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Seasonal Variation in Phytoplankton Diversity, Distribution, Composition and Chlorophyll-*A* at Yewa Lagoon, Nigeria

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ABSTRACT: Yewa Lagoon, part of the Lagos Lagoon complex on the Guinea coast of West Africa, is subject to intense anthropogenic activity, necessitating regular monitoring of its water chemistry and biological properties. Hence, the objective of this paper was to evaluate the seasonal variation in phytoplankton diversity, distribution, composition and chlorophyll *A* at Yewa Lagoon, Nigeria using various standard methods, over an 18-month period (August 2017 – January 2019). Monthly sample collections revealed seasonal fluctuations influenced by rainfall and runoff, affecting water quality parameters. Air and water temperatures were high (24.0 – 34.0 °C and 26.5 – 37.5 °C), with salinity ranging from 0.0 – 9.0 ‰ and pH (5.7 – 7.9). Dissolved oxygen (1.0 – 9.6 mg/L) and biochemical oxygen demand (1.1 – 12.3 mg/L) indicated variable pollution levels, with chemical oxygen demand (≤478 mg/L). Chlorophyll *A* levels (1.04 – 16.8 µg/L) were higher in the dry season. Heavy metal concentrations were low, while nutrient levels (reactive nitrogen, phosphorus, sulphate, and silica) were high. Calcium and magnesium concentrations were higher in the rainy season. Significant differences ($p<0.05$) across stations were only observed for sulphate and COD in the rainy season, and air temperature and water depth in the dry season. Phytoplankton diversity included 315 species from 112 genera across 11 classes and 7 divisions, with notable taxa such as *Microcystis aeruginosa*, *Nitzschia*, *Navicula*, and *Cyclotella*. Seasonal changes and pollution affected phytoplankton diversity and abundance. Carlson's Trophic State Index classified the lagoon as eutrophic (60–80), supported by the dominance of cyanophytes (44%) and diatoms (40%) and low ecological index values (Shannon ≤1.929, Margalef ≤8.436, equitability ≤0.477), indicating moderate biodiversity and potential ecological stress.

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Lagoons represent 15% of the world's coastal zone and their productivity results from the interaction between oceanic and continental inputs which enable them to play a considerable biological and economic role far beyond their seemingly limited geographical extent (UNESCO, 2023; Solarin and Kusemiju, 2003). Lagoons vary in size and shape depending on their geomorphology and are influenced by various forcing factors such as river inflow, tidal cycles, precipitation, wind stress, evaporation, and surface heat balance. Their response to these forces can differ significantly (Kirk and Lauder, 2000; Nwankwo and Onyema, 2004). Characteristically shallow, lagoons typically exhibit a high horizontal-to-mean-depth ratio, which

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gives rise to distinct hydraulic and hydrographic features. In Nigeria, lagoons are predominantly found in the southwest, where they are expansive, shallow, and run parallel to the coastline, eventually draining into the Atlantic Ocean through the Lagos Harbour (Nwankwo and Adesalu, 2019). However, some of these water bodies, such as Yewa Lagoon, lie farther inland and do not experience direct maritime influence. Yewa Lagoon remains fresh throughout the year, unlike the adjoining Badagry Lagoon, which experiences brackish conditions during the rainy season. This difference is attributed to the fact that Yewa Lagoon lies perpendicularly to Badagry Lagoon (Effiong and Inyang, 2016).

The objective of this investigation is to evaluate the seasonal variation in phytoplankton diversity, distribution, composition and chlorophyll *A* at Yewa Lagoon, Nigeria.

MATERIALS AND METHODS

Study Area Description: Yewa Lagoon lies along the boundary between Ogun and Lagos States. It is quite sickle-shaped and perpendicular to Badagry Lagoon (Fig. 1). It is microtidal, hyposaline and barely experiences any maritime influence from either Lagos or Cotonou Harbour as both lie distally from it. It has an average depth of 3.28 m. River Yewa is the major river emptying into the lagoon, while Eere and Iragbo are its adjoining tributaries.

The floral assemblage of Yewa Lagoon is very rich. It is characterized by fringing vegetation such as *Paspalum vaginatum* (seashore paspalum), *Typha* sp. (cattail), spike rush, *Elodea* sp. (water weed), *Cocos nucifera* (coconut tree), water fern, *Laguncularia racemosa* (white mangrove), *Rhizophora racemosa* (red mangrove), *Terminalia catappa* (almond tree), *Delonix regia* (flamboyant tree), *Pinus* sp. (pine tree), among numerous others.

Floating aquatic macrophytes include *Lemna paucicostata* (duckweed) and *Eichhornia crassipes* (water hyacinth), while submersed macrophytes include *Ceratophyllum demersum* (hornworth).

Fisherfolks catch fish here using the 'acadja' (a fish aggregating device, FAD) fishing method; manatees are caught with suspended harpoon traps. Crustaceans include *Penaeus notialis* (pink shrimp) and *Sesarma huzardii* (hairy mangrove crab); molluscs found here include periwinkles such as *Pachymelania aurita, Tympanotonus fuscatus* var. *radula,* and bivalves such as *Crassostrea tulipa* (West African mangrove oyster) amongst a variety of others.

Anthropogenic activities here include farming, fishing, smuggling, making of local gin and commerce. Sediment type found here is swampy.

The study area is approximately 15.58 km (9.68 mi) long and seven sampling stations located within Lat. N 06°26′00.5″ to Lat. N 06°34′03.2″ and Long. E 002°50′55.2″ to Long. E 002°53′31.0″ were established.

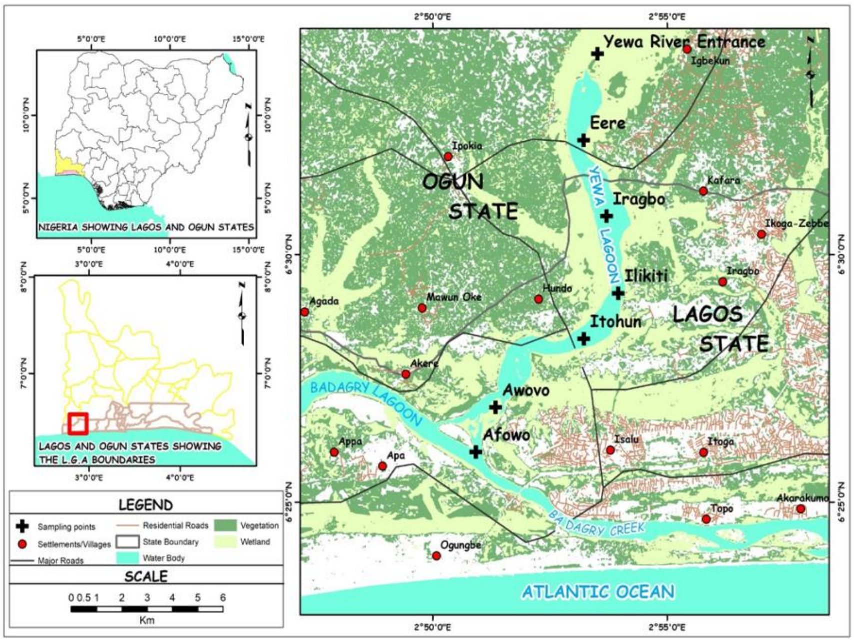

Fig. 1: Yewa Lagoon showing the sampling stations.

Collection of Water Samples: Surface water samples for physical and chemical analyses were collected monthly, for eighteen months (August, 2017 - January, 2019), during the early hours of daylight at the seven sampling stations, just a few centimeters below the water surface, to cover both rainy and dry seasons, using 750 ml plastic bottles with screw caps. On each sampling trip, all equipment used were thoroughly calibrated, while containers were pre-rinsed with surface water at each station. Water samples collected in plastic bottles for water quality analyses of parameters that could not be determined *in situ* were transported to the laboratory for analyses in an ice chest.

Descriptive and Inferential Statistics: Descriptive (mean and standard deviation) and inferential statistics (one-way ANOVA and Pearson correlation) were calculated using IBM SPSS Statistics ver. 25. Data were pooled and presented as monthly, seasonal and spatial mean variances.

The data were compared by means of one-way ANOVA in order to evaluate if their difference was statistically significant (P-value < 0.05) and Duncan Multiple Range Test (DMRT) post-hoc analysis for spatial level significance. Pearson correlation matrix analysis was employed to identify possible significant relationships among the environmental variables at both 0.01 and 0.05 levels of significance. Principal component analysis was used to reduce the correlated observed variables to a smaller set of important independent and positive variables.

Table 1: Water quality parameters and the methods for their determination

S/N	Parameter	Method
1	Air and Surface Water Temperatures (°C)	Mercury-in-glass thermometer (APHA, 2012)
3	Transparency (cm)	Secchi disc (black and white painted; Ø20 cm) (Onyema, 2009)
4	Depth (m)	Weighted graduated rope (Onyema, 2009)
5	pH (Hydrogen Ion Concentration)	Electrometric Method (pH meter, model LT luton-201) (APHA, 2012)
6	Salinity (‰)	Refractometer (APHA, 2012)
7	Dissolved Oxygen (mg/L)	Titrimetric (Iodometric) Method using Azide Modification Procedure (APHA 4500 – 0C, 2012)
8	Biochemical Oxygen Demand (BOD_5) (mg/L)	Winkler's Method (APHA 4500 – 0C, 2012)
9	Chemical Oxygen Demand (COD) (mg/L)	Titrimetric Method (APHA 4500 – 0C, 2012)
10	Conductivity (µS/cm)	Philips PW 9505 Conductivity meter (3 µS/cm - 100,000 µS/cm) (APHA, 2012)
11	Reactive Nitrogen (NO_3 - N) and Reactive Phosphorus (PO_4 - P) (mg/L)	Colorimetric Cadmium Reduction Method (HACH DR 2010 colorimeter) (APHA, 2012)
13	Sulphate (mg/L)	Turbidimetric method (4500 - SO42- E, APHA 2012)
14	Silicate (mg/L)	Colorimeter (DR2010) (APHA, 2012)
15	Calcium and Magnesium (mg/L)	EDTA Titrimetric Method (APHA, 2012)
17	Lead, Copper, Iron and Zinc (mg/L)	Perkin Elmer 5000 atomic absorption spectrophotometer (APHA, 2012)
21	Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) (mg/L)	Gravimetric method 2540C (APHA, 2012)
23	Rainfall (mm)	Data was supplied by Nigerian Meteorological Agency (NIMET), Oshodi, Lagos
24	Chlorophyll *A* (µg/L)	Qin *et al.* (2013)

Collection of Plankton Samples: Plankton hauls were made using a 25 µm mesh size standard net tied to a motorized boat and towed horizontally for five minutes at low speed (<4 knots). The filtered plankton was emptied into well-labelled 500 ml plastic containers with screw caps, capped tightly and then, preserved immediately by fixing in 10% unbuffered formalin solution, from which sub-samples were also taken for analyses.

Investigation of Phytoplankton: Fixed samples were allowed to settle in the laboratory for at least 24 hours and the supernatant decanted until a concentration of about 50 ml was obtained. Direct phytoplankton counts were done using the drop count method (Ramachandra and Solanki, 2007) and Onyema (2007). For each 0.04 ml (1 drop) of plankton sample, several transects to cover the total area under the cover slip were thoroughly investigated with each transect at right angle to the previous one and five replicates per sample. All phytoplankton species were thoroughly examined, identified and counted using an Olympus® and also, a Nikon® binocular photomicroscope with a calibrated eyepiece at 10X magnification and objective lenses at different magnifications (4X, 10X, 20X, 40X and 100X) as well as a 4-digit hand-held tally counter. After appropriate conversions, the number of each taxon occurring in each field and the total number of taxa per group were recorded as number of species (cells, filaments, colonies and coenobia) per ml. Photomicrographs of phytoplankton were taken using a high-resolution (1.3 megapixels) HDCE-10C digital camera, with the aid of a ScopeImage 9.0 ver. NXC software. Identification was done by means of relevant texts and ordered according to Onyema, 2021 and WoRMS Editorial Board, 2025 using the Barcode of Life Data (BOLD) system of classification.

Community Structure Analysis: Diversity indices such as Margalef index for species richness, Shannon-Wiener, which combines both richness and evenness to provide an overall measure of biodiversity or species diversity in a given sample and Simpson's dominance for assessing the dominance or concentration of individuals within a community, and Equitability for assessing the evenness or uniformity of the distribution of individuals across different species or categories in a community, were estimated using Paleontological Statistics (PAST) software version 4.12b.

RESULTS AND DISCUSSION

Physicochemical Parameters: The results of some physical and chemical parameters are summarized in Table 2 and Figs. 2a – 2d. The water quality and phytoplankton population dynamics data from this study fall within natural conditions known for tropical fluctuating fresh cum brackish water ecosystems as described by previous works - in particular, the coastal waters of Nigeria (Onyema and Emmanuel, 2009; Adesalu and Nwankwo, 2010; Nwankwo *et al.*, 2012; Onyema, 2008, 2013; Akagha, 2017). Rainfall seasonality and semi-diurnal tidal cycles are the forcing functions which drive processes in the lagoons of Southwest Nigeria (Nwankwo, 2004a; Adedipe and Nwankwo, 2016). Rainfall significantly influenced water quality during the wet season, while salinity levels (0 – 9 ‰,), ranging from freshwater to brackish, reflected the impact of the inflow of saltier water, as indicated by changes in chloride, conductivity (44.2 – 7850.0 µS/cm) and total dissolved solids (14.56 – 72.80 mg/L). These fluctuations create a dynamic environment where different species adapt and appear at various times. The study supports Nwankwo (2004b), who identified freshwater discharge and tidal seawater incursion as key factors shaping the biological, physical, and chemical properties of the Lagos Lagoon. Notable variations in nitrate and sulphate were also observed. Water quality variations at different stations along the lagoon are influenced by weather and tidal dynamics. The Lagos Mariculture site at Afowo likely caused low brackish conditions (7 – 9 ‰) and maritime effects, especially in the dry season. Chlorides mainly enter the lagoon from agricultural fertilizers, sewage, industrial waste, and leaching near shorelines (Alhader, 2000 and Akintunde *et al.*, 2022). Air (24.0 – 34.0 °C) and surface water temperatures (26.5 – 37.5 °C) were higher in the dry season due to tropical climate patterns, while cooler rainy season temperatures possibly resulted from increased cloud cover, low insolation and cooler freshwater inflow from the wetlands and adjoining tributaries. Temperature dips (25.5 – 29 °C) during the dry months were linked to the annual harmattan winds. Overall, temperature changes are driven by sunlight and evaporation (Cataudella *et al.*, 2015). Rainfall (0 – 329.5 mm) was higher in the rainy season and plays a more crucial role than temperature in shaping tropical aquatic and terrestrial environments (Adedipe and Nwankwo, 2016). Floodwaters from rains likely diluted the lagoon water and stirred up organic matter, raising total dissolved solids. Strong currents may harm phytoplankton, while moderate currents support benthic communities (Nwankwo, 2004b). Nutrients, parasitism, and rainfall mainly influence lagoon ecosystems like Yewa and Ologe, with rainfall increasing water inflow and introducing dissolved materials and organic acids from surrounding wetlands (Nwankwo and Adesalu, 2019). The fresh to low-brackish water conditions (0 – 9 ‰) observed during the dry season likely resulted from saltwater intrusion and reduced floodwater input as rainfall decreased. Wind plays a significant role in lagoon dynamics, affecting currents and water level fluctuations based on wind speed and depth (Cataudella *et al.*, 2015). Strong winds may have increased brackish water mixing from Badagry Lagoon, influencing the overall salinity variations. Seasonal studies indicate that salinity levels tend to be higher between December and April and lower between May and November in the Lagos Lagoon (Nwankwo, 2004a and Onyema, 2021). Dissolved oxygen (1.0 – 9.6 mg/L) and biochemical oxygen demand (1.1 – 12.3 mg/L) levels were generally higher during the rainy season, occasionally exceeding WHO limits for inland waters. Dissolved oxygen levels are influenced by temperature, photosynthesis, respiration, water currents, and mixing with atmospheric oxygen (Watt, 2000; Nwankwo and Onyema, 2004).

Low oxygen levels were observed at specific sites (Itohun, Eere, and Yewa River Entrance) in November and December 2018, likely due to seasonal transition and decomposition of organic matter, which consumed oxygen. High biochemical oxygen demand (BOD) in the study was attributed to increased metabolic activity of aquatic species. According to Dwivedi (2017), BOD values of 6 – 8 mg/L indicate moderate pollution, while values above 8 mg/L signify severe pollution.

In this study, low dissolved oxygen levels (<4 mg/L) combined with high BOD (>8 mg/L), particularly at Eere and Yewa River Entrance in August 2017 and at Afowo in September and October 2018, indicated severe pollution stress in the lagoon. Chemical oxygen demand (COD) followed seasonal patterns, with higher levels during the rainy season. This increase was likely due to land-based biodegradable materials transported into the lagoon by floodwaters and river inflow. According to Cataudella *et al.* (2015), a rise in organic material input leads to elevated COD levels in aquatic ecosystems.

Cations: Magnesium (1.02 – 72.8 mg/L) and calcium (3.11 – 200.4 mg/L) levels were higher in the rainy season (Table 2 and Fig. 3b). Elevated magnesium may support phytoplankton growth due to its role in chlorophyll, while calcium is essential for cellular processes and coccolithophore development (Wang *et al.*, 2019; Mason *et al.*, 2021). However, excessive calcium can hinder some phytoplankton species by disrupting cell functions (Müller *et al.*, 2015).

Heavy Metals: Heavy metal concentrations: lead (≤0.077 mg/L), copper (≤0.070 mg/L), iron (≤2.05 mg/L) and zinc (≤0.309 mg/L), were generally low and higher in the rainy season, except zinc, which showed the opposite trend (Table 2 and Fig. 3c). Eutrophication influences iron bioavailability, affecting phytoplankton community structure. Dissolved organic matter enhances iron availability in coastal waters. Pearson correlation analysis indicated that metal concentrations were within WHO (2024) standards. Positive correlations between some metals suggest common, possibly anthropogenic, sources in Yewa Lagoon (Armah *et al.*, 2010).

Nutrients: During the rainy season, increased reactive nitrogen (0.1 – 6.29 mg/L), sulphate (2 – 190 mg/L, and silica (1.08 – 16.6 mg/L) levels were linked to floodwater influx from organic-rich wetlands (Table 2 and Fig. 3a).

This rise likely promoted cyanophyte proliferation, particularly *Microcystis* and *Oscillatoria*, influenced diatom populations such as *Aulacoseira granulata* and *Cyclotella comta* and also, the singular dominant occurrence of the diatom, *Aulacoseira granulata* f. *angustissima* in the dry month of March 2018. Silica is vital for diatoms, as they use it to form their glass-like cell walls, affecting food chain dynamics. In September 2017, diatoms remained highly associated despite not being dominant, highlighting ongoing silica utilization (Hildebrand and Lerch, 2015). Diatoms play a crucial role in the silicon cycle, incorporating dissolved silica into their frustules (Ragueneau *et al.*, 2006; Serôdio and Lavaud, 2020). Additionally, cyanobacteria can produce harmful cyanotoxins, causing abdominal pain, nausea, and diarrhoea in humans (Anderson *et al.*, 2002).

Chlorophyll *A* concentration (1.04 – 16.80 μg/L), an indicator of primary production, was higher in the rainy season due to floodwater influx from Yewa River and the lagoon's tributaries, Eere and Iragbo (Table 2 and Fig. 3a). These floodwaters carry rich organic matter into the lagoon, while persistent cloud cover and strong winds destabilize the water column (Effiong and Inyang, 2016). This turbulence dislodged planktonic algae from wetlands and creeks, increasing chlorophyll levels, which coincide with high concentrations of total suspended solids (Adedipe and Nwankwo, 2016).

Phytoplankton Biomass and Diversity: The phytoplankton of the Yewa Lagoon belonged to 7 divisions, 43 orders and 73 families. A total of 11 classes: Bacillariophyceae (40%), Conjugatophyceae (1%), Klebsormediophyceae (<1%), Chlorophyceae (3%), Trebouxiophyceae (2%), Cyanophyceae (44%), Euglenophyceae (8%), Dinophyceae (2%), Chrysophyceae (<1%), Eumastigophyceae (<1%) and Xanthophyceae (<1%), and also, 315 species belonging to 112 genera were recorded. Throughout the sampling period, the highest (4,521 (19.17%) individuals per ml) average phytoplankton occurrence was recorded at Awovo, while the least (2,362 (10.01%) individuals per ml) average was recorded at Yewa River Entrance (Table 3). The more frequent genera were: *Microcystis* spp., which had the highest abundance (8,454 individuals per ml) and occurred across all stations; *Aulacoseira* spp., which had a high number (6,349 individuals per ml) and occurred in all stations; *Trachelomonas* sp. had a slightly high number (944 individuals per ml) and occurred across all stations. *Diatoma* spp. (740 individuals per ml) occurred across all stations except Afowo, Awovo and Yewa River Entrance; *Thalassionema* spp. (536 individuals per ml) had relatively high abundances and were prominent across all stations; *Coelosphaerium kuetzingianum* (525 individuals per ml) occurred across all stations except Yewa River Entrance. *Oscillatoria* spp. (460 individuals per ml) occurred across all stations; *Euglena* spp. (335 individuals per ml) occurred across all stations. *Phacus* spp. (325 individuals per ml) occurred across all stations except Awovo; *Nitzschia* spp. (260 individuals per ml) occurred across all stations. *Chlorella* spp. (230 individuals per ml) occurred in Afowo, Awovo and Yewa River Entrance. *Peridinium* spp. (216 individuals per ml) occurred across all stations. *Anabaena spiroides* f. *minima* (215 individuals per ml) occurred across Ilikiti and Eere; *Cyclotella* spp. (210 individuals per ml) occurred across all stations. *Ulnaria* spp. (194 individuals per ml) occurred across all stations; *Nostoc* spp. (185 individuals per ml) occurred in Awovo and Yewa River Entrance; *Lepocinclis* spp. (182 individuals per ml) occurred across all stations; *Dolichospermum* spp. (170 individuals per ml) occurred in Awovo, Ilikiti, Eere and Yewa River Entrance. *Gonatozygon* spp. (165 individuals per ml) occurred across all stations except Awovo and Yewa River Entrance.

Table 2: Mean values of water quality parameters in the surface water at Yewa Lagoon (Rainy and Dry seasons).

Parameters	Afowo	Awovo	Itohun	Ilikiti	Iragbo	Eere	Yewa RE	WHO Standard (2011)
Air Temp. (ºC)	29.0±2.09[a]	29.028±1.72[a]	29.733±2.40[a]	29.9±2.13[a]	30.02±2.19[a]	30.3±2.01[a]	30.4±2.22[a]	
Water Temp. (ºC)	29.9±1.45[a]	30.5±1.61[a]	30.3±1.57[a]	30.8±1.89[a]	30.8±2.08[a]	30.7±2.56[a]	30±2.24[a]	<40
Salinity (‰)	4±2.23[a]	4±2.05[a]	4±2.31[a]	4±2.38[a]	3±2.25[a]	3±2.14[a]	3±2.32[a]	
Rainfall (mm)	142.67±101.88	142.67±101.88	142.67±101.88	142.67±101.88	142.67±101.88	142.67±101.88	142.67±101.88	
Transp. (in)	31.6±7.31[a]	36.8±10.73[ab]	41.8±14.48[b]	42.3±17.28[b]	38.2±12.94[ab]	37.5±13.02[ab]	36.0±10.99[ab]	
Water Depth (m)	1.1±0.43[a]	1.5±0.56[ab]	2±0.79[bc]	1.8±0.96[bc]	2.1±0.91[c]	2.1±0.85[c]	2.2±0.75[c]	
pH at 25°C	7±0.64[b]	6.9±0.55[ab]	6.9±0.61[ab]	6.7±0.7[ab]	6.7±0.61[ab]	6.7±0.53[ab]	6.5±0.46[a]	6.5 - 9.5
Cond. (µS/cm)	744.5±1829.97[b]	485.3±1076.20[ab]	208.5±178.29[ab]	195.1±176.88[ab]	126.8±62.84[a]	94.7±34.82[a]	96±36.01[a]	400 - 1500
TSS (mgL-l)	12±21.16[a]	11±15.13[a]	9±12.74[a]	10±12.87[a]	8±11.46[a]	7±11.99[a]	8±12.08[a]	-
TDS (mgL-l)	108±85.84[a]	302.2±628.85[b]	119.2±97.51[a]	120.7±107.44[a]	85.8±40.36[a]	59.5±14.85[a]	58.1±14.48[a]	<1000
Mg (mgL-l)	14.55±19.03[a]	11.37±12.32[a]	12.23±17.16[a]	8.76±10.40[a]	7.2±12.20[a]	7.88±12.01[a]	6.1±5.27[a]	
Calcium (mgL-l)	41.71±51.79[a]	32.3±34.64[a]	36.97±48.60[a]	20.31±25.83[a]	19.01±33.57[a]	20.59±33.18[a]	15.63±13.34[a]	
Nitrate (mgL-l)	1.76±0.86[a]	2.09±1.08[a]	1.68±0.80[a]	2.31±1.63[a]	2.13±0.98[a]	2.25±1.28[a]	2.38±1.64[a]	50
Phosp. (mgL-l)	0.54±0.88[a]	0.64±1.11[ab]	0.83±1.50[ab]	0.51±0.94[a]	0.79±1.18[ab]	0.7±1.35[ab]	1.61±2.23[b]	
Sulphate (mgL-l)	34±54.84[b]	27±43.49[ab]	17±19.45[ab]	13±15.43[a]	7±2.97[a]	6±3.39[a]	6±4.32[a]	500
Silica (mgL-l)	5.1±2.58[a]	6±3.04[a]	5.88±3.56[a]	5.59±2.99[a]	5.65±3.06[a]	5.98±3.52[a]	5.82±3.49[a]	
Lead (mgL-l)	0.005±0.018[a]	0.005±0.014[a]	0.001±0.001[a]	0.002±0.002[a]	0.001±0.001[a]	0.001±0.001[a]	0.001±0.001[a]	0.01
Copper (mgL-l)	0.012±0.01[ab]	0.019±0.02[b]	0.008±0.01[a]	0.008±0.01[a]	0.005±0.01[a]	0.011±0.02[ab]	0.009±0.01[ab]	
Iron (mgL-l)	0.73±0.65[a]	0.69±0.76[a]	0.45±0.35[a]	0.46±0.42[a]	0.46±0.34[a]	0.45±0.35[a]	0.55±0.53[a]	
Zinc (mgL-l)	0.03±0.03[ab]	0.05±0.05[b]	0.04±0.04[ab]	0.02±0.03[ab]	0.02±0.03[ab]	0.01±0.01[a]	0.03±0.08[ab]	5
DO (mgL-l)	4.44±0.03[a]	4.63±0.05[a]	4.03±0.04[a]	4.75±0.03[a]	4.4±0.03[a]	4.42±0.01[a]	4.32±0.08[a]	6
BOD (mgL-l)	4.22±2.74[b]	3.33±1.46[ab]	3.54±1.60[ab]	2.72±0.94[a]	3.51±1.44[ab]	3.31±2.22[ab]	3.27±1.74[ab]	10
COD (mg/L)	85.2±115.33[b]	55.1±53.76[ab]	29.4±20.33[a]	28±17.50[a]	22.2±10.25[a]	19.4±9.62[a]	23.8±13.72[a]	-
Chl *A* (µg/L)	5.81±3.08[a]	6.17±2.87[a]	6.4±3.24[a]	6.75±3.70[a]	6.26±3.36[a]	7.47±2.82[a]	6.66±3.30[a]	-

N.B: Mean values with the same superscript in a row are not statistically significantly different (P > 0.05) after post hoc test

Actinoptychus undulatus (141 individuals per ml) occurred across all stations except Awovo and Eere; *Dermatochrysis reticulata* (130 individuals per ml) occurred across all stations. *Chroococcus* spp. (118 individuals per ml) occurred across all stations except Afowo; *Surirella* spp. (110 individuals per ml) occurred across Afowo, Awovo, Itohun and Ilikiti, while *Closterium* spp. (105 individuals per ml) occurred across all stations except Yewa River Entrance (Table 3 and Figs. 4a – 4b).

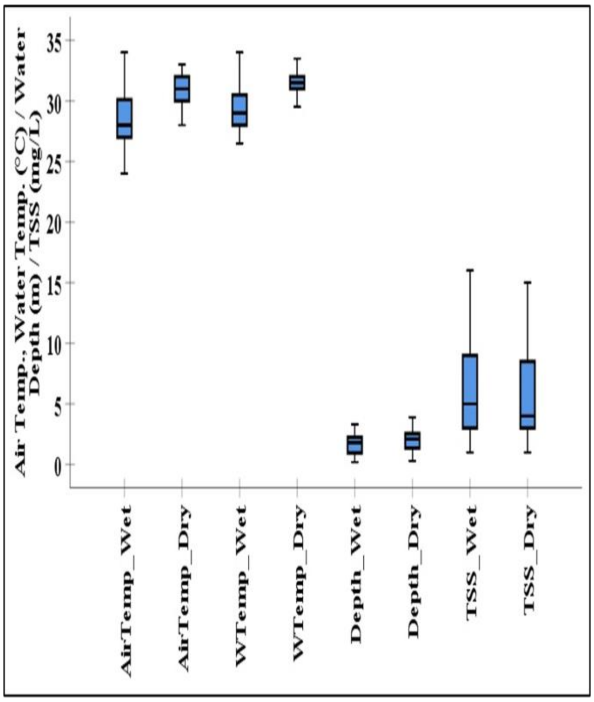

Fig. 2a: Variation in air (AirTemp) and water (WTemp) temperatures, depth and total suspended solids (TSS) in the rainy (wet) season and dry season.

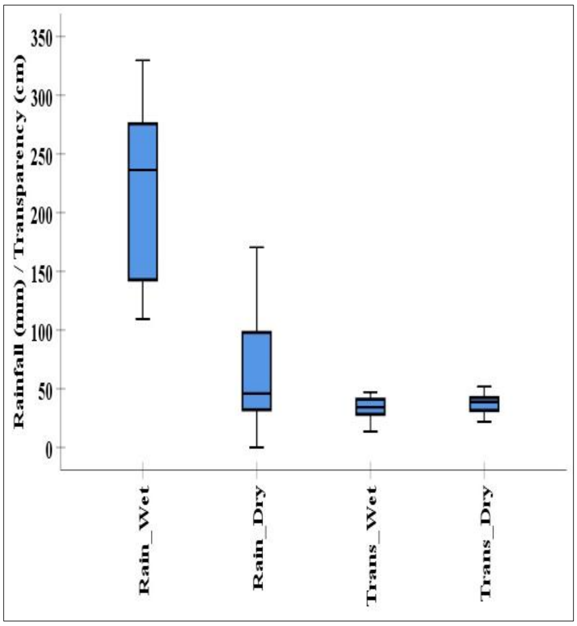

Fig. 2b: Variation between rainfall (Rain) and transparency (Trans) in the rainy (wet) season and dry season.

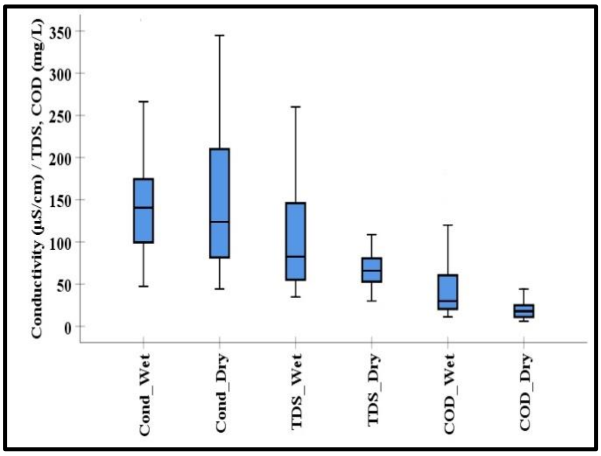

Fig. 2c: Variation in conductivity (Cond), total dissolved solids (TDS) and chemical oxygen demand (COD) in the rainy (wet) season and dry season.

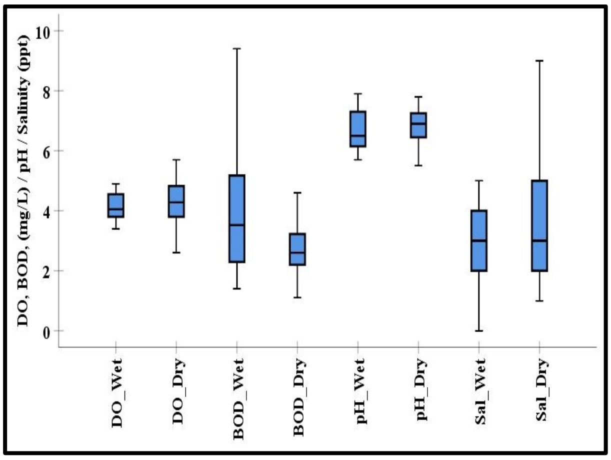

Fig. 2d: Variation in dissolved oxygen (DO), biochemical oxygen demand (BOD), pH and salinity (Sal) in the rainy (wet) season and dry season.

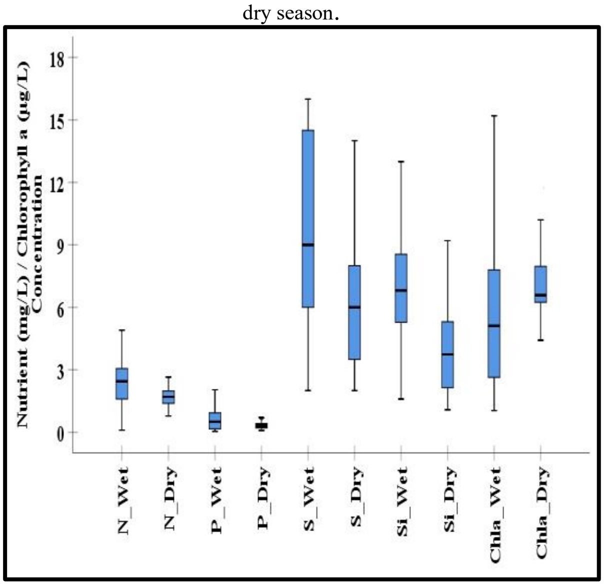

Fig. 3a: Variation in reactive nitrogen (N), reactive phosphorus (P), silica (Si) and chlorophyll *A* concentration (Chla) in the rainy (wet) season and dry season.

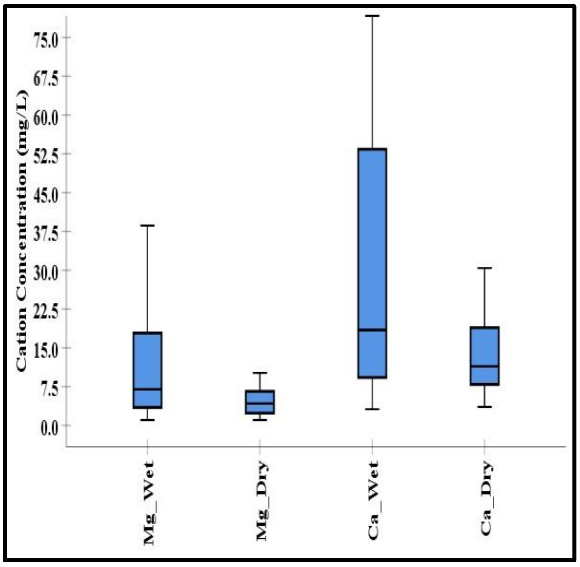

Fig. 3b: Variation between magnesium (mg) and calcium (ca) in the rainy (wet) season and dry season.

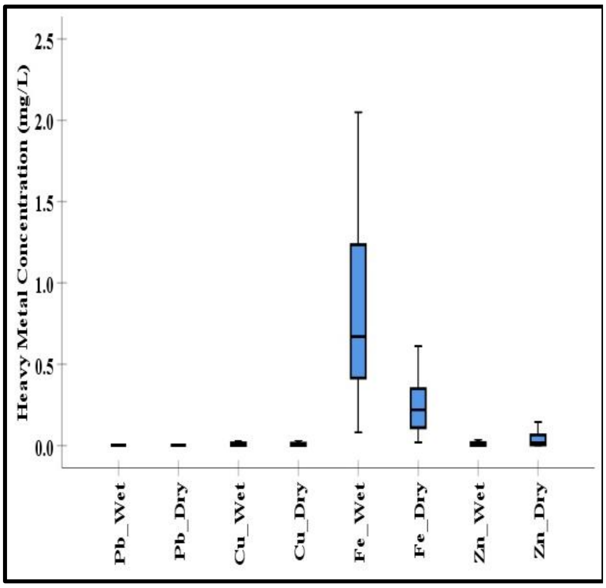

Fig. 3c: Variation in lead (Pb), copper (Cu), iron (Fe) and zinc (Zn) in the rainy (wet) season and dry season.

Biological Characteristics

According to Keister (2013) and Kitikidou *et al.* (2024), the number of species in an assemblage and the degree of evenness are closely related to the species diversity. Low values of diversity index might indicate dominance by one or two species, while high values of diversity index might indicate that the species numbers are more evenly dispersed. This probably explains the low Shannon (H), Margalef (d) and equitability (j) values recorded when *Microcystis aeruginosa* was more prevalent in Afowo and *Aulacoseira* sp. in Awovo among the sampled stations (Table 4 and Figs. 5a – 5d and 6). On the other hand, species were more evenly distributed across Itohun, Ilikiti, Iragbo, Eere and Yewa River Entrance, despite *Microcystis aeruginosa* being the most numerically abundant species across these stations (Table 4 and Figs. 5a – 5d and 6)

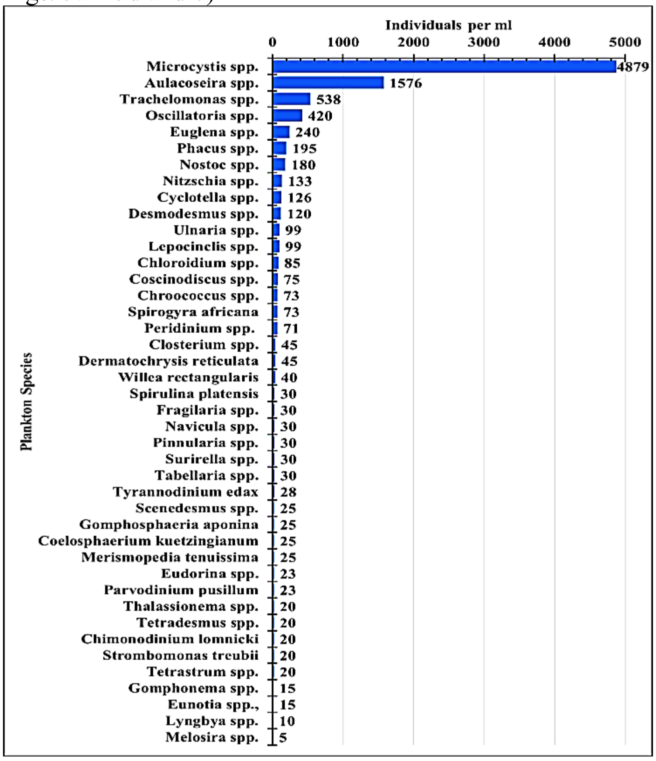

Fig. 4a: Ranking of top recorded species in the surface water during the rainy season.

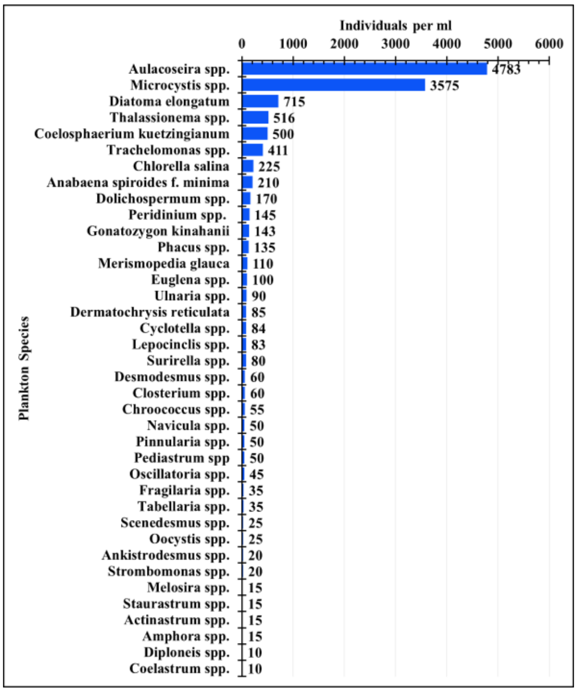

Fig. 4b: Ranking of top recorded species in the surface water during the dry season

Table 3: Species composition and abundance of phytoplankton in the surface water at Yewa Lagoon during the sampling period (abridged).

Taxa	Afowo	Awovo	Itohun	Ilikiti	Iragbo	Eere	Yewa Riv. Entrance	% Composition
Class: BACILLARIOPHYCEAE								
Acanthoceras zachariasii (Brun) Simonsen	-	-	-	-	-	5	-	
Achnanthes exigua Grunow	5	-	-	-	-	-	-	
Actinocyclus undulatus J. W. Bailey	116	-	5	10	5	-	5	
Actinoptychus splendens (Shadbolt) Ralfs	5	-	-	-	-	-	5	
Amphora spp.	-	-	-	5	5	5	-	
Anomoeoneis sphaerophora E. Pfitzer	-	-	-	-	-	-	5	
Aulacoseira spp.	869	2842	821	739	502	400	176	
Bacillaria paxillifera (O. F. Muller) T. Marsson	5	-	8	-	-	-	-	
Cocconeis placentula Ehrenberg	-	-	-	-	5	-	5	
Coscinodiscus spp.	10	5	15	10	25	25	15	
Cyclotella spp.	5	14	70	46	38	27	10	
Cymbella spp.	-	5	80	10	5	-	-	
Diatoma spp.	-	-	710	10	10	10	-	
Diploneis spp.	-	-	-	-	5	5	-	
Epithemia argus var. *longicornis* (Ehrenberg) Grunow	-	-	-	-	5	-	-	
Eunotia spp.	-	-	5	-	-	5	10	
Fragilaria spp.	15	-	5	-	5	30	10	
Gomphonema spp.	5	-	-	-	5	5	-	
Gossleriella tropica Shütt	-	-	-	-	-	5	-	
Halamphora coffeaeformis (C. Agardh) Levkov	-	-	-	5	-	5	-	
Hemiaulus hauckii Grunow ex Van Heurck	-	-	-	-	5	-	-	39.46
Leptocylindrus spp.	15	-	5	-	-	-	10	
Melosira spp.	-	15	-	5	-	-	-	
Navicula spp.	10	-	-	25	15	-	30	
Neidium iridis (Ehr.) Cleve	-	-	-	-	-	-	5	
Nitzschia spp.	30	30	60	28	46	28	38	
Pinnularia spp.	-	5	5	20	10	20	15	
Pleurosigma angulatum (J.T. Quekette) W. Smith	5	5	-	-	-	-	5	
Pseudo-nitzschia spp.	-	-	5	-	5	-	-	
Rhizosolenia spp.	-	-	5	-	5	5	-	
Rhopalodia gibberula var. *producta* (Grun.) A. Cleve	-	-	-	-	5	-	-	
Stauroneis kriegeri R. M. Patrick	-	-	-	-	-	-	5	
Surirella spp.	10	65	15	20	-	-	-	
Synedra crystallina (C.Agardh) Kützing	-	-	-	-	5	-	5	
Tabellaria spp.	10	-	10	10	10	10	15	
Tabularia fasciculata (C. Agardh) D. M. Williams and Round	10	-	-	-	-	-	-	
Thalassionema spp.	10	5	8	48	37	388	40	
Thalassiosira rotula Meunier	-	5	-	-	-	-	-	
Tropidoneis sp.	-	-	10	-	-	-	-	
Ulnaria spp.	13	34	40	40	28	29	10	
Urosolenia eriensis (H. L. Smith) Round and R. M. Crawford	-	-	5	-	-	-	-	
Class: CONJUGATOPHYCEAE								
Closterium spp.	10	10	15	25	20	25	-	
Euastrum sibiricum Boldt	-	-	-	5	5	-	-	
Gonatozygon spp.	12	-	128	5	10	10	-	
Phymatodocis nordstedtiana Wolle	-	-	-	-	-	-	5	
Pleurotaenium clavatum (Kütz.) de Bary	-	-	-	-	-	5	-	1.71
Spirogyra africana Fritsch Cruda	8	40	-	5	5	10	15	
Spirotaenia condensata Brébisson	-	-	-	-	-	5	-	
Staurastrum spp.	-	-	-	15	5	5	-	
Staurodesmus brevispina (Brébisson) Croasdale	-	-	-	-	-	5	-	
Class: KLEBSORMEDIOPHYCEAE								
Stichococcus bacillaris Nägeli	-	-	-	-	10	-	-	0.04
Class: CHLOROPHYCEAE								
Gonium formosum Pascher	-	-	-	10	10	5	-	
Acutodesmus acutiformis (Schröder) P. M. Tsarenko and D. M. John	-	-	-	-	-	10	-	2.51
Ankistrodesmus spp.	-	5	10	20	15	5	15	
Chlorotetraëdron incus (Teiling) Komárek and Kovácik	-	-	5	-	-	-	-	
Coelastrum spp.	-	5	-	15	-	-	-	

Desmodesmus spp.	**-**	**50**	**25**	**35**	**40**	**20**	**15**	
Eudorina spp.	**-**	**5**	**-**	**5**	**18**	**-**	**-**	
Golenkinia spp.	**-**	**-**	**-**	**5**	**-**	**10**	**-**	
Monoraphidium griffithii (Berkeley) Komárková-Legnerová	**-**	**5**	**-**	**5**	**5**	**-**	**-**	
Pandorina morum (O. F. Müller) Bory	**-**	**-**	**5**	**5**	**10**	**5**	**-**	
Pediastrum spp.	**-**	**5**	**10**	**10**	**20**	**10**	**5**	
Scenedesmus spp.	**-**	**10**	**5**	**20**	**5**	**10**	**-**	
Selenastrum bibraianum Reinsch	**-**	**-**	**25**	**5**	**5**	**-**	**-**	
Tetradesmus spp.	**-**	**5**	**10**	**-**	**-**	**-**	**5**	
Tetraëdron quadricuspidatum (Reinsch) Hansgirg	**-**	**-**	**-**	**-**	**5**	**-**	**-**	
Tetrastrum spp.	**-**	**-**	**5**	**5**	**10**	**5**	**-**	
Class: TREBOUXIOPHYCEAE								
Actinastrum spp.	**-**	**5**	**-**	**5**	**5**	**5**	**-**	
Chlorella spp.	**200**	**25**	**-**	**-**	**-**	**-**	**5**	
Chloroidium spp.	**-**	**-**	**-**	**15**	**80**	**-**	**-**	
Crucigenia spp.	**-**	**-**	**-**	**-**	**-**	**5**	**5**	
Crucigeniella irregularis (Wille) P. M. Tsarenko and D. M. John	**-**	**-**	**10**	**-**	**-**	**-**	**-**	**2.30**
Gloeotila scopulina (Hazen) Heering	**-**	**5**	**5**	**5**	**5**	**5**	**-**	
Lemmermannia triangularis (Chodat) C. Bock and Krienitz	**-**	**5**	**5**	**5**	**13**	**5**	**5**	
Nephrocytium lunatum West	**-**	**-**	**-**	**-**	**5**	**5**	**-**	
Oocystis spp.	**-**	**10**	**5**	**25**	**10**	**-**	**-**	
Willea rectangularis (A. Braun) D. M. John, M. J. Wynne and P. M. Tsarenko	**-**	**10**	**-**	**5**	**20**	**5**	**15**	
Class: CYANOPHYCEAE								
Anabaena spiroides f. *minima* (Nygaard) Kossinskaja	**-**	**-**	**-**	**210**	**-**	**5**	**-**	
Chroococcus spp.	**-**	**10**	**33**	**10**	**25**	**25**	**15**	
Coelosphaerium kuetzingianum Nag.	**5**	**10**	**490**	**5**	**10**	**5**	**-**	
Dolichospermum spp.	**-**	**35**	**-**	**120**	**-**	**10**	**5**	
Gomphosphaeria aponina Kützing	**5**	**-**	**5**	**-**	**5**	**5**	**5**	
Lyngbya spp.	**5**	**-**	**5**	**-**	**-**	**-**	**-**	
Merismopedia spp.	**-**	**25**	**105**	**-**	**-**	**5**	**-**	**43.93**
Microcystis spp.	**1252**	**1084**	**875**	**1009**	**1223**	**1902**	**1109**	
Nostoc spp.	**-**	**5**	**-**	**-**	**-**	**-**	**180**	
Oscillatoria spp.	**5**	**10**	**225**	**145**	**25**	**20**	**30**	
Phormidium uncinatum Gomont	**5**	**-**	**-**	**-**	**-**	**-**	**-**	
Pseudanabaena catenata Lauterborn	**-**	**-**	**5**	**-**	**-**	**-**	**-**	
Spirulina platensis Geitler	**-**	**-**	**-**	**-**	**-**	**5**	**25**	
Stigonema mesentericum Geitler	**5**	**-**	**5**	**5**	**-**	**-**	**5**	
Class: EUGLEOPHYCEAE								
Colacium cyclopicola (Gicklh.) Bourrelly	**-**	**-**	**-**	**5**	**-**	**5**	**-**	
Euglena spp.	**5**	**15**	**30**	**55**	**50**	**140**	**40**	
Lepocinclis spp.	**5**	**5**	**20**	**40**	**40**	**49**	**23**	**7.78**
Phacus spp.	**5**	**-**	**55**	**85**	**85**	**80**	**15**	
Strombomonas spp.	**-**	**-**	**5**	**10**	**15**	**10**	**-**	
Trachelomonas spp.	**30**	**35**	**58**	**179**	**130**	**194**	**318**	
Class: DINOPHYCEAE								
Alexandrium catenella (Whedon and Kofoid) Balech	**-**	**-**	**5**	**-**	**-**	**-**	**-**	
Chimonodinium lomnicki (Woloszynska) Craveiro, Calado, Daugbjerg, Gert Hansen and Moestrup	**-**	**5**	**-**	**5**	**10**	**5**	**-**	
Cystodinium unicorne G. A. Klebs	**-**	**-**	**-**	**-**	**-**	**-**	**5**	
Glenodinium pusillum Lemmermann	**-**	**-**	**-**	**-**	**-**	**5**	**-**	**1.56**
Gonyaulax orientalis Lindemann	**-**	**-**	**-**	**-**	**5**	**-**	**-**	
Gymnodinium hyalinum (A. J. Schilling)	**-**	**-**	**5**	**-**	**-**	**-**	**-**	
Jadwigia neglecta (A. J. Schilling) Moestrup	**-**	**-**	**-**	**-**	**10**	**-**	**-**	
Nusuttodinium aeruginosum (F. Stein) Y. Takano and T. Horiguchi	**-**	**-**	**5**	**-**	**-**	**-**	**-**	
Parvodinium pusillum (Penard) Carty	**-**	**10**	**10**	**5**	**5**	**8**	**5**	
Peridinium spp.	**5**	**15**	**25**	**22**	**21**	**88**	**40**	

Tyrannodinium edax (A. J. Schilling) Calado	**-**	**5**	**5**	**10**	**13**	**10**	**-**	
Class: CHRYSOPHYCEAE								
Dermatochrysis reticulata (K. I. Meyer) Entwisle and R. A. Andersen	**24**	**22**	**17**	**12**	**14**	**18**	**23**	**0.55**
Class: EUSTIGMATOPHYCEAE								
Pseudostaurastrum gigas (Pascher) Bourrelly	**-**	**-**	**-**	**-**	**5**	**-**	**-**	**0.02**
Class: XANTHOPHYCEAE								
Centritractus belonophorus (Schmidle) Lemmermann	**5**	**-**	**-**	**-**	**5**	**5**	**5**	**0.13**
Ophiocytium capitatum Wolle	**-**	**-**	**-**	**-**	**5**	**-**	**5**	

Table 4: Diversity indices of phytoplankton recorded across the sampling stations**.**

	Afowo	Awovo	Itohun	Ilikiti	Iragbo	Eere	Yewa River. Entrance
Taxa_S	57	72	111	142	148	143	106
Individuals	2739	4521	4143	3218	2823	3781	2362
Dominance_D	0.2775	0.4094	0.1081	0.1271	0.2002	0.2636	0.231
Simpson_1-D	0.7225	0.5906	0.8919	0.8729	0.7998	0.7364	0.769
Shannon_H	1.929	1.635	2.948	3.251	3.097	2.666	2.762
Evenness_e^H/S	0.1207	0.07126	0.1718	0.1818	0.1496	0.1005	0.1493
Brillouin	1.889	1.604	2.894	3.165	2.997	2.593	2.677
Menhinick	1.089	1.071	1.725	2.503	2.786	2.326	2.181
Margalef	7.075	8.436	13.21	17.46	18.5	17.24	13.52
Equitability_J	0.477	0.3824	0.626	0.6559	0.6198	0.5371	0.5922
Fisher_alpha	10.18	12.16	20.98	30.4	33.23	29.4	22.79
Berger-Parker	0.4279	0.6027	0.2088	0.3104	0.4269	0.4978	0.4674
Chao-1	57	72	111	142	148	143	106

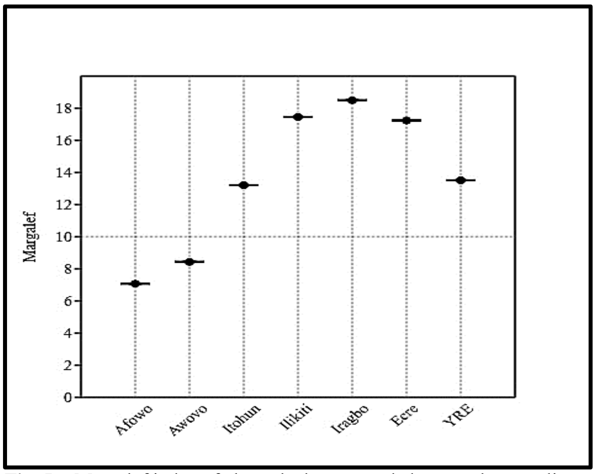

Fig. 5a: Margalef index of phytoplankton recorded across the sampling stations during the rainy and dry seasons.

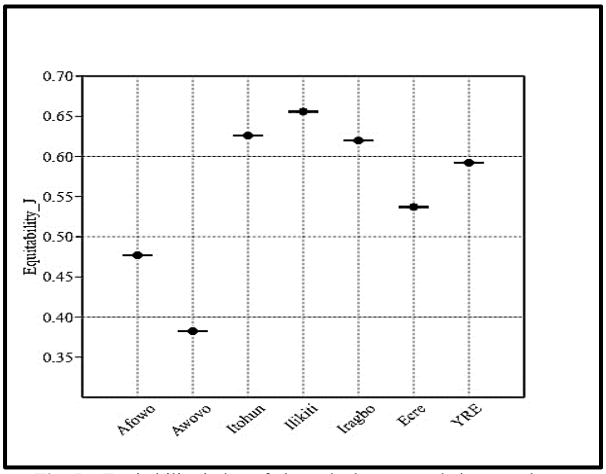

Fig. 5c: Equitability index of phytoplankton recorded across the sampling stations during the rainy and dry seasons.

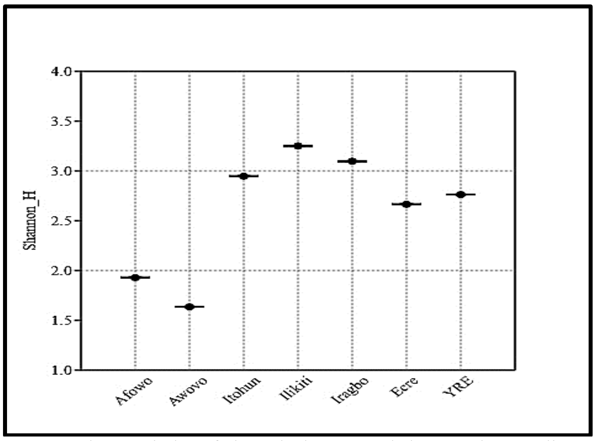

Fig. 5b: Shannon index of phytoplankton recorded across the sampling stations during the rainy and dry seasons.

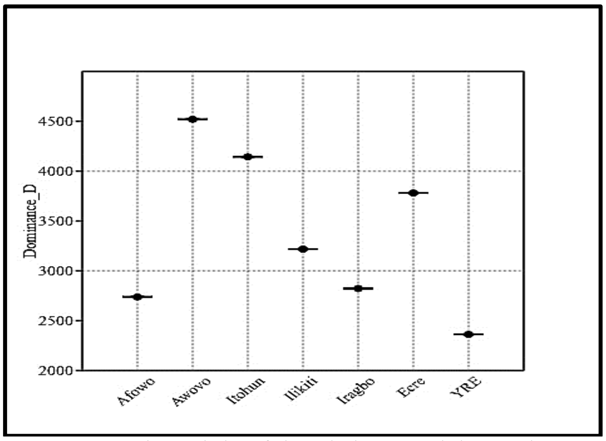

Fig. 5d: Dominance index of phytoplankton recorded across the sampling stations during the rainy and dry seasons.

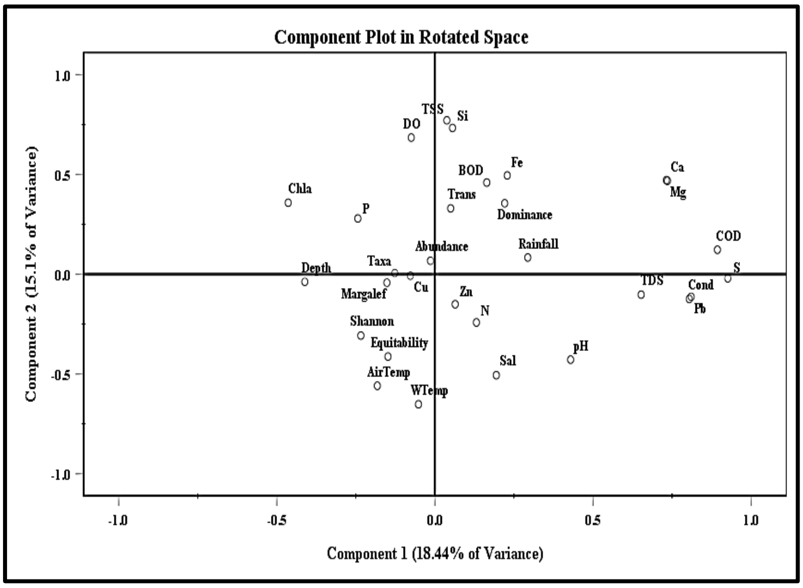

Fig. 6: Principal component analysis of physicochemical parameters and diversity indices of phytoplankton across the sampling stations during the rainy and dry seasons.

Table 5: Pearson correlation coefficient of physicochemical parameters and some diversity indices at Yewa Lagoon (Aug. '17 – Jan '19).

	AirTemp	WaterTemp	Salinity	Rainfall	Transparency	Depth	pH	Conductivity	TSS	TDS	Magnesium	Calcium	Nitrate	Phosphate	Sulphate	Silica	Lead	Copper	Iron	Zinc	DO	BOD	COD	Chl a	Taxa	Individuals	Shannon	Margalef	Equitability	Dominance
AirTemp	1																													
WaterTemp	.740**	1																												
Salinity	0.16	.250**	1																											
Rainfall	-0.16	-.208*	-.205*	1																										
Transparency	0.05	-0.14	-0.01	-0.14	1																									
Depth	.284**	0.13	-.242**	-0.13	-0.02	1																								
pH	0.02	0.14	.190*	0.02	-0.03	-.311**	1																							
Conductivity	-0.03	0.10	0.12	0.15	-0.05	-.213*	.213*	1																						
TSS	-.207*	-.303**	-.277**	-0.12	.489**	-0.12	-.371**	-0.01	1																					
TDS	-0.15	0.06	0.13	0.17	-0.01	-.206*	.238**	.558**	-0.05	1																				
Magnesium	-.262**	-.238**	-0.04	0.15	.426**	-.278**	0.13	.482**	.457**	.358**	1																			
Calcium	-.252**	-.234**	-0.04	0.15	.417**	-.271**	0.10	.482**	.457**	.360**	.973**	1																		
Nitrate	-0.03	-0.03	0.08	.400**	-.206*	-0.10	.217*	0.04	-.389**	0.04	-0.10	-0.14	1																	
Phosphate	-.219*	-.267**	-.356**	.180*	-.298**	0.12	-.239**	-0.10	-0.02	-0.10	-0.12	-0.16	0.08	1																
Sulphate	-.212*	-0.04	0.15	.236**	-0.04	-.335**	.431**	.715**	-0.03	.659**	.665**	.659**	0.10	-0.14	1															
Silica	-.634**	-.573**	-.480**	0.12	0.03	-0.06	-.230**	-0.04	.376**	0.06	.286**	.259**	0.01	.381**	0.14	1														
Lead	-0.05	0.11	0.09	.177*	-0.04	-0.17	.207*	.946**	-0.01	.633**	.498**	.482**	0.03	-0.08	.721**	-0.01	1													
Copper	0.10	.203*	-0.08	0.04	-.197*	0.05	-0.07	-0.08	-0.03	-0.05	-0.12	-0.10	-0.05	0.03	-0.07	-0.02	-0.10	1												
Iron	-.446**	-.451**	0.01	.330**	0.05	-.210*	-0.01	-0.14	.286**	0.04	.328**	.356**	0.09	0.03	.220*	.404**	-0.12	0.05	1											
Zinc	-0.06	-0.06	0.13	-.308**	-0.10	0.00	.283**	-0.06	-0.14	0.07	-0.05	-0.03	-0.10	-0.15	0.10	-0.04	-0.05	0.03	0.02	1										
DO	-.293**	-.298**	-.247**	-0.10	.400**	-0.07	-.278**	-0.07	.712**	-0.08	.328**	.337**	-.318**	0.04	-0.11	.298**	-0.05	-0.08	.197*	-0.16	1									
BOD	-0.10	-0.11	-.243**	.214*	0.12	-0.08	-.198*	0.02	.426**	0.12	.375**	.419**	-.209*	0.03	0.10	.211*	0.03	0.14	.304**	-0.15	.342**	1								
COD	-.228*	-0.11	0.05	.298**	-0.05	-.308**	.310**	.745**	0.11	.405**	.663**	.672**	0.04	-0.13	.873**	0.17	.739**	-0.02	.343**	0.01	-0.01	.193*	1							
Chl a	-0.09	-0.05	-.352**	-.386**	0.05	.216*	-.395**	-0.15	.287**	-.180*	-0.16	-0.17	-.262**	.372**	-.341**	.317**	-.179*	0.00	-0.16	-0.15	.378**	-0.02	-.341**	1						
Taxa	-.186*	0.00	0.01	0.17	0.09	0.00	-0.01	-0.12	-0.07	0.00	-0.03	-0.02	-0.01	0.00	-0.06	0.09	-0.07	-0.10	0.11	-0.01	0.12	-0.04	-0.08	0.00	1					
Individuals	-0.07	0.00	0.00	-0.10	0.06	-0.03	0.02	-0.05	-0.01	-0.04	0.05	0.06	0.01	-0.07	-0.02	-0.01	-0.03	-0.07	0.02	-0.04	0.01	-0.04	-0.02	0.01	.283**	1				
Shannon	0.00	0.14	0.11	0.08	0.04	-0.05	0.07	-0.12	-.201*	0.00	-.192*	-.192*	-0.07	0.02	-0.12	-0.13	-0.09	-0.15	-0.10	-0.10	0.00	-0.07	-.205*	0.10	.594**	-0.07	1			
Margalef	-0.16	0.02	0.02	.195*	0.08	0.00	0.00	-0.13	-0.10	0.00	-0.07	-0.05	0.00	0.01	-0.07	0.07	-0.08	-0.10	0.09	-0.03	0.09	-0.06	-0.10	0.00	.986**	.195*	.685**	1		
Equitability	0.17	.190*	0.16	-0.12	0.01	-0.02	0.09	-0.02	-.191*	0.05	-.195*	-.191*	-0.09	-0.04	-0.08	-.313**	-0.03	-.184*	-.241**	-0.06	-0.10	0.06	-0.17	0.05	-0.07	-.265**	.637**	0.02	1	
Dominance	-0.06	-.185*	-0.15	0.02	-0.05	0.07	-0.08	0.09	.192*	-0.01	.186*	.182*	0.12	0.01	0.12	.211*	0.08	.180*	0.15	0.08	0.00	0.01	.213*	-0.12	-.395**	0.08	-.937**	-.471**	-.809**	1

*. Correlation is significant at the 0.05 level (2-tailed).; **Correlation is significant at the 0.01 level (2-tailed).

Carlson's Trophic State Index (CTSI): Carlson's trophic state index (CTSI) in both rainy and dry seasons (Tables 6 and 7) ranged between 60 and 80, indicating that Yewa Lagoon is eutrophic. The water of the lagoon classified under this category is dominated by blue-green algae, probable occurrence of algal scum and extensive macrophyte problems, and also the possibility of heavy algal blooms throughout the dry season, often hypereutrophic (Carlson and Havens, 2005).

Relationship between the Phytoplankton and Environmental Variables: The Pearson correlation coefficient (r) values between the phytoplankton and the physicochemical parameters are presented in Table

5. Of all physicochemical parameters, air temperature showed significant correlation ($p<0.05$) with Taxa, water temperature showed significant correlation ($p<0.05$) with Equitability and Dominance, rainfall correlated significantly ($p<0.05$) with Margalef, TSS, magnesium and calcium correlated significantly ($p<0.05$) with Shannon, Equitability and Dominance, silica and copper correlated significantly ($p<0.01$ and $p<0.05$) with Equitability and Dominance, iron correlated significantly ($p<0.01$) with Dominance, COD correlated significantly ($p<0.05$) with Shannon and Dominance.

Table 6: Carlson's trophic state index at Yewa Lagoon (Rainy Season)

Parameter	Afowo	Awovo	Itohun	Ilikiti	Iragbo	Eere	YRE	Ave
TSI of Trans	64.26	60.93	59.22	59.18	60.59	60.14	61.13	60.779
TSI of P	98.57	102.75	107.62	99.5	107.7	104.37	119.22	105.68
TSI of Chl *A*	45.99	46.55	47.2	47.61	46.83	50.89	50.49	47.937
CTSI	**69.61**	**70.08**	**71.35**	**68.76**	**71.71**	**71.8**	**76.95**	**71.464**

Table 7: Carlson's trophic state index at Yewa Lagoon (Dry Season)

Parameter	Afowo	Awovo	Itohun	Ilikiti	Iragbo	Eere	YRE	Ave
TSI of Trans	62.15	61.03	59.05	58.74	60.26	61.29	61.43	60.564
TSI of P	90.06	88.2	88.53	85.57	84.15	88.67	86.4	87.369
TSI of Chl *A*	49.45	50.04	50.18	50.79	50.09	49.73	47.73	49.716
CTSI	**67.22**	**66.42**	**65.92**	**65.03**	**64.83**	**66.56**	**65.19**	**65.883**

Principal Component Analysis: From the rotation sums of squared loadings (Fig. 6), PC 1 and PC 2 account for roughly 33.54% of the variance in the data set. Sulphate, COD, Lead, Conductivity, Magnesium and Calcium are strongly correlated with PC 1, while TSS and Silica are strongly correlated with PC 2. On the other hand, TDS is moderately correlated with PC 1, while DO, Water Temperature, Air Temperature and Salinity are strongly correlated with PC 2.

Conclusion: Yewa Lagoon undergoes nutrient enrichment, moderate pollution, and seasonal ecological shifts affecting phytoplankton. Continuous monitoring is essential to assess the impact of industrial and municipal effluent discharges on its ecosystem.

Data Availability Statement: Data are available upon request from the corresponding author.

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