used in performing Non-metric Multidimensional Scaling (NMDS) analysis and Canonical Correspondence Analysis (CCA) (Clarke and Gorley, 2006). Principal Component Analysis (PCA) was conducted using the `prcomp` function from the `stats` package. Analysis of Similarity (ANOSIM) and Similarity Percentage (SIMPER) analysis was utilized using the `betadiver` and `anosim` functions from the `vegan` package (Clarke and Warwick, 2001). All analyses were performed using R statistics version 4.2.2 for macOS. Shannon's diversity index (H′) (Magurran, 2004), Simpson index (D) (Simpson, 1949) and index (E) was utilized to measure diversity, quantify species richness, and evenness respectively. PAST version 4.04 was used to analyze the species diversity indices. Figures 3 and 4 were prepared using MS Office Excel 2016 (Kilonzo *et al*., 2014).

RESULTS AND DISCUSSION

Physicochemical Characteristics: The dry season had higher air temperature than the rainy season (Table 1). Air temperature was generally greater than 28 °C in the dry season, while wet season temperatures were less than 29 °C. Water temperature readings were similar to air temperature; however, the seasonal differences were mostly minimal and, in most cases, within a degree Celsius margin. In both dry and wet season, highest values of total dissolved solids (TDS) values was observed in Station 4 as 57.58 mg L^{-1} and 44.17 mg L^{-1}. Similar to the air and water temperature findings, TDS values were generally higher in the dry season than in the wet season. The highest and lowest values for water transparency (Table 1) were 29.89 and 27.56 respectively. Mean dry season phosphate phosphorus levels in station 1, 2, and 4 samples were at least three times higher than those reported in the wet season (Table 2). On the other hand, there was no significant difference in the phosphate levels at station 5 samples collected in both wet and dry seasons. Although nitrate levels varied between the wet and dry seasons in the water bodies, the changes were rarely up to twofold. Also, the changes in nitrate-nitrogen concentrations were not significantly different between seasons in the aquatic ecosystems. pH was mostly circum-neutral. Furthermore, the water pH was lower in the dry season in all the water bodies, sometimes reaching levels lower than seven, especially in stations 5, 6, and 7. pH was highest in station 4 in the wet season at 7.97, followed by station 2 at 7.91. Dissolved oxygen (DO) concentration was mostly around 5.00 mg L^{-1}, with no significant differences between the wet and dry seasons (Table 2). BOD was highest in station 7 (2.44 mg L^{-1}), followed by station 2 (2.11 mg L^{-1}) and station 1 (2.00 mg L^{-1}) in the wet season. Most water bodies, excluding the station 6, had higher in the wet season than the dry season. The BOD of station 3 was primarily identical between the wet and dry seasons, with a mean average value of 1.78 mg L^{-1}. In the wet season, COD peaked in station 7 with 7.89 mg L^{-1}, followed by station 3 with 6.56 mg L^{-1}. Station 5 had the lowest dry and wet season COD throughout the study at 2.22 mg $L^{-1}$and 3.0 mg L^{-1}, respectively. Salinity was mainly around 5 in both the dry and wet seasons in most of the water bodies. The only exceptions were station 6 and station 4 in the wet season.

Seasonal and Water Source-associated Correlations between Physicochemical Parameters: Principal components analysis of seasonal and water source changes in physicochemical conditions revealed that the first two components accounted for 36.8% of the total variation (Figure 2A and 2B). The second principal components were positively associated with Total suspended solids (TSS), NO_3^-, salinity, TDS, and DO. These parameters were negatively associated with water and air temperatures and water transparency on the second principal component. Changes in TSS, NO_3^-, salinity, TDS, and DO were positively related to dry season sampling, while temperature changes were mostly positively associated with wet season sampling. Stations 3, 5 and 6 were positively associated with transparency and air and water temperatures. The relationship between the source of water and physicochemical changes revealed that stations 3 and 7 were positively associated with salinity. Stations 4 and 6 were positively related to TDS and NO_3^-.

Phytoplankton Composition and Abundance: Number of phytoplankton recorded in the 18 months of study indicates August 2018 had the highest number of taxa (205) while December 2017 had the lowest (108) (Table 3). Similarly, the Simpson's diversity index (D1), Menhinick's index (D), and Margalef's species richness index had the highest phytoplankton diversity in August 2018 as 0.97, 3.12, 24.38 respectively (Table 3), Shannon diversity index (H′) and Simpson's evenness index (E) had the lowest and highest values in December 2018 ranging from 4.35 to 1.97 and 0.19 to 0.49 respectively (Table 3)

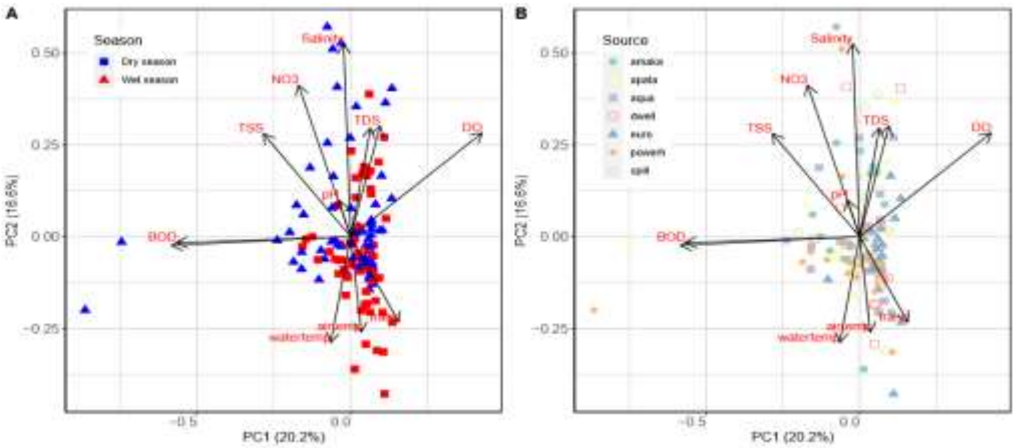

Fig 2: Principal components analysis results of physicochemical parameters of water samples collected from different sources during the dry and wet seasons

TABLE 1: Mean values (±SD) of water quality variables and nutrient concentrations during the dry and wet seasons in Ikere Gorge dam during the study period from September 2017 to February 2019.

Source	Season	Air Temp (°C)	Water Temp (°C)	TDS ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)	Transparency (m)
Station 1	Dry season	29.56±1.51	29.22±1.86	43.69±7.11	7.22±1.39	1.55±0.7
	Wet season	28.56±3.17	28.11±1.36	41.53±7.44	10.67±7.07	1.25±0.48
Station 2	Dry season	29±1.87	29.56±2.35	44.64±6.07	7.11±1.62	1.26±0.36
	Wet season	26.78±1.79	28±2	39.99±6.94	8.78±4.79	1.26±0.38
Station 3	Dry season	28.78±1.64	29.89±2.26	43.91±6.17	7±1.12	1.54±0.62
	Wet season	27.78±2.44	28±2	39.42±6.78	13.67±13	1.28±0.4
Station 4	Dry season	32±4.66	29.44±1.88	42.99±6.79	6.89±0.93	1.71±0.63
	Wet season	27.78±2.91	27.56±1.81	43.08±7.64	10.22±7.1	1.55±0.32
Station 5	Dry season	30.78±3.35	29.44±1.51	43.1±6.1	7.33±2.24	1.77±0.61
	Wet season	28±2.45	28.33±1.8	39.27±6.89	7.11±3.18	1.63±0.33
Station 6	Dry season	33.22±5.24	29.78±1.09	45.76±8.43	8.44±1.01	1.91±0.51
	Wet season	28±2	28.16±1.78	39.5±6.95	13.67±7.31	1.63±0.38
Station 7	Dry season	29.56±2.7	28.44±3.54	57.58±39.11	7.11±0.6	1.7±0.62
	Wet season	28.44±3.94	27.89±1.27	44.17±11.8	10.44±7.02	1.49±0.32

Table 2: Changes in physicochemical parameters of different aquatic ecosystems in Ikere Gorge dam. Values represent mean plus or minus standard deviation for n = 3. $P\text{-}PO_4$ = Phosphate phosphorus, $N\text{-}NO_3^-$ = Nitrate nitrogen, DO = Dissolved oxygen, BOD = Biological oxygen demand, COD = Chemical oxygen demand

Source	Season	$P\text{-}PO_4$ ($mg\ L^{-1}$)	$N\text{-}NO_3^-$ ($mg\ L^{-1}$)	DO ($mg\ L^{-1}$)	BOD ($mg\ L^{-1}$)	COD ($mg\ L^{-1}$)
Station 1	Dry season	1.26±1.78	1.93±0.77	5.32±0.25	1.78±0.67	3.44±1.67
	Wet season	0.89±2.42	1.43±0.61	5.38±0.34	1.78±0.83	4.22±2.54
Station 2	Dry season	0.89±1.23	2.01±0.79	5.34±0.24	1.44±0.53	3.44±1.42
	Wet season	0.14±0.1	1.62±0.81	5.25±0.59	2±1.66	6.56±9.72
Station 3	Dry season	0.88±1.2	1.34±0.57	5.41±0.27	1.33±0.71	3.67±2.12
	Wet season	0.15±0.21	1.17±0.54	5.3±0.37	2.11±0.93	4.67±2.65
Station 4	Dry season	0.15±0.15	1.02±0.87	5.26±0.48	1.67±0.5	3.11±0.93
	Wet season	0.18±0.29	1.15±0.57	5.23±0.53	1.22±0.44	2.44±0.73
Station 5	Dry season	0.47±0.6	0.98±0.55	5.37±0.18	1.11±0.33	2.22±0.67
	Wet season	1.42±4	0.99±0.35	5.43±0.38	1.44±0.73	3±1.12
Station 6	Dry season	0.14±0.1	1.06±0.45	5.28±0.2	1.78±0.67	4.22±1.48
	Wet season	0.14±0.17	1.75±1.96	5.06±0.69	2.44±1.88	7.89±10.07
Station 7	Dry season	0.54±0.7	1.16±0.64	5.36±0.24	1.56±0.53	3.78±1.09
	Wet season	0.14±0.2	1.03±0.57	5.34±0.31	1.67±1	3.67±1.58

Table 3: Temporal changes in diversity indices and number of taxa of phytoplankton during the study period from September 2017 to February 2019

	17-Sep	17-Oct	17-Nov	17-Dec	18-Jan	18-Feb	18-Mar	18-Apr	18-May	18-Jun	18-Jul	18-Aug	18-Sep	18-Oct	18-Nov	18-Dec	19-Jan	19-Feb
Taxa_S	119	151	147	108	133	136	142	126	176	203	151	205	153	189	197	159	120	131
Individuals	9133	15139	4732	3556	2332	4256	16967	9552	8449	29005	9323	4309	20346	25928	3767	2662	3458	3944
Dominance_D	0.09	0.24	0.09	0.15	0.04	0.03	0.13	0.15	0.06	0.04	0.2	0.02	0.08	0.04	0.02	0.02	0.05	0.03
Simpson_1-D	0.9	0.75	0.9	0.85	0.95	0.96	0.86	0.84	0.93	0.95	0.79	0.97	0.91	0.95	0.97	0.97	0.95	0.96
Shannon_H	3.14	1.97	3.39	2.84	3.78	3.97	2.82	2.63	3.86	3.9	2.5	4.2	3.3	3.75	4.31	4.35	3.65	3.94
Evenness_e^H/S	0.19	0.04	0.2	0.15	0.33	0.39	0.11	0.11	0.27	0.24	0.08	0.32	0.17	0.22	0.38	0.49	0.32	0.39
Menhinick	1.24	1.22	2.13	1.81	2.75	2.08	1.09	1.28	1.91	1.19	1.56	3.12	1.07	1.17	3.21	3.08	2.04	2.08
Margalef	12.94	15.58	17.25	13.09	17.02	16.16	14.48	13.64	19.35	19.66	16.41	24.38	15.32	18.5	23.8	20.03	14.6	15.7
Equitability_J	0.65	0.39	0.67	0.6	0.77	0.8	0.56	0.54	0.74	0.73	0.49	0.79	0.65	0.71	0.81	0.85	0.76	0.8

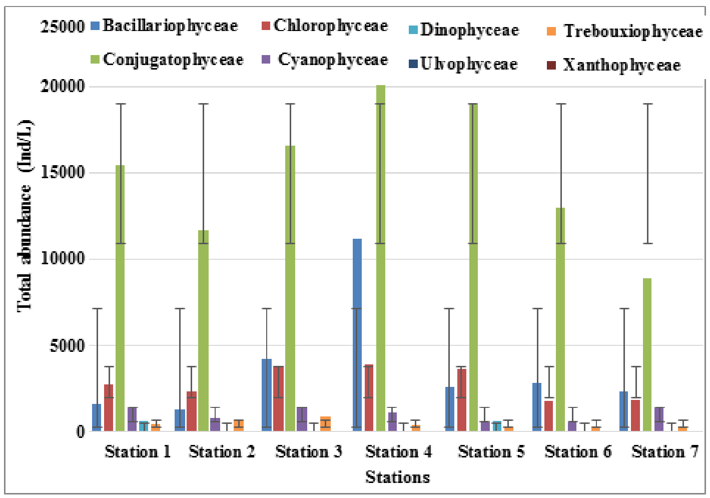

Fig 3: Comparison of mean plankton abundance at different sampling stations in Ikere Gorge dam from September 2017 to February 2019

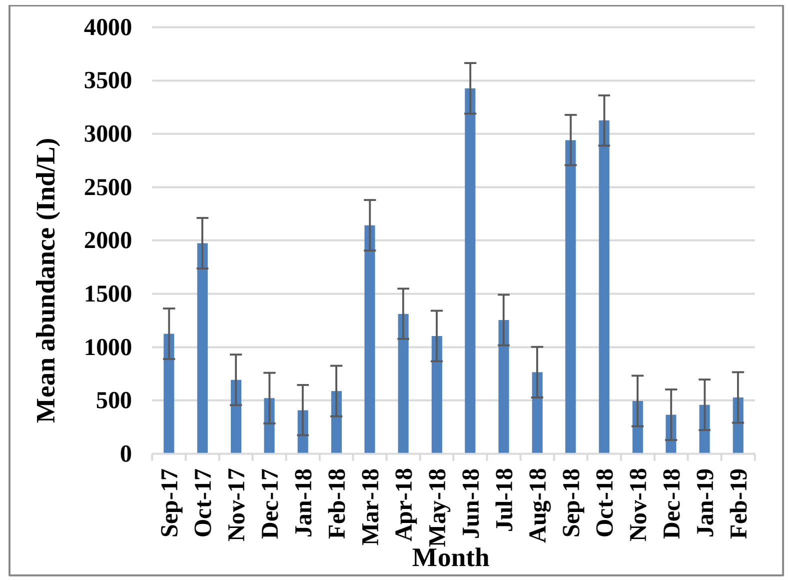

Fig 4: Temporal monthly variation of phytoplankton abundance in Ikere Gorge dam from September 2017 to February 2019

The Zygnematophyceae (desmids) was the most dominant phytoplankton group in terms of abundance at all the 7 sampling stations. Xanthophyceae was the least abundant group in all the stations (zones). Chlorophyceae was the second most abundant at the littoral zone (stations 1 and 2), and open water station (stations 5) (Figure 3). During December 2018, phytoplankton abundance was the lowest while June 2018, phytoplankton abundance was recorded highest (Figure 4). Overall, phytoplankton had highest abundance during wet season (May, June, July, August, September, October) compared to dry season (November, December, January, February, March, April). A mean total abundance of 9035.167 Ind/L of phytoplankton was recorded at Ikere gorge dam during this period (Figure 4).

The most abundant phytoplankton species belonged to the following classes: Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Zygnematophyceae (Conjugatophyceae) (Tables 4 and 5). In the wet and dry seasons, the group with more species occurring among the most abundant species was Zygnematophyceae. Next was Chlorophyceae with nine (9) species, Bacillariophyceae with (6) species, and Cyanophyceae with three (3) species.

Table 4: Most abundant phytoplankton taxa recorded during the wet season at different water bodies in Ikere Gorge dam. Values represent mean plus and minus standard deviation for the number of cells per litre of the species.

Class	Species	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Bacillariophyceae	*Aulacoseira* sp.	48±105.48	17.11±15.25	22.78±47.98	76±134.36	44.33±89.6	13.44±17.39	16.11±37.47
	Aulacoseira distans (Ehrenberg) Simonsen	1.56±1.94	3.44±5.36	0.33±1	47.22±83.92	0.67±1.66	27.78±38.96	67.56±131.81
	Aulacoseira granulata (Ehrenberg) Simonsen	230.22±441.24	8±9.1	3.33±4.56	27.56±41.97	77±114.65	34.22±62.44	814±833.09
	Aulacoseira muzzanensis (F.Meister) Krammer	15.67±29.64	3.56±6.21	8.33±12	9.44±15.24	5.44±8.97	5±5.94	128.56±214.83
	Aulacoseira subarctica (O.Muller)Haworth	55.22±93.33	11.11±21.13	7.44±12.41	31.67±54.43	0.33±1	12.56±19.76	22.11±38.26
	Melosira italica (Ehrenberg) Kützing	66.56±122.99	95.89±135.99	67.22±92.64	3.89±5.3	8.33±12.31	101.33±179.17	137.78±333.66
Chlorophyceae	*Ankistrodesmus falcatus (*Corda) Ralfs	59.22±101.4	10.56±14.31	5.78±6.24	5.11±6.39	4.44±6.65	3.11±4.2	8.33±12.6
	Coelastrum reticulamtum (P.A.Dangeard) Senn	1.22±2.22	8.67±14.12	5±7.89	17.67±30.1	141.22±290.56	46.22±99.14	14.67±22.54
	Coelastrum sp.	7.11±8.43	7.44±6.84	15±19.27	5.22±6.96	5.11±14.22	0.11±0.33	16.56±25.97
	Golenkinia radiata Chodat	26.11±46.42	46±82.47	28.22±76.53	11.33±23.99	7±9.37	24.78±65.47	7.56±16.67
	Kirchnerrella sp.	136.22±359.21	26.89±30.46	24±29.41	15.33±20.04	36.78±86.08	7.78±15.43	64±150.4
	Koliella longiseta (Vischer) Hind	23.67±38.06	67.33±128.02	40.22±66.55	0.11±0.33	0.11±0.33	3.11±3.55	0.11±0.33
	Oocystis lacustris Chodat	44.56±133.67	20.56±61.67	25.89±77.67	21.44±63.22	23.56±70.67	8.67±26	17.89±53.67
	Pandorina sp.	2.11±3.72	1.44±2.24	4.22±9.28	3.89±10.56	1.67±2.4	2.11±4.59	0.22±0.44
	Microspora sp.	3.22±6.96	5.67±15.52	11.67±13.22	12.44±31.79	1.67±2.35	9.11±22.55	1.67±3.57
Cyanophyceae	*Chroococcus dispercus* G.M. Smith	11.44±17.58	5.33±10.32	2.67±3.81	9.44±23.36	9.67±23.55	88.89±120.73	9.67±21.65
	Gleocapsa punctata (Carn) Kuetzing	24.11±49.91	46.11±114.46	10.56±22.31	13.33±34.19	12.33±30.17	9.56±27.55	12.11±29.46
	Gleocapsa sp.	2.78±5.52	8.89±20.79	18.44±36.46	1.89±4.26	1±1.73	2.22±3.38	4.22±11.56
Zygnematophyceae	*Actinastrum hantzschii* Lagerheim	12.11±17.72	7.11±9.03	12.44±16.96	8.56±9.95	4.67±7.94	11±12.58	12.11±19.15
	Staurastrum inversenii Nygaard	193.33±325.48	68.33±90.46	127±271.58	170.56±240.54	135.33±248.19	36.56±52.6	512.44±694.61
	Staurastrum arachne W. & G.S West		0.56±0.88	0.67±1.32	1±3	0.78±2.33	1.56±3.13	0.56±1.33
	Staurastrum avicula var *avicula* West	19.56±44.54	6.33±6.91	7.33±16.57	10.22±23.01	10.11±22.26	9.44±24.72	33.56±73.04
	Staurastrum bibrachiatum F.Wolle	6.11±8.88	6.56±10.71	16.33±40.39	5.22±8.18	5.11±8.28	3.56±5.1	9±9.38
	Staurastrum boergesenii Messik	58.44±155.65	34.22±95.61	4.44±8.09	5.22±10.58	21.89±35.17	20.11±41.46	39.33±94.99
	Staurastrum bulbosum West	24.11±47.57	22.44±40.58	18.22±32.62	20±31.65	64.89±160.82	15.56±37.03	26.89±44.85
	Staurastrum chaetoceras Brook	344.22±892.57	189.78±450.31	94.56±185.36	84.67±128.09	178.89±326.37	81±117.43	346.67±825.99
	Staurastrum cingulum (W & G.S West) G.M. Smith	4.22±5.74	11.33±10.93	11.56±15.39	4.44±8.03	2.89±5.78	6.67±12.09	7.22±6.28
	Staurastrum convergens Coesel	19.78±33.07	35.11±38.46	16.22±27.52	13.44±25.31	28.56±48.71	27.22±69.55	21.56±37.97
	Staurastrum crenulatum (Nägeli) Delponte	41.33±103.15	56.11±149.99	14.89±37.85	15.44±32.28	13.56±34.89	7.67±23	13.11±34.73
	Staurastrum cupsidatus Ralf	41±55.38	113.56±177.87	44.89±65.36	42.89±54.98	32.22±39.23	38.78±48.78	19.11±28.25
	Staurastrum dorsidentiferum West & G.S.West	0±0	0±0	0±0	0.22±0.67	0±0	0.67±2	0±0
	Staurodesmus glaber West	130±341.66	13.11±22.98	8.44±12.9	15.78±19.68	11.33±17.3	16.33±40.59	18.22±34.5
	Staurastrum gracile Coesel	33.89±69.57	25.67±29.53	21.33±43.65	12.44±10.33	325.67±896.54	8.33±16.46	27.33±46.69
	Staurastrum inconspicuum Nordstedt	6.67±6.82	11.89±18.71	7.78±11.68	9.22±21.02	7.33±17.01	4.78±8.7	7.67±12.88
	Staurastrum johnsonii Skuja	21.89±40.18	19±26.86	21.67±42.05	27.89±43.61	36.67±52.78	24.22±45.94	31.78±61.78
	Staurastrum lenzenwegeri Nygaard	5.89±9.39	56±77.01	5.67±6.96	12.33±12.01	27.33±40.06	12.22±16.78	2.56±2.88
	Staurodesmus megacanthus West	10.89±31.92	2.33±6.28	2.33±4.69	4.11±7.41	5.56±9.58	4.22±10.18	23.89±71.67
	Staurastrum micron Coesel	2±2.65	1.56±3.24	1.78±3.7	1.44±2.19	1.33±2.24	0.67±1.66	1.56±3.97
	Staurastrum multinodulosum Gronblad	7.44±9.4	12.44±13.63	9.22±8.24	17.56±16.9	4.67±6.06	5.22±9	6.44±8.4
	Staurastrum neglectum G.S West	19.22±43.63	74.56±79.16	12.78±8.87	15.22±14.21	10.22±8.58	2.56±3.61	22.44±44.17
	Staurodesmus omearae Archer	7.78±16.79	8.67±13.17	14.44±25.21	13.22±33.04	15.22±32.55	5±10.21	12.11±28.6
	Staurastrum paradoxum Coesel	9.89±24.2	18±37.06	7.78±20.78	5.56±15.92	8±23.25	5.22±11.62	42.67±125.75
	Staurastrum pseudopelagicum West & West	6.22±16.1	2.22±3.15	1±1.66	4.56±11.11	3.56±6.54	0.11±0.33	2.67±5.15
	Staurastrum saltator Gronblad	40.22±68.48	11.89±8.92	9.78±14.44	27.33±38.11	20.67±26.27	17.11±34.79	14.67±14.2
	Staurastrum sp.	0±0	1.44±1.67	3.67±8.43	7.22±21.29	0.33±1	14.67±44	0.56±1.33
	Staurastrum subexcavatum Allorge & Allorge	46.22±66.26	41.78±49.8	57.78±80.36	26±32.34	29.78±31	10.11±9.39	48.78±70.97
	Staurastrum tetracerum West & al	0.78±0.67	3.44±6.06	1±2	9.44±15.08	1.11±1.45	16.89±49.18	1.22±2.11
	Staurastrum trapezoides Homfield	33.56±63	21.89±41.51	20.44±37.09	10.11±7.67	10.11±17.43	18.44±34.19	16±18.73

Table 5: Most abundant phytoplankton taxa recorded during the dry season at different stations in Ikere Gorge Dam. Values represent mean plus and minus standard deviation for the number of cells per litre of the species.

Class	Species	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Baccilariophyceae	*Aulacoseira* sp . 1	8.89±25.93	6.78±13.47	3.78±8.64	3.56±9.93	4.44±10.03	8.67±26	4±11.26
	Aulacoseira distans (Ehrenberg) Simonsen	0±0	0.44±1.33	0±0	0.33±1	0±0	0±0	0±0
	Aulacoseira granulata (Ehrenberg) Simonsen	3.67±5.63	1.44±4.33	2.89±5.64	0±0	5.67±11.67	2.22±4.44	2.67±6.63
	Aulacoseira muzzanensis (F.Meister) Krammer	1.67±3.39	3.89±8.37	3.11±5.35	2.56±6.02	1.44±2.7	0±0	2±3.97
	Aulacoseira sp.2	0.89±2.03	0.11±0.33	1±1.5	0.33±1	0.56±0.88	0±0	0.56±1.13
	Melosira italica (Ehrenberg) Kützing	0±0	1.33±3.64	4.44±12.59	87.11±260.21	106.22±317.54	28.11±76.09	20.22±58.8
Chlorophyceae	*Ankistrodesmus falcatus (*Corda) Ralfs	0±0	0.67±2	0.44±1.33	0±0	0±0	0±0	0.44±1.33
	Coelastrum reticulamtum (P.A.Dangeard) Senn	0.44±1.33	8.33±16.76	0.89±2.67	10.33±31	11.67±29.48	0±0	4.89±12.49
	Coelastrum sp.	0.78±0.83	1.56±1.51	0.11±0.33	2.44±2.88	1±1	0.44±0.53	0.22±0.44
	Golenkinia radiata Chodat	0.11±0.33	0.22±0.67	0±0	0±0	0±0	1.22±3.67	1.22±3.67
	Kirchnerrella sp.	0±0	0±0	0±0	0±0	0±0	0±0	0±0
	Koliella longiseta (Vischer) Hind	0.56±1.67	9.56±28.29	5.44±10.94	3.78±11.33	0±0	8.33±25	8.11±24.33
	Oocystis lacustris Chodat	0±0	0.33±0.5	0.11±0.33	0.44±0.73	0.67±1	0±0	0±0
	Pandorina sp.	4.33±10.07	7±19.54	5.33±10.14	3±9	3.56±9.26	2.78±7.28	6.56±11.88
	Microspora sp.	1.89±5.67	4±7.66	5.56±9.36	3.22±7.24	0.89±2.03	9.89±29.67	14.33±27.6
Cyanophyceae	*Chroococcus dispercus* G.M. Smith	0±0	0±0	0.11±0.33	10.11±30.33	8.78±26.33	11.89±35.67	56.89±170.29
	Gleocapsa punctata (Carn) Kuetzing	0±0	4.67±12.53	2.33±7	0.67±2	0.89±2.67	0±0	1±2.65
	Gleocapsa sp.	8.11±24.33	0±0	0±0	0±0	0±0	0±0	1.11±2.2
Zygnematophyceae	*Actinastrum hantschii* Lagerheim	0.11±0.33	0.11±0.33	0.22±0.67	0.22±0.67	0.22±0.44	0.11±0.33	0.11±0.33
	Staurastrum inversenii Nygaard	26.11±58.02	12.33±13.44	16.44±22.45	100.67±269.69	16.56±27.89	11.44±22.33	19.44±40.79
	Staurastrum arachne W. & G.S West	6.44±14.11	12.89±25.09	6.78±8.56	6.33±11.22	8.44±9.93	1.44±3.28	6.56±11.77
	Staurastrum avicula West & al	5.11±12.73	5.78±8.74	4.44±8.49	2.78±4.06	3.67±4.21	2.22±1.92	2.78±6.16
	Staurastrum bibrachiatum F. Wolle	10.78±27.05	2.78±4.18	8±19.94	2.22±4.02	6.44±13.18	1.78±3.35	9.89±25.42
	Staurastrum boergesenii Messik	1.67±2.83	7.22±9.31	3.89±5.64	1±1.32	1.22±1.64	0.44±0.53	2.33±3.67
	Staurastrum bulbosum West & al	8.22±7.98	16.22±18.64	12.67±12.79	15.89±13.81	13.56±14.24	22.89±29.47	16.11±16.17
	Staurastrum chaetoceras Brook	9.56±13.79	15.44±20.27	12.56±8.92	22.78±20.72	14.78±11.21	5.78±4.66	12.89±10.37
	Staurastrum cingulum (W & G.S West) G.M. Smith	5.22±7.16	5.78±6.46	6.89±10.06	4.22±5.19	4.44±7.18	1.11±2.32	7.67±10.71
	Staurastrum convergens Coesel	3.78±5.38	1.89±2.37	4.56±5.59	4.22±8.38	7.22±8.86	4.44±9.72	4.56±4.75
	Staurastrum crenulatum (Nägeli) Delponte	1.89±2.85	2.78±2.86	2.56±4.53	7.44±6.11	1±1.41	12.78±17.2	1.56±2.65
	Staurastrum cupsidatus Ralf	12.44±11.07	16.78±6.78	13.33±10.68	9.33±6.78	12±10.74	3.56±3.97	8.11±10.83
	Staurastrum dorsidentiferum West & G. S. West	0.33±1	12.44±37.33	1.33±4	0±0	4.56±11.28	3.11±6.86	34.33±100.03
	Staurodesmus glaber West & al	3.22±3.8	9.11±8.12	8.22±4.66	6.44±9.76	8±8.97	5.33±6.18	4.78±3.73
	Staurastrum gracile Coesel	14.78±16.01	32.22±48.62	17.44±23.32	53.33±64.8	25.78±36.98	14.89±23	22.33±29.19
	Staurastrum inconspicuum Nordstedt	0.56±0.88	1.67±1.5	0.78±1.3	0.67±1.32	0.89±0.93	0.78±1.3	1.33±1.87
	Staurastrum johnsonii Skuja	5.11±11.01	10.44±21.85	7.22±11.41	12.78±12.29	11.67±12.87	8.56±10.19	11±13.64
	Staurastrum lenzenwegeri Nygaard	78.89±166.65	92.22±83.59	57.11±68.43	136.89±211.92	280.33±585.92	111.11±308.62	80.44±91.87
	Staurodesmus megacanthus West & al	0.33±0.71	0.89±1.05	0.22±0.44	1.56±3.24	0.56±1.01	0±0	1.22±1.39
	Staurastrum micron Coesel	3.67±4.18	12.56±10.6	4.67±4.9	5.22±5.65	5.67±9.46	1.33±1.73	6±6.78
	Staurastrum multinodulosum Gronblad	9.44±8.55	10.78±9.82	13.22±7.29	12.56±12.88	7.78±6.46	11.44±11.58	17.67±20.69
	Staurastrum neglectum G.S West	15.44±24.96	27.56±20.83	17.78±19.35	21.78±22.57	17.56±23.65	5.78±5.56	22.11±33.33
	Staurodesmus omearae Archer	1.44±1.74	4.44±7.25	5.44±10.32	3±6.6	5.22±7.48	3.44±10.33	1.11±2.32
	Staurastrum paradoxum Coesel	8.33±14.65	4.89±8.58	5.22±10.02	4.78±7.74	5.11±14.59	6.89±18.44	4.33±10.79
	Staurastrum pseudopelagicum West & West	6.78±13.18	11.44±20	10±17.31	7.67±14.07	3.56±5.5	0.89±0.6	4.33±7.48
	Staurastrum saltator Gronblad	4.78±8.21	6.22±5.93	1.67±1.41	5.89±6.66	2.78±1.92	4.56±4.25	4±4.3
	Staurastrum sp	3.78±8.74	4.56±7.35	1.11±2.67	1.89±2.42	2.44±4.56	1.11±2.67	2.22±4.66
	Staurastrum subexcavatum Allorge & Allorge	18.11±11.27	31.11±24.48	18.22±15.4	26±25.06	26.11±24.24	16.44±22.61	20.78±17
	Staurastrum tetracerum West & al	7.56±15.3	14.67±30.93	9±21.78	3.56±3.05	4.67±5.72	0.78±0.83	10.22±15.01
	Staurastrum trapezoides Homfield	10.44±17.17	8.11±8.31	7.11±8.84	10.56±10.6	14±15.69	4.11±4.2	10.33±14.07

Distribution of phytoplankton: The most abundant species in station 1 were the diatom *Aulacoseira granulata*, the Chlorophyceae *Kirchnerrela* sp., and the Zygnematophyceae *Staurastrum inversenii* and *Staurodesmus glaber* (Table 4). The species distribution patterns found in the other water bodies was different from each other and rarely consistent between seasons. For example, the highest phytoplankton biomass per species found in the wet season occurred in station 4, with *A. granulata* having an average of 814.00 cells L^{-1}. The second most abundant species in station 4 was another diatom, *Melosira italica*, having 137.78 cells L^{-1}. *Aulacoseira muzzanensis* had varying abundance, with the highest in station 1 (128.56 cells L^{-1}) and the lowest in station 6 (5.00 cells L^{-1}). *Aulacoseira* sp.1 also varied in abundance, with the highest in station 4 (55.22 ± 93.33 cells per litre) and the lowest in station 1 (0.33 ± 1 cells per litre). Other notable species in station 4 belonged to *Staurastrum inversenii* with 512.44 cells L^{-1} and *Staurastrum chaetoceras* with 356.67 cells L^{-1}. Also, *S. chaetoceras* had consistently high numbers in all the sampled aquatic ecosystems, with cell densities ranging from 81.00 to 346.67 cells L^{-1}. Other green microalgae, such as *Ankistrodesmus falcatus* and *Coelastrum reticulamtum*, had varying abundance in the different water bodies, where their abundance peaked in station 3 (59.22 cells L^{-1}) and station 5 (141.22 cells L^{-1}) water bodies. Among the Cyanophyceae species found to be the most abundant, *Chroococcus dispercus* had the highest cell density in station 7 at 88.89 cells L^{-1} and the lowest in station 3 at 11.44 cells L^{-1}. The cyanobacterium with the most elevated biomass in station 1 was *Gleocapsa punctata* (46.11 cells L^{-1}) and the lowest in station 4 (9.56 cells L^{-1}). *Melosira italica* was the most abundant diatom in all the investigated water bodies, with cell densities as high as 87.11 cells L^{-1} in the station 6 and 106 cells L^{-1} in the station 5 (Table 5). The lowest cell density of this diatom was recorded in station 3 (0.00) and station 1 (1.33 cells L^{-1}). Diatoms such as *Aulacoseira* spp. generally had cell densities that were lower than 10.00 cells L^{-1}. Various species of Chlorophyceae were found in low numbers during the dry season, but those with the most remarkable, i.e., cell densities reaching >10 cells L^{-1}, were *Coelastrum reticulamtum* at station 5 and 6 and *Microspora* sp. at station 4. *Staurastrum lenzenwegeri* consistently maintained the highest biomass among the Zygnematophyceae species in all the investigated aquatic ecosystems. Compared to the wet season, lower cell densities of cyanobacteria were recorded during the dry season, where the highest number of cells per litre was found in *Chroococcus dispercus* populations reaching a maximum average of 56.89 cells L^{-1}. Also, the cell densities of this cyanobacterium were the highest in station 5, 6, and 7, with cell densities greater than 8.00 cells L^{-1}. In station 1, 2, and 3, the highest contributors to cyanobacterial biomass were *Gleocapsa* spp. One noticeable trend was the variability in the abundance of different phytoplankton species within each class. For example, in the Bacillariophyceae, the species *M. italica* stood out with significantly higher mean cell counts per litre than other diatom species in the same class. This suggests that *M. italica* may be particularly well-suited to thrive in the conditions prevalent during the dry season in Ikere gorge dam waters. In Chlorophyceae, species like *Coelastrum reticulamtum* and *Pandorina* sp. had relatively high mean cell counts per litre across different water bodies. This indicated that green algae, represented by these species, were prevalent and potentially dominant during the dry season. Their ability to thrive under these conditions might be attributed to their ecological adaptability. Cyanobacteria, represented by species like *Chroococcus dispercus* and *Gleocapsa punctata*, showed interesting trends. Some species in this class had relatively low mean cell counts per litre, while others, like *Chroococcus dispercus*, displayed notably higher counts. This variability suggested localized cyanobacterial blooms in specific water bodies, possibly influenced by nutrient availability and other environmental factors. Class Zygnematophyceae revealed diverse species with varying mean cell counts per litre. *Staurastrum inversenii*, for instance, displays high counts, suggesting its prevalence in the sampled water bodies. Conversely, species like *Actinastrum hantschii* show lower mean cell counts, indicating lower abundance. This diversity within the Zygnematophyceae class highlights the coexistence of different green algae species in the studied ecosystems. It is essential to note the standard deviations accompanying the mean cell counts. Higher standard deviations indicate more variability in the data, suggesting that certain species may exhibit sporadic or patchy distribution patterns within the water bodies. Local environmental conditions, including nutrient availability, temperature, and light levels, could influence this variability. ANOSIM analysis revealed that the water source did not significantly impact the phytoplankton community structure and dynamics during the study, with a p-value of 0.363. On the other hand, the most significant impact on phytoplankton community structure and function was seasonal changes with ANOSIM statistic R of 0.2419 and a p-value of 0.001. SIMPER analysis showed variations in the abundance of phytoplankton taxa between the wet and dry seasons, and the "Relative Contribution (%)" values provide insights into which taxa have a significant impact on the differences in composition. For instance, the taxon *Staurastrum* sp. has a relatively high contribution of

7.657%, indicating it plays a significant role in the dissimilarity between the two seasons. Conversely, the taxon *Kirchnerrella* sp. had a mean abundance in the wet season but disappeared entirely in the dry season, resulting in a 2.308% contribution to dissimilarity (Table 6).

Table 6: Phytoplankton ranked abundance SIMPER contributors to percentage (%) dissimilarity in phytoplankton composition between the wet and dry seasons

Taxon	Mean abundance		Relative contribution (%)
	Wet season	Dry season	
Staurastrum sp.	178	29	7.657
Staurastrum chaetoceras Brook	189	13.4	7.06
Chlorella sp.	116	4.76	5.613
Aulacoseira granulata (Ehrenberg) Simonsen	171	2.65	5.166
Staurastrum lezenwegeri Nygaard	17.4	120	5.032
Staurastrum manfeldtii Delponte	66	62.7	4.495
Staurastrum pingue Teiling	118	30.3	4.392
Melosira italica (Ehrenberg) Kützing	68.7	35.3	3.814
Staurastrum gracile Ralfs	65	25.8	2.609
Staurodesmus cuspidatus Ralf	47.5	10.8	2.542
Aulacoseira sp.	34	5.73	2.323
Kirchnerrella sp.	44.4	0	2.308
Staurastrum johnsonii	26.2	9.54	1.815
Staurastrum sp. 3	37.2	22.4	1.719
Staurastrum sp. 4	10.9	25.8	1.596
Staurastrum neglectum G.S West Coesel & Alfmito	22.4	18.3	1.465
Staurastrum bullardii Coesel & Alfmito	27.4	15.1	1.431
Coelastrum reticulamtum	33.5	5.22	1.379
Chroococcus dispercus G.M. Smith	19.6	12.5	1.358
Staurastrum saltator Gronblad	20.2	4.27	1.251
Staurodesmus glaber Coesel	30.5	6.68	1.219
Staurastrum convergens Coesel	23.1	4.38	1.166
Staurodesmus triangularis Nygaard	18.7	9.24	1.106
Chroococcus sp.	13.9	5.1	1.063
Staurastrum paradoxum Coesel	13.9	5.65	1.037
Staurastrum crenulatum Coesel	23.2	4.29	1.035
Staurastrum boergesenii Messik	26.2	2.54	0.9073
Golenkinia radiata	21.6	0.397	0.8878
Koliella longiseta (Vischer) Hind	19.2	5.11	0.8558
Aulacoseira sp.	20.1	0.492	0.8299
Aulacoseira distans	21.2	0.111	0.8044

Association between environmental variables and the diversity and abundance of phytoplankton: Variation inflation factor (VIF) analysis showed that all the parameters had values less than 5.00, which means there was no collinearity between the factors. Canonical correspondence analysis (figure 5) revealed high DO concentration correlated with *Arthrodesmus* sp., *Cyclotella* sp., *Tetraedron gracile*, *Merismopedia* sp., and *Pediastrum simplex* in the first CCA axis. A close association was found between TDS and *Scenedesmus brasiliensis*, while *Cyclotella* sp. was closely related to high salinity levels. High nitrate-nitrogen and water transparency levels were associated with *Staurastrum chaetocera*, *Staurastrum dorsidentiferum*, and *Kirchnerrella* sp. on the second CCA axis. Water temperature related positively with *Scenedesmus raciborskii* and *Merismopedia elegans* on the second CCA axis. Spatial and temporal analysis of phytoplankton community structure and composition in Ikere gorge dam between September 2017 and February 2019 revealed strong seasonality with minimal or homogeneous spatial variation. The Zygnematophyceae (desmids) was the most dominant phytoplankton group in terms of abundance at all the 7 sampling stations. Xanthophyceae was the least abundant group in all the stations (zones). A total of 494 microalgal taxa belonging to eight divisions were recorded. Zygnematophyceae comprised 360 taxa (64%), Bacillarophyceae 22 taxa (14%), Chlorophyceae 66 taxa (13%), Cyanophyceae 20 (4%), Dinophyceae 8 (1%), Trebouxiophyceae 13 taxa (2%), Ulvophyceae 3 taxa (0.02%), Xanthophyceae 2 taxa (0.01%). Phytoplankton recorded higher abundance during the wet season than during the dry season. Phytoplankton abundance showed homogeneity among the sites. However, phytoplankton composition showed dominance of Zygnematophyceae in all the sites (figure 3). The observations and results confirm hypotheses that phytoplankton abundance varies more between season (wet and dry) than spatially in Ikere gorge dam. No single taxon or a combination of two or three taxa accounted for more than 80% of the phytoplankton abundance. This also confirms our hypothesis on lack of equilibrium in the phytoplankton community in the dam.

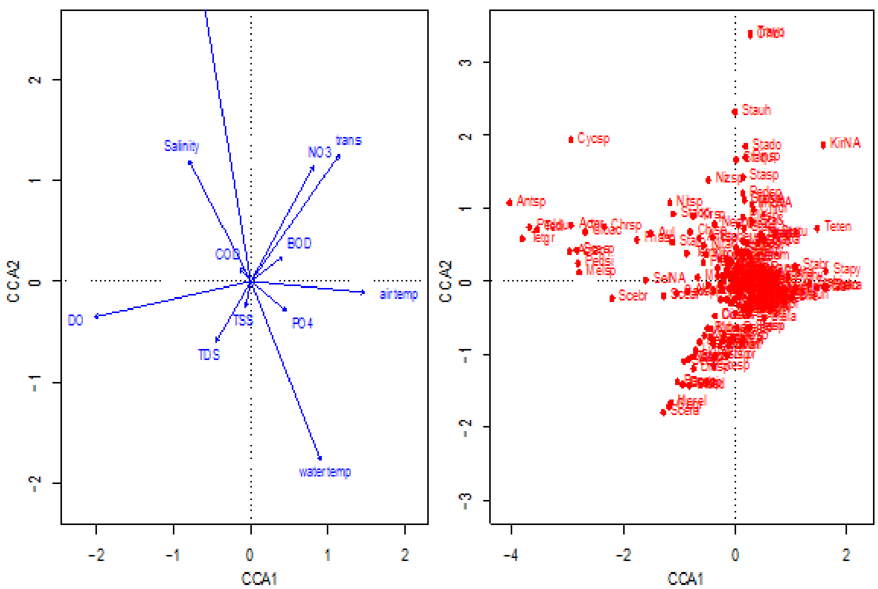

Fig 5: Canonical correspondence analysis (CCA) between physicochemical variable among sites and phytoplankton community and dynamics in Ikere Gorge dam from September 2017 to February 2019.

Dynamics in Environmental Conditions: There was a stronger seasonal variation in physicochemical water quality variables owing to the size of the dam that is not well-mixed, and with long water residence times. Water transparency levels was lowest (reduced turbidity) during the wet season showing seasonal variations due to rate of discharge from effluent rivers. The concentration of DO, nitrates, phosphate was higher in dry season. Higher nitrates during dry season can be attributed to decreasing pH. A pH range between 6.5 and 9 is considered as suitable for fish, other aquatic life, and safe for drinking. The pH value ranged from 6.1 - 9.8 except in month of January which observed a very low pH which was similar to the findings of Aziz *et al*., (2021) and Shefat *et al*., (2020). The observed high pH values during dry season might be due to the influence of high saturation of salt (low rainfall). DO is dependent on temperature and demands on organisms which resulted in lower BOD during the dry season. Respiration, photosynthesis, flushing rate, river influx, and mixing influence DO levels in reservoirs (Akagha *et al*., 2020). In this study, DO was relatively low during the start of wet season, June 2018 with value 3.47 at station 7 correlating with high BOD value of 7. TDS and TSS were high during the dry season run-offs from surrounding forest. This agrees with observations of Nwankwo (1996, 1997a), Onyema and Nwankwo (2006), Adesalu and Nwankwo (2010). Phytoplankton community composition is correlated with fluctuation of physico-chemical parameters. Data analysis study revealed that both temperature and nitrates (dissolved inorganic nitrogen) had potential effects on phytoplankton community composition, indicating that the temperature effect was significant based on nutritional condition, which can be the result of the interplay of temperature and species variation of the same dominant species (Frank *et al*., 2023;Wang *et al*., 2022; Wei *et al*., 2022a).

Dynamics in Phytoplankton Communities: Non-metric Multidimensional Scaling (NMDS) analysis showed that species such as *Anthrodesmus* sp., *Cyclotella* sp., *Closterium aculum*, *Pediastrum duplex*, *Actinastrum* sp., and *Scenedesmus* sp. had similar distribution patterns in the investigated water body in the first dimension (figure 6). Seasonal changes greatly influenced their occurrence because they had a positive relationship with the wet season (figure 6A). These species had a negative relationship with *Scenedesmus bijuga*, *Desmodesmus* sp., *Crucigenia crucifera*, *Staurastrum adornatum*, and *Monoraphidium minutum*. *Microspora floccosa*, *Staurastrum natator*, *Tetrastrum* sp., *Kirchneriella elongata*, *Micrasterias arcuata*, *Closteriopsis longissima*, and *Gloeocapsa* sp. had a negative relationship with *Closteriopsis longissima*, *Kirchnerella* sp., *Staurasrum americanum*, and *Kirchnerella* sp. While *Chlorococcus disperses*, *Kirchnerella* sp., *Staurasrum americanum*, and *Kirchnerella* sp., were positively associated with wet season sampling in the water bodies, *Kirchnerella* sp., *Tetrastrum* sp., *Selanastrum* sp., *Micrasterias arcuata*, and *Closteriopsis longissima* were related to the dry season. In terms of phytoplankton species relationship with the investigated water body, *Actinastrum* sp., *Pediastrum simplex*, *Closterium aculum*, and *Melosira* sp. were mostly associated with station 1; *Scenedesmus* sp., *Staurastrum adornatum* and *Scenedesmus bijuga* with station 2 and *Staurastrum adornatum*, *Tetraedron irregulare*, *Gloecapsa granosa*, and *Monoraphidium minutum* were closely related with stations 3,4,6, and 7 (figure 6B). Station 7 was found to correlate with the presence of *Staurastrum euprepes*, *Closteriopsis longissima*, *Monoraphidium* sp., and *Kirchneriella elongata* on the second dimension. Overall, phytoplankton abundance in Ikere gorge dam showed a dominance of Zygnematophyceae green algae (Table 4), contrary to a previous study in the same reservoir by Ajagbe *et al*. (2019) that reported dominance of Chlorophyceae green algae by a relative abundance of 42%. Akinyemi and Adesalu (2015) also reported that the phytoplankton abundance of Ikere-gorge is dominated by Chlorophyceae (92.26%) using a single sample strategy. The dominance of Zygnematophyceae geen algae in Ikere gorge dam was also in contrast with many Nigerian reservoirs. Akin-Oriola (2003) reported the dominance of blue-green algae (Cyanophyceae), Ikenweiwe *et al*., (2011) reported of a dominance of Chlorophyceae green algae (57.5%) in Lekan-Are lake, Omoboye *et al*., (2022) reported a dominance of Zygnematophyceae green algae with an abundance of 35.3%. The high diversity of desmids in Ikere gorge dam is an indication of unpolluted water body with similar report by Ekhator (2010) who reported that Chlorophyceae occurred most with a wide assortment of desmids (41.3%). The high abundance of desmids of this study is typical of freshwater (Kadiri, 2002), adequate nutrient water, and an indication that the water body is much unpolluted (Kadiri and Omozusi, 2002).

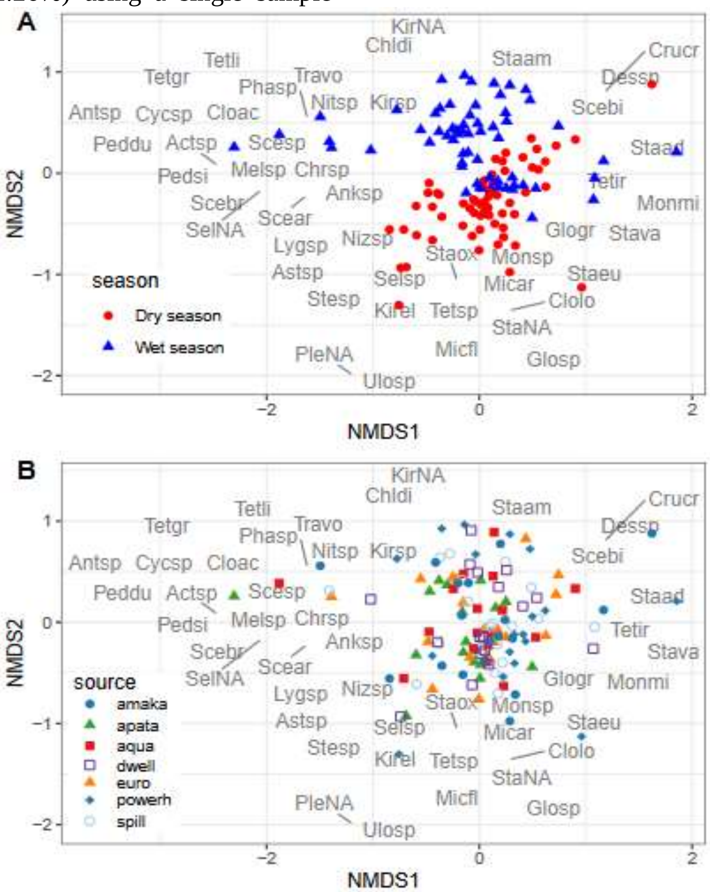

Fig 6: NMDS results of phytoplankton species collected from different sources during the dry and wet seasons

Conclusion: Statistical analysis of data showed strong influence of physico-chemical parameters on seasonal distribution and variations of abundance of phytoplankton community in Ikere Gorge Dam, Oyo State, Southwest Nigeria. This study contributes to understanding the water quality, determinant factors, and drivers of biological communities in dams of tropical regions that are being influenced by anthropogenic activities.

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