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Phytoplankton flora of asejire reservoir, Southwest Nigeria

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Abstract
An appraisal of the current ecological status of Asejire Reservoir was carried out using the reservoir phytoplankton composition and community structure. Monthly sampling was carried out in nine selected sites for twelve months. Data were analysed using descriptive statistics, analysis of variance, Shannon-Weiner and Evenness indices. One hundred and fifty-four phytoplankton taxa were identified. Taxa dominance was in the following order: Bacillariophycea>Chlorophycea>Charophycea>Cyanophycea>Euglenophycea>Ochrophycea>Dinophyceaa. *Microcystis* sp. were the most abundant species followed by *Anabaena* sp. and *Closterium* sp. The riverine zone accounted for 50.8% of the total phytoplankton population. One-way analysis of variance between the zones indicated that there was a significant difference (F=11.41, df=2, p=0.0000146) in the spatial distribution among the stations. Most of the recorded phytoplankton species are cosmopolitan with the presence of the following species: *Staurastrum*, *Closterium*, *Cosmarium*, *Anabaena*, and *Oscillatoria*. The presence of some pollution indicator species is a cause of concern and the need to ensure holistic and effective monitoring measure is put in place to safeguard the reservoir.

Keywords: Asejire, reservoir, phytoplankton, community, taxa, cosmopolitan

1. Introduction
The total surface area covered by water in Nigeria is estimated to be 149,919km^2, constituting about 15.9% of the total area of the country [1]. These water bodies are often used for the disposal of domestic, industrial and other forms of anthropogenic effluents with the wrong assumption that the aquatic ecosystems have self-purifying ability [2, 3]. The primary producers in these waterbodies are the phytoplankton and are usually impacted by these discharges. The phytoplankton are food source for planktonic consumers and other higher organisms in the water and also represent the primary oxygen source in streams, rivers and reservoirs [4].

They number and type of phytoplankton are used as bio-indicators of water quality as they respond very quickly to changes in environmental stress which could result in consequences in their make-up and community structure [5, 6, 7]. Therefore, the composition, population and community structure of plankton are useful in assessing the biological integrity and functioning of aquatic ecosystem [8].

Aside the studies carried out by Egborge between 1972 and 1980 [9] when the reservoir was created; and [10]; most studies on the reservoir has been limited to the ichtyofauna and physico-chemical characteristics of reservoir [11, 12, 13, 14, 15, 16, 10, 17, 18, 19, 20, 21]. Paucity of information on the phytoplankton community especially their biodiversity, population and community structure is a setback to a proper understanding of the life process of the limnology of this vast and important reservoir, hence the need for this study. Therefore, the objectives of this study were to determine the taxonomic composition of the phytoplankton flora of the reservoir with regards to its composition, abundance and community structure. This will aid in updating the status of the phytoplankton community, develop a model for an effective management of the reservoir.

2. Materials and Methods
2.1 Study Area
The study area falls into the equatorial tropical climate [22], characterized by average annual rainfall of 100±40cm and temperature of 28±1.04 ºC).

Relative humidity is usually high ranging from 58% in the dry season to above 80% in the rainy season [23]. The surrounding vegetation is lowland tropical rainforest and dense savannah woodland at the northern fringe, but human interference and persistent annual bush burning for farming have reduced the natural vegetation to one described by [24] as forest regrowth. The Reservoir extend from longitudes 004^0 07'017"E - 004^0 08'925"E and from latitudes 07^0 21'48"N and 07^0 26'84"N (Figure 1). The reservoir is a manmade lake that was created in 1970 by the impoundment of River Osun to provide potable water for the city Ibadan and environs [11] and officially opened in 1972. Other ancillary benefits such as fishing, transportation, recreation, agriculture, etc. have since emerged after the dam creation [15]. The reservoir receives the bulk of its water input from two rivers, Rivers Osun and its main tributary River Oba. The catchment area of the dam is 7,800 km^2 and the impounded area is 23.42 km^2. The surface area of the reservoir is about 24 km^2. Its gross storage capacity is approximately 7,403.4 million litres per day while its discharge capacity is 136.26 million litres per day with maximum water capacity of about 675 m^3. The reservoir supply water to more than two million inhabitants of Oyo and Osun States in the Southwestern part of Nigeria.

2.2 Selection, Description of sampling stations and Sample Collection

After a reconnaissance survey of the Reservoir, nine sampling sites (Stations A, B, C, D, E, F, G, H and I) were established along the course of the Reservoir (three each were along the horizontal axis of the reservoir, covering the upper basin-riverine zone), middle basin - transition zone and lower basin-lacustrine zone) of the lake (Figure 1). A Global positioning system (GPS) handset was used to determine the grid coordinates of the sampling sites. Samples were collected from April 2017 to March 2018. Samples were collected at each station by filtering 100 litres of water through a plankton net of 60 µm mesh size and reducing it to a concentrated volume of approximately 30 ml. The concentrated samples were preserved in 5% formalin solution.

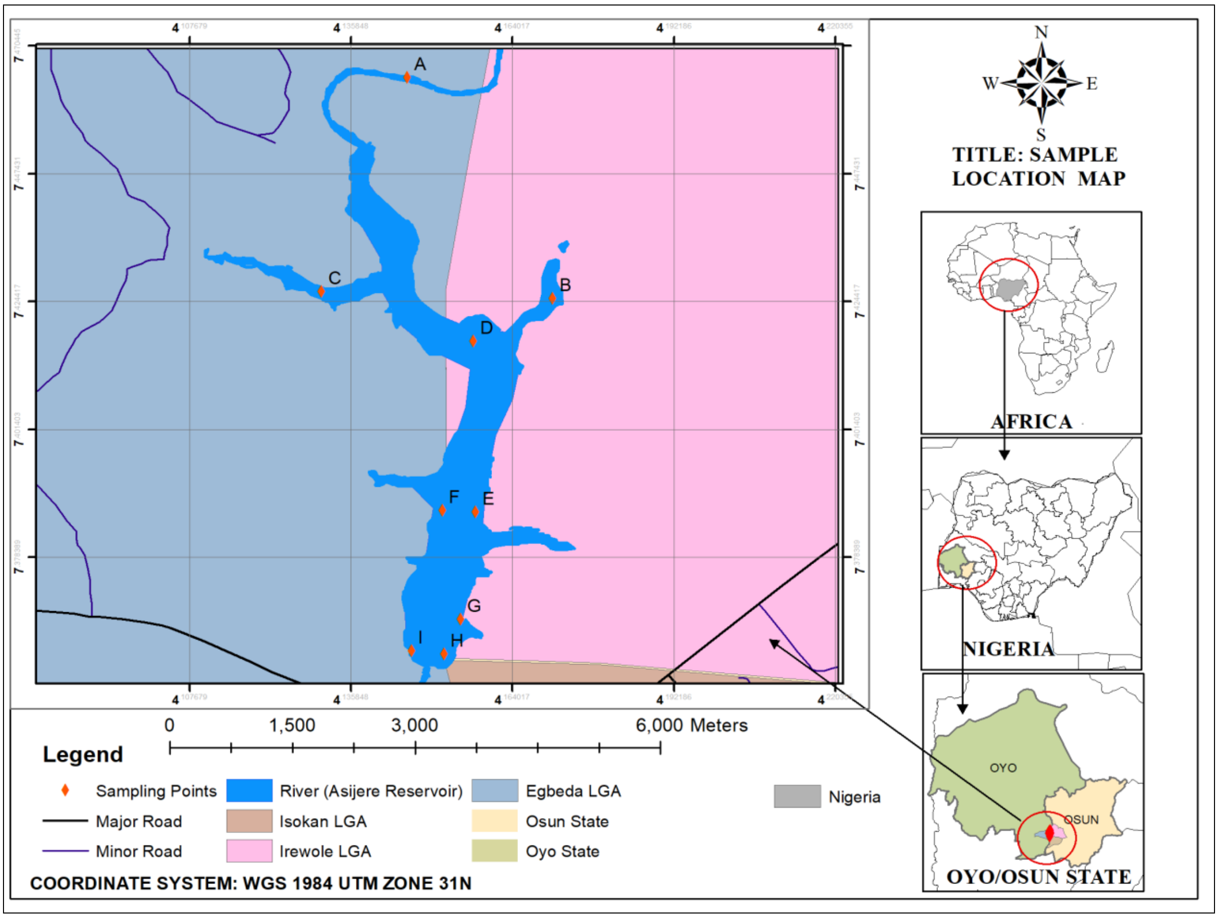

Fig 1: Asejire reservoir showing locations of sampling stations

2.3 Laboratory analyses

The 30 ml concentrate volume was further reduced to 5 ml, withdrawn using pipette and observed under the a compound microscope equipped with an ocular micrometer calibrated using a stage micrometer. Phytoplankton organisms were identified using guides by [25, 26, 27, 28, 29, 30, 31 32, 33]. Species abundance were determined by direct count, aided by a counting chamber whose number of ocular fields had already been determined through calibration. Zooplankton abundance were determined from the count records of the final concentrated volume in relation to the original volume of water strained through the plankton net. Community structure was assessed using the indices of species diversity, Simpson's dominance index (S). Abundance of each species was estimated based by multiplying the number in the final concentrate volume (30 ml for 30 Litres) by 1000 and expressed as organism/L (Org/L).

2.4 Statistical Analysis

The taxa richness, diversity, and evenness indices were calculated using Berger-Parker, Shannon-Wiener and Simpson and Margalef indices. All the statistical analyses were carried out using the Paleontological Statistics [34], Statistical Package for Social Sciences Software package and Statistical Ecology [35].

3. Results

3.1 Phytoplankton composition

A checklist of the phytoplankton species identified in Asejire Reservoir are presented in Table 1. A total of one hundred and fifty four (154) phytoplankton taxa were identified belonging to seven groups were recorded during the twelve months study period. This comprises of fifty-one species of Bacillariophyceae, twenty-five species of Charophyceae, twenty-nine species of Chlorophyceae, twenty-one species of Cyanophyceae, five species of Dinophyceae, seventeen species of Euglenophyceae and six species of Onchophyceae. Taxa of Bacillariophyceae, Charophyceae, Chlorophyceae and Cyanophyceae were found in all the nine sampled locations, while Euglenophyceae, Dinophyceae and Onchophyceae were found in eight, six and four stations. The order of dominance in relation to species richness in the reservoir was Bacillariophyceae (32.12%), Chlorophyceae (18.83%), Charophyceae (16.23%), Cyanophycea (13.64%), Euglenophyceae (11.04%), Ochrophycea (3.90%) and Dinophyceaa (3.25%). In terms of abundance, Cyanophyceae recorded the highest with 32.68%, followed by Bacillariophyceae (25.48%), Chlorophyceae (20.59%), Charophyceae (13.81%), Euglenophyceae (5.12%), Dinophyceae (1.69%) and Ochrophyceae (0.64%). Among individual species, *Microcystis* sp. were the most abundant (20.39%), followed by *Anabaena* sp. (6.28%), *Closterium* sp. (5.94%), *Oedogonium* sp. (3.74%) and *Achnanthes* sp. (2.60%). Other phytoplankton species with relatively high abundance were *Synedra* sp., *Flagellaria* sp., *Eunotia* sp. and *Phacus* sp.

Table 1: Checklists of Phytoplankton recorded from Asejire Reservoir

Division	Species	Stations									Total
		A	B	C	D	E	F	G	H	I	
Bacillaceae	*Achnanthes* sp.	750	250	400	200	100	50	150	200	250	2350
	Asterionella formosa	250	100	550	200	50	25	200	150	50	1575
	Asterionella gracillima	100	0	0	100	250	0	0	125	100	675
	Bacillaria sp	0	0	0	50	25	50	0	100	100	325
	Coscinodiscus sp	200	50	100	250	300	150	0	100	100	1250
	Cyclotella comta	25	175	125	50	25	50	75	0	0	525
	Cyclotella kutzingiana	0	0	0	50	25	50	0	0	0	125
	Cymatopleura solea	50	0	0	0	0	0	0	0	100	150
	Cymbella affinis	0	0	0	25	0	50	25	25	0	125
	Cymbella lanceolate	0	0	0	0	0	0	25	0	0	25
	Diatoma hiemale	250	100	25	50	0	0	0	25	25	475
	Diatoma sp.	0	100	25	50	0	0	0	0	0	175
	Diatomella balfouriana	250	100	25	50	0	0	0	25	0	450
	Euphora sp.	200	125	25	50	0	0	0	25	50	475
	Eunotia naegelii	150	100	25	50	0	0	0	25	50	400
	Eunotia obliquestriata	200	50	25	50	0	125	50	25	25	550
	Eunotia sp.	250	100	25	50	250	250	200	25	50	1200
	Fragilaria construens	200	450	25	50	150	25	50	100	0	1050
	Fragilaria crotonensis	200	150	25	50	250	200	100	150	25	1150
	Gomphoenema sp.	0	0	0	0	0	0	0	50	25	75
	Guinardia delicatula	0	0	0	50	100	0	0	50	25	225
	Hantzschia amphioxys	0	100	25	50	0	0	0	0	0	175
	Humidophilia contenta	300	450	150	50	250	250	200	100	125	1875
	Hyalodiscus radiates	100	100	25	0	0	0	0	0	25	250
	Mastogloia elliptica	0	100	25	50	0	100	250	0	25	550
	Mastogloia sp.	0	100	25	50	0	100	250	0	25	550
	Melosira granulata	25	50	100	0	0	0	0	0	0	175
	Navicula capitatoradiata	125	100	25	50	0	25	0	0	0	325
	Navicula cinta	0	50	25	0	0	0	0	0	0	75
	Navicula cryptocephala	0	50	0	0	0	0	0	0	0	50
	Navicula cuspidata	0	50	0	50	0	0	0	0	0	100
	Navicula expansa	0	50	25	0	0	0	0	0	0	75
	Navicula lanceolate	25	50	0	0	0	0	0	0	0	75
	Navicula mutica	50	50	0	0	0	0	0	0	0	100
	Navicula rhynchocep	50	25	0	0	0	25	0	0	0	100
	Navicula viridula	250	50	100	0	0	25	0	0	0	425
	Nitzschia sp.	200	50	75	0	0	25	50	25	50	475
	Pinnularia borealis	0	50	25	0	0	0	0	0	0	75
	Pinnularia brunii	25	50	25	0	0	0	0	0	0	100
	Pinnularia gibba	25	0	0	0	0	0	0	0	0	25
	Pinnularia nobilis	0	50	25	0	0	0	0	0	0	75
	Pinnularia sp.	100	50	25	0	0	0	0	0	0	175
	Pinnularia viridis	0	50	25	0	0	0	0	0	0	75
	Pinnularia lata	25	50	25	0	0	0	0	0	0	100
	Pleurosigma sp.	100	50	0	25	0	0	25	0	50	250

	Suireria tenera	125	50	25	0	0	0	0	0	0	200
	Synedra faculata	500	50	100	50	100	25	100	50	25	1000
	Synedra fascicula	250	100	100	25	50	25	75	25	25	675
	Synedra ulna	150	50	100	100	50	25	25	75	50	625
	Tabellaria sp.	200	50	125	75	50	25	75	75	50	725
	Thalassiosira angustelineata	100	0	0	50	50	0	0	0	0	200
Charophyceae	*Chara* sp.	100	50	50	0	0	50	100	150	50	550
	Closterium costatum	250	100	0	100	50	250	100	50	50	950
	Closterium ehrenbergii	100	250	50	100	50	100	100	0	50	800
	Closterium gracile	300	200	0	50	0	0	100	50	50	750
	Closterium incurvum	100	100	50	0	50	100	50	100	25	575
	Closterium leiblenii	0	125	0	0	50	50	100	50	50	425
	Closterium lunula	0	0	0	0	50	0	0	50	50	150
	Closterium moniliferum	0	100	0	0	50	0	0	50	50	250
	Closterium parvulum	0	0	0	0	0	250	0	50	0	300
	Closterium rostatum	25	0	0	50	50	0	0	50	50	225
	Closterium sp.	250	100	0	100	50	250	100	50	50	950
	Cosmarium obtusatum	0	0	0	0	0	0	50	0	0	50
	Cosmarium quadrum	0	200	550	75	100	200	75	25	0	1225
	Cosmarium speciosum	0	0	0	50	0	250	300	25	0	625
	Desmidium coarctatum	0	0	0	0	0	0	0	25	0	25
	Hyalotheca undulate	0	0	100	50	100	50	25	25	0	350
	Micrasterias foliacea	25	150	100	350	200	100	50	50	0	1025
	Micrasterias moebii	100	0	250	50	0	0	50	25	0	475
	Pleurotaenium trabeculla	200	100	350	0	50	25	25	0	0	750
	Spirogyra borgeana	100	50	0	100	50	0	0	100	50	450
	Spirogyra californica	100	150	0	0	50	0	0	0	0	300
	Spirogyra fluviatilis	125	50	0	0	0	0	0	0	50	225
	Spirogyra sp.	200	125	100	0	50	0	0	0	0	475
	Staurastrum triangularis	0	100	50	0	0	0	25	50	0	225
	Staurodesmus convergens	100	150	50	0	0	0	0	50	0	350
Chlorophyceae	*Ankistrodesmus falcatus*	100	75	100	75	50	25	75	75	100	675
	Asterionella formosa	150	100	50	50	50	100	0	0	50	550
	Chlamydomonas sp.	50	150	200	50	0	0	25	0	0	475
	Chlorella sp.	200	0	50	0	0	0	150	0	0	400
	Chlorosarcina minor	100	50	50	0	0	0	0	0	0	200
	Coelastrum microsporum	50	100	250	0	0	0	50	50	0	500
	Coelastrum sphaericum	100	100	250	0	0	0	50	50	0	550
	Eudorina sp.	150	100	200	0	0	50	0	25	0	525
	Gonatozygon monotaenium	250	450	200	50	75	125	50	25	0	1225
	Hantzchia amphioxys	25	0	0	0	50	0	0	0	100	175
	Micrasterias sp.	25	0	0	0	0	0	0	0	0	25
	Microspora floccosa	125	100	25	75	0	0	25	75	100	525
	Oedogonium capillare	25	0	0	0	50	250	300	0	100	725
	Oedogonium sp.	750	500	300	0	50	300	250	100	400	2650
	Oocystis crassa	50	100	50	25	0	0	0	200	75	500
	Oocystis elliptica	100	100	0	25	0	0	0	50	100	375
	Pediastrum dupiex	0	0	0	100	0	0	0	50	100	250
	Rhizoclonium hieroglyphicum	100	100	0	25	75	100	200	250	300	1150
	Scenedesmus bijuga	25	125	175	75	100	25	50	100	50	725
	Scenedesmus quadricauda	100	25	100	75	50	125	200	25	0	700
	Sphaerocystis schroeteri	50	0	100	0	50	0	100	0	0	300
	Staurastrum leptocladium	150	300	200	0	50	75	0	0	0	775
	Staurastrum limneticum	50	200	0	0	50	0	0	0	0	300
	Staurastrum trifidum	200	150	100	50	75	50	25	50	0	700
	Tetraedron minimum	0	100	150	0	50	100	0	0	0	400
	Treubaria crassipina	150	250	150	125	50	100	50	25	0	900
	Ulothrix sp.	100	250	50	200	150	100	0	0	50	900
	Volvox aureus	200	100	50	150	50	100	0	25	50	725
	Volvox globulus	100	150	50	100	150	100	0	0	50	700
Cyanophyceae	*Anabaena circularis*	200	100	50	100	100	50	75	100	25	800
	Anabaena constricta	25	75	100	25	125	50	100	50	125	675
	Anabaena subcylindrica	750	250	100	100	50	200	250	100	75	1875
	Anabena circinalis	200	25	25	150	75	250	150	100	125	1100
	Anabaena sp.	100	75	150	125	75	150	200	250	100	1225
	Aphanocapsa delicatissima	125	75	100	125	75	75	200	100	100	975
	Chroococcus cohaerens	100	125	150	100	75	150	200	250	100	1250

	Gloeotrichia echinulata	0	100	150	0	0	0	50	25	0	325
	Lyngbya martensiana	100	50	25	0	0	0	0	0	0	175
	Microcystis aeruginosa	750	850	300	750	650	450	400	550	50	4750
	Microcystis flosaquae	850	950	550	650	750	750	575	750	100	5925
	Microcystis turgidis	1550	750	850	1050	750	850	650	550	750	7750
	Oocystis eremosphaeria	125	50	100	75	25	0	0	25	25	425
	Oocystis solitaria	100	50	75	75	25	0	50	25	75	475
	Oscillatoria aghardii	100	200	0	0	25	50	0	0	0	375
	Oscillatoria limnosa	150	50	125	0	0	25	25	0	0	375
	Oscillatoria sancta	50	0	100	0	0	0	0	0	0	150
	Oscillatoria tenuis	100	50	0	0	0	25	0	0	0	175
	Rivularia sp.	0	25	0	0	0	0	0	0	0	25
	Spirulina platensis	100	50	150	0	0	50	0	0	0	350
	Spirulina sp.	100	150	50	0	50	0	0	0	0	350
Dinophyceae	*Peridiniopsis thompsonii*	100	25	150	0	0	0	0	25	25	325
	Peridinium sp.	50	50	100	0	0	0	0	0	25	225
	Peridinium bipes	100	25	75	0	0	0	0	25	25	250
	Didinium bolbianii	25	75	50	0	25	0	0	25	25	225
	Oodinium limneticum	125	100	75	0	125	0	0	50	25	500
Euglenophyceae	*Euglena acus*	0	0	0	25	50	75	100	0	100	350
	Euglena caudata	100	75	150	0	0	0	0	0	50	375
	Euglena gracilis	50	75	0	0	0	0	0	0	50	175
	Euglena oxyuris	100	75	150	0	0	0	0	0	50	375
	Euglena viridis	100	50	0	0	0	0	0	0	0	150
	Lepocinclis ovum	0	50	0	0	0	0	0	0	0	50
	Phacus curvicauda	175	0	50	0	0	0	0	0	0	225
	Phacus longicauda	200	125	175	100	25	50	0	0	0	675
	Phacus orbicularis	150	175	200	75	50	50	25	0	0	725
	Phacus suecicus	175	0	50	0	0	0	0	0	0	225
	Trachelomonas ensifera	150	50	25	0	25	0	25	0	0	275
	Trachelomonas hisipida	125	50	25	0	0	0	0	0	0	200
	Trachelomonas horrida	50	75	25	0	0	0	0	0	0	150
	Trachelomonas lacustris	100	50	25	0	0	0	0	0	0	175
	Trachelomonas oblonga	0	50	0	0	0	0	0	0	0	50
	Trachelomonas similis	75	50	25	0	0	0	0	0	0	150
	Trachelomonas tambowica	100	50	125	0	25	0	0	0	0	300
Ochophycea	*Encyonema auerswaldii*	0	0	0	25	50	50	0	0	0	125
	Encyonema sp.	0	0	0	0	0	50	0	0	0	50
	Geissleria sp.	0	0	0	0	0	50	0	0	0	50
	Gyrosigma acuminatum	100	0	0	25	50	50	0	0	0	225
	Gyrosigma sp.	0	0	0	25	0	50	0	0	0	75
	Luticola sp.	0	0	0	0	0	50	0	0	0	50

The highest number of individuals for phytoplankton was recorded in the riverine zone (upper reach) of the reservoir in stations A (19075), B (15025) and C (11775) followed by the the transition zone in stations F (8675) and D (7975), while the location with the least number of individuals was stations I (5650) and H (6750) in the lacustrine region of the reservoir. In summary the riverine zone accounted for 50.77% of the total phytoplankton population, while the transition and lacustrine zone accounted for 26.81% and 22.41% respectively (Tables 2, 3 and 4). The highest Margalef (d) value (0.672) was recorded for Station E followed by Station A (0.609) while the lowest Margalef was recorded in Stations G, H and B with the values of 0.446, 0.454 and 0.520.The highest Shannon index values of 1.646, 1.593 and 1.577 were recorded in Stations C, A and B all in the riverine zone of the reservoir, while the lowest Shannon index was recorded Stations H, G and D in the lacustrine and transition zones of the reservoir. The Equitability shows that the highest values of 0.919 and 0.880 was recorded in Stations C and B; all in the riverine zone of the reservoir, while the lowest value of 0.774 was recorded in the transition zone of the reservoir.

Table 5 shows the relationship between the individual phytoplankton species in the reservoir. The highest Shannon index values of 4.39, 4.32 and 4.19 were recorded in Stations B, A and C all in the riverine zone of the reservoir, while the lowest Shannon index was recorded Stations D, E and G in the transition and lacustrine zones of the reservoir. This similar trend was also by the Simpson, Menhinick and Margalef, Fisher alpha and Berger-Parker indices. One-way analysis of variance between the zones indicated that there was a significant difference (F=11.41, df=2, p=0.0000146) in the spatial distribution of the organisms among the stations. A similar trend was also observed in the one-way analysis of variance between the zones with regards to species occurrence as there was a significant difference (F = 12.53, df = 2, p = 0.00000501) between the stations.

Table 2: Phytoplankton abundance among the sampled locations

Taxa	Stations									
	A	B	C	D	E	F	G	H	I	Total
Bacillariophyceae	5800	3925	2600	2050	2075	1675	1925	1550	1425	23025
Charophyceae	2075	2100	1700	1075	1000	1675	1250	1025	575	12475
Chlorophyceae	3475	3675	2850	1250	1225	1725	1600	1175	1625	18600
Cyanophyceae	5575	4050	3150	3325	2850	3125	2925	2875	1650	29525
Dinophyceae	400	275	450	0	150	0	0	125	125	1525
Euglenophyceae	1650	1000	1025	200	175	175	150	0	250	4625
Onchophyceae	100	0	0	75	100	300	0	0	0	575
Total	19075	15025	11775	7975	7575	8675	7850	6750	5650	90350

Table 3: Phytoplankton occurrence among the sampled locations

Taxa	Stations								
	A	B	C	D	E	F	G	H	I
Bacillariophyceae	34	41	35	30	17	22	18	22	24
Charophyceae	15	17	11	11	15	12	15	19	12
Chlorophyceae	27	23	22	16	18	16	15	16	14
Cyanophyceae	19	20	18	12	14	14	13	13	12
Dinophyceae	05	05	05	0	02	0	0	04	05
Euglenophyceae	14	14	12	03	05	03	03	0	04
Onchophyceae	01	0	0	03	02	06	0	0	0

Table 4: Diversity between the major divisions in the Stations (abundance)

Taxa	Station								
	A	B	C	D	E	F	G	H	I
	7	6	6	6	7	6	5	5	6
Individuals	19075	15025	11775	7975	7575	8675	7850	6750	5650
Dominance	0.231	0.225	0.209	0.283	0.261	0.246	0.266	0.288	0.244
Shannon index	1.593	1.577	1.646	1.411	1.506	1.519	1.405	1.366	1.520
Simpson index	0.769	0.775	0.791	0.717	0.739	0.755	0.734	0.712	0.756
Menhinick	0.051	0.049	0.055	0.067	0.080	0.064	0.056	0.061	0.080
Margalef	0.609	0.520	0.533	0.557	0.672	0.551	0.446	0.454	0.579
Equitability	0.819	0.880	0.919	0.787	0.774	0.848	0.873	0.849	0.848
Fisher alpha	0.684	0.592	0.608	0.636	0.760	0.630	0.520	0.529	0.663
Berger-Parker	0.304	0.270	0.268	0.417	0.376	0.360	0.373	0.426	0.292

Table 5: Diversity between individuals in the stations (abundance)

Taxa	Station								
	A	B	C	D	E	F	G	H	I
	115	120	103	75	73	73	64	74	71
Individuals	19075	15025	11775	7975	7575	8675	7850	6750	5650
Dominance	0.0213	0.0195	0.0223	0.043	0.0388	0.0334	0.031	0.038	0.037
Shannon indx	4.320	4.389	4.189	3.768	3.78	3.829	3.780	3.785	3.849
Simpson indx	0.9787	0.981	0.978	0.957	0.961	0.967	0.969	0.962	0.963
Menhinick	0.8327	0.979	0.949	0.840	0.838	0.784	0.722	0.901	0.945
Margalef	11.570	12.37	10.88	8.237	8.06	7.94	7.025	8.279	8.102
Equitability	0.9104	0.917	0.904	0.873	0.881	0.892	0.909	0.879	0.903
Fisher alpha	16.27	17.81	15.53	11.46	11.2	10.93	9.531	11.62	11.44
Berger-Parker	0.0813	0.063	0.072	0.132	0.099	0.098	0.083	0.111	0.133

4. Discussion

The different divisions of phytoplankton namely: Bacillariophyceae, Charophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Onchophyceae and Cyanophyceae identified in Asejire Reservoir were to an extent similar to assemblages of some previously identified species from different Nigerian aquatic environment [11, 36, 37, 38, 39, 40, 10, 41, 42, 43].

Phytoplankton of the Cyanophyceae (blue-green algae) group was found to be the most abundant phytoplankton group in the reservoir during the study period. This agrees with the observations of [44, 45] who worked in Awba Lake (Nigeria) and Lake George (Uganda). *Microcystis* spp. have been reported to dominate the phytoplankton group in Awba Lake in Nigeria according to [44] and an earlier study in Asejire Reservoir by Egborge [12], while *Anabeana* sp., a filamentous form of blue-green algae was reported to dominate phytoplankton in Lake Rudolf (Kenya) and Lake Albert [46]. Contributions to the group were mainly from *Microcystis*, *Anabaena*, *Aphanacapsa*, *Chroonococcus*, *Oscillatoria* and *Spirulina*. A similar observation made by [47] in a freshwater in Uyo.

The second dominant group was Bacillariophyta with 23,025 species and 51 taxa. Species numbers of Bacillariophytes were high in all the locations. *Eunotia*, *Synedra*, *Achnanthes*, *Asterionella*, *Flagillaria*, *Nitzichia and* Cyclotella were the dominant genus and were widely found in all the locations. [30] remarked that *Fragilaria* and *Nitzschia* species are known indicators of eutrophic lakes, while [48] stated that *Cyclotella* species are bioindicators of transient phase from oligotrophic to eutrophic conditions. [30] also obsered that *Asterionella* formosa is the characteristic species of mezotrophic lakes.

The third dominant group was Chlorophyceae taxa with 18625 individuals, but with the second most occurring species (29). The occurrence maybe due to high oxygen level and mixing as noted by [49, 50] who observed that diatoms green algae dominate the phytoplankton community of many tropical African lakes.

The occurrence of *Microcystis*, *Anabaena* and *Aphanocapsa* is a clear indication anthropogenic pollutants into the reservoir as observed by [39] in Awba Reservoir at the University of Ibadan. The anthropogenic activities could be as result of laundry wastewater, chemicals, agricultural run-off and wastes washed into the reservoir from communities around the upper reach the reservoir. [51] reported that reservoirs where domestic, agricultural and industrial pollution is accelerated, growth of blue-green algae results in noxious bloom of such form as *Microcystis* and *Anabaena*. A similar observation was made by Egborge [11] that *Anabaena and Microcystis* are indication of eutrophication following upwelling in Lake Kainji in Nigeria. The presence of *Oscillatoria* indicates the presence of high concentrations of organic matter and low oxygen content. However, these plant nutrients may been derived from fertilized farm lands at upper sections of the reservoir. This phenomena has also been reported by [52].

The Euglenphyceae taxa identified in the Asejire Reservoir were generally low (5.12%) compared to the Cyanophyceae (32.7%), Bacilliarophyceae (25.5%), Chlorophyceae (20.6%) and Charophyceae (13.8%). Euglenoids species can tolerate various levels of organically polluted waters and therefore can be used as indicators of organic pollution [30, 53, 54, 55]. Pollution indicator species like *Euglena*, *Phacus*, *Lepocinclis* and *Trachelomonas*, *Navicula*, *Melosira*, *Pinnularia*, *Synedra*, *Oscillatoria*, *Spirulina*, *Fragilaria and Nitzschia* were encountered during the study. The presence of these Euglonoid species encountered in some of locations this may indicate the presence of anthropogenic influence on the reservoir. Egborge [14] pointed out that the euglenoids are good indicators of polluted or meso and eutrophic freshwater bodies. Therefore, there is a possibility of algal bloom formation if there is excessive nutrients enrichment of the water by the presence of human habitations around the reservoir.

In Asejire Reservoir, most of the recorded phytoplankton species are cosmopolitan. One of the most used methods for the codification of trophic state of lake is phytoplankton indexes, though these indexes may not totally reliable due to the short period of water retention time in reservoir systems [56]. It is quite tasking to understand the trophic status of the lake using only species composition results, but [57, 55] stated that *Staurastrum*, *Closterium* and *Cosmarium* (*Charophyceae*), *Anabaena* and *Oscillatoria* (Cyanophycea) are found; *Peridinium* and *Ceratium* (Dinophyceae), *Cyclotella*, *Stephanodiscus* and *Asterionella* (Bacillariophyceae) are dominant in eutrophic and mesotrophic water. Based on these findings, Asejire Reservoir can be termed a productive eutrophic reservoir.

5. Conclusion

This study on phytoplankton of Asejire Reservoir is considered important and can be utilized as a basis for impact assessment, planning and implementation. Development of policies for monitoring and effective development of the reservoir should incorporate phytoplankton indices. The phytoplankton community structure to an extent have great impact on reservoir survival on the long run. Their presence provide suitable conditions for micro habitats and other grazers within the lake.

6. References

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