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Full Length Research Paper

Taxonomic Composition and Assessment of Phytoplankton Flora in Esa-Odo Reservoir, Osun State, Nigeria

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ABSTRACT: This study presents a compilation of phytoplankton species composition of Esa-Odo reservoir, Osun state, Southern Nigeria. Three sampling stations (Stations 1, 2 and 3) were established at the inflow of the reservoir, the mid basin portion, and the outflow very close to the dam site along the horizontal axis of the reservoir. Samples collection spanned a period of nine (9) months (February to October, 2017), covering both dry and rainy seasons. The phytoplankton samples collected were examined, recorded, measured, photographed and enumerated with a light compound microscope (Olympus599807) at the Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Osun State. The results showed that a total of one hundred and forty three (143) species of phytoplankton recorded belonged to sixty four (64) genera, forty (40) families, twenty-eight (28) Orders, ten (10) classes and seven (7) Divisions of Algae as summarized in (Table 1). Cyanobacteria were the phytoplankton group found in the highest percentage (48%) of occurrence in total phytoplankton population, while Ochrophyta had the lowest percentage (1%) occurrence. Bacillariophyta had the highest abundance of species and were the dominant genera across the upper, middle and lower basins of the reservoir.

Keywords: Taxonomic composition, phytoplankton, abundance and distribution

INTRODUCTION

Phytoplanktons are a flora of freely floating, microscopic organisms that drift with water currents. They comprise two very different kinds of organisms. The larger category include, single-celled algae known as protists and advanced eukaryotic cells, similar to protozoans. These forms include diatoms and are most abundant near coasts. Occasionally, these organisms form blooms rapid population explosions in response to changing seasons and the availability of nutrients such as nitrogen, iron, and phosphorus. The study of plankton (phytoplankton and zooplankton) is very important because they serve as a base upon which the aquatic ecosystem is supported (Dimowo, 2013). Many Scientists including Adedeji *et al.* (2018); Adedeji *et al.* (2015); Abohweyere, (1990); Adakole *et al.* (2008); Adeogun et al. (2005); Adejuwon and Adelakun, (2012); Adesalu and Nwankwo, (2008); Agbaire and Obi, (2009); Ajuonu *et al.* (2011); Atobatele and Ugwumba, (2008); Ayeni *et al.* (2011); Balarabe, (2001); Bwala et al. (2010); Chia *et al.* (2011); Chinedu *et al.* (2011); Davies and Ansa, (2010); Erondu and Chindah, (1991); Essien-Ibok et al. (2010); Ezekiel et al., (2011); Ezeribe et al., (2012); Fafioye et al. (2005); Ibrahim, (2009); Imoobe and Egborge, (1997); Ladipo et al., (2011); Mood, (2004); Muhibbu-din et al. (2011); Mustapha and Omotosho, (2005); Nkwoji et al. (2010); Offem et al. (2011); Ogbuagu and Ayoade, (2012); Onuoha and Vyverman, (2010); Onyema, (2007); Oso and Fagbuaro, (2008); Ovie, (1995); Ude et al. (2011); Dimowo, (2013); have worked on the various aspects of ecosystem studies of reservoirs, rivers, lakes, creeks and estuaries in Nigeria. However, not much work has been carried out on the taxonomic composition and assessment of phytoplankton flora in Esa-odo reservoir, Osun state, Nigeria. This study is therefore aimed at assessing the taxonomic composition, spatial occurrence and distribution of phytoplankton flora in Esa-odo reservoir.

METHODOLOGY

Study area

Esa-Odo reservoir is located in Obokun Local Government Area of Osun State. Esa-Odo lies within Latitude 7º45'0"N, 4º49'0" E and 7º47' 18"N, 4º50' 12"E on an elevation of ±458 m above sea level. The reservoir was impounded in 1971 from the River Osun by the old Oyo State (now Oyo and Osun States) and completed in 1977. The reservoir was impounded for the purpose of water storage to supply potable water to the riparian communities as well as the industries around. It is an earth fill and concrete dam, with a crest length of 677 m and an initial height of 11.3 m, a catchment area of 120 km^2. It had a surface area of 50.2 hectares initially, with current surface area at 27.5 hectares. The reservoir which had a capacity of 8.2 million cubic meters at impoundment (more than 5 times the original size of Obafemi Awolowo University's Opa reservoir) now appears like a big pond. The reservoir has over time undergone rapid siltation due to land use within its catchment basin and that of the R. Oni, which is one of the tributaries of river of River Osun.

Sampling sites

Three sampling stations (Stations 1, 2 and 3) were established along the horizontal axis of the Esa-Odo reservoir. Station 1 was located at the upstream or inflow basin of the reservoir, station 2 was located at the midstream portion of the reservoir, while station 3 was located at the dam site portion of the basin. The grid co-ordinates of each station were recorded using a Global Positioning System (GPS) handset while rubber floaters were used to indicate the permanent locations of the stations for subsequent recognition (Figures 1 and 2).

Sampling programme and field determinations

Field survey of the three sampling stations was conducted over the period of February 2017 to October 2017, covering both dry and rainy seasons. The stations were all sampled at the littoral regions (L1 and L2) and open water (S, M and B) except for Station 1 which was sampled only at the open water.

Construction of phytoplankton counting chamber

A glass slide (2.5 cm by 6 cm) was placed on a plain portion of old tyre inner tube and using a biro, a line was traced out on the edge of the slide on the tube, reflecting the rectangular shape of the slide. A razor blade was used to cut out the rectangle shape on the tyre inner tube. Maintaining a margin of at least 0.5 cm on each side of the rectangular shape that was cut out, a biro and a ruler was used to draw a smaller rectangle with the specification of 5 cm (length) by 2 cm (breadth) right in the middle of the rectangular tyre tube. The smaller rectangle drawn was cut out using a sharp razor blade to ensure the desired 5 cm by 2 cm was obtained. The tyre tube with regular hole was neatly glued to a glass slide and allowed to dry to prevent water leakage. Another slide was used to cover the slide containing the phytoplankton sample to be viewed under the microscope.

Phytoplankton collection and analysis

Net plankton (Quantitative Analysis) was sampled by pouring 30 litres of reservoir water sample through a plankton net of 50 µm mesh size and the plankton contained strained into 30 ml universal bottles and preserved with 5% formalin solution and Lugol's solution for examination and identification. Samples for total plankton (net and nano plankton) were prepared in the laboratory; this was done by taking 500 ml of water samples into an improvised total plankton flask and Lugol's solution added (1:100) after which the water sample was allowed to settle and sediment over a couple of days. Carefully, the sample was reduced to a concentrate volume of 30 ml by decanting the clear supernatant. The concentrate volume was poured into universal bottle and preserved with 5% formalin solution. The preserved plankton samples were examined in the laboratory both at scanning and low power using a light compound microscope. Measurements and photomicrographs as well as enumeration of the recorded planktons were carried out.

Calibration of counting chamber

The volume or holding capacity of the constructed counting chamber was determined by filling the counting chamber ten times with distilled water and pouring it into a measuring cylinder each time the chamber was filled.

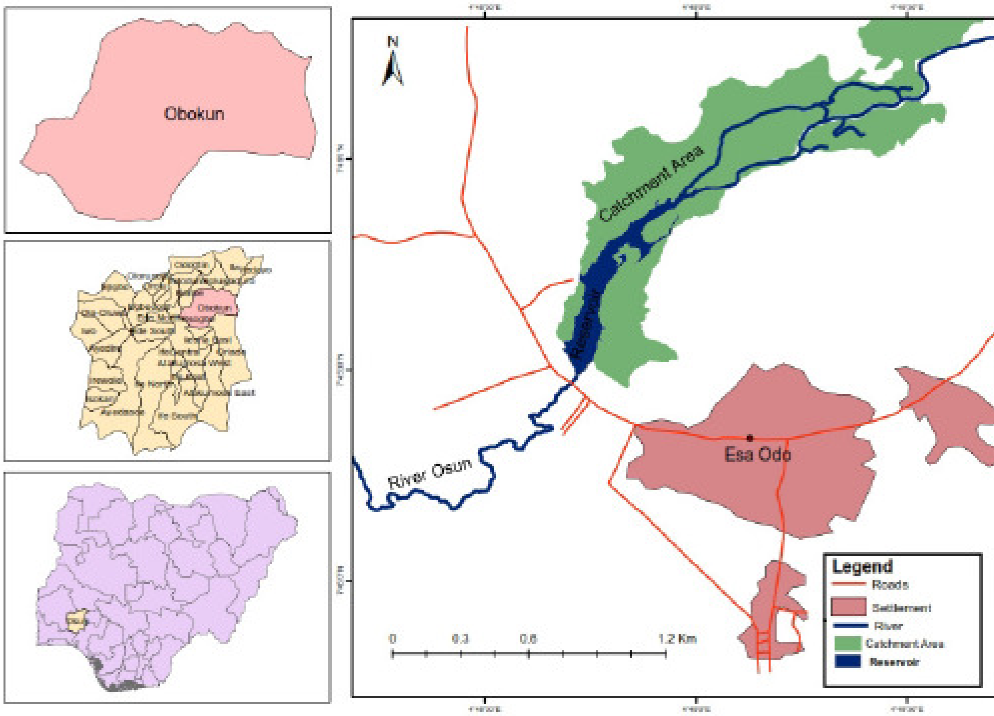

Figure 1: (a) Map of Nigeria showing Osun State, (b) map of Osun State showing obokun local government, (c) map of esa-odo reservoir. (Source: Author's Fieldwork).

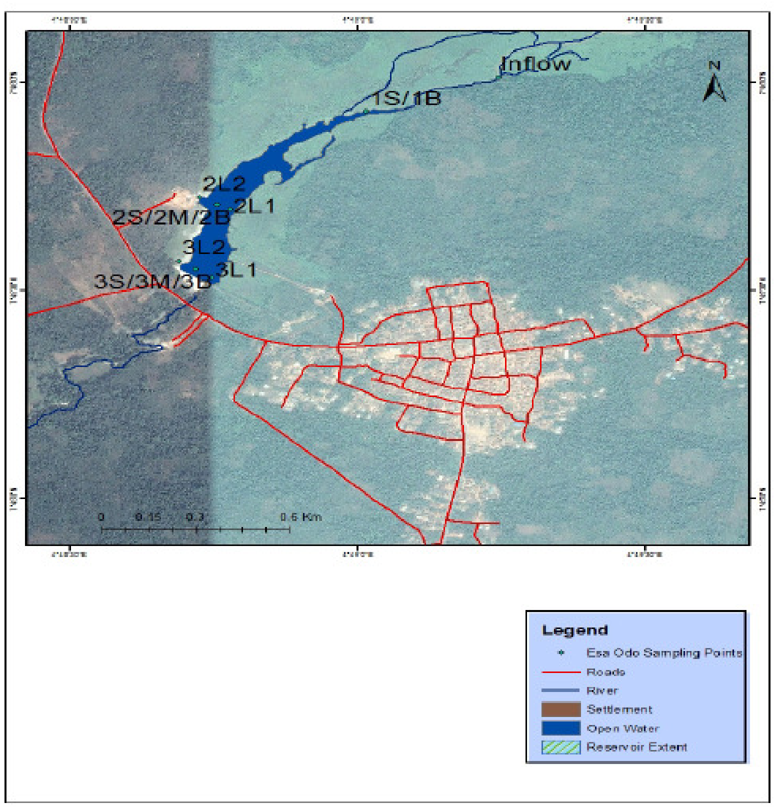

Figure 2: Map of study area showing sampling stations.

The measuring cylinder was observed to be 15ml full of water and this was divided by ten. The volume of the counting chamber was therefore estimated to be 1.5 ml capacity. Each sample was viewed and the phytoplankton obtained, added up to represent the content in the litres of original water sample collected, which was 30 litres. The total abundance was estimated using this equation:

$$A\ (Org/m^3) = \frac{ab \times 1000}{C}$$

Where A = Total abundance of organisms
a = Number of organisms counted per litre of sample volume
b = Sample volume used in chamber (3 ml)
c = Original volume of water strained (30 L) for net plankton and (0.5 L) for total plankton
The abundance was expressed as organism per cubic metre (Org/m^3).

Calibration of microscope

An ocular micrometre was placed in one of the two eyes of the microscope and a portion of a linear graph sheet was also placed on a slide and viewed under the scanning and low power of magnification of the light compound microscope (Olympus599807) for calibration. Under the scanning power (x 40), 1 mm (equal one graph sheet division) on the graph sheet was equivalent to 40 ocular divisions of the ocular micrometre. Therefore, 1 ocular division was equal to 25 µm. For each phytoplankton species viewed under scanning power, the specifications obtained were multiplied by 25 to get the actual size of the species in µm. Under the low power (x 100), 1 mm on the graph sheet was equivalent to 100 ocular divisions of the ocular micrometre. Therefore, 1 ocular division was equal to 10 µm. For each phytoplankton species viewed under low power, the specification obtained was multiplied by 10 to get the actual size of the species in µm. The number of fields of vision within the counting chamber was determined by placing a portion of the graph sheet on a slide and viewed under both scanning and low power of the microscope. Under the scanning power (x 40), the diameter of a field of vision was 4.5mm. Thus, the area of the field of vision was calculated using the formula $A = \pi r^2$ which was calculated to be 16mm^2.

Number of fields of vision in the = Area of the counting chamber ÷ Area of field of vision counting chamber = (50 X 20) mm ÷ 16mm^2 = 63 fields of vision
Under low power (x 100), the diameter of a field of vision was equal to 1.75mm and the area of field was calculated to be 2.40mm^2.

Number of fields of vision in the Area of the counting chamber ÷ Area of field of vision counting chamber = (50 X 20) mm ÷ 2.40mm^2 = 417 fields of vision

A compound microscope equipped with camera and tracing device (camera lucida attachment) used for producing photomicrographs was used to examine and identify the phytoplankton. Phase–contrast or interference (Normarski) microscopy improved the contrast for smaller specimens. Scanning and transmission electron microscopes (SEM, TEM) are essential tools requiring fine details for identifying very small phytoplankton.

Taxa identification

The taxonomic composition of phytoplankton flora was determined using identification keys by Hilary and Erica (1978), Jansevan Vuuren *et al* (2006), Bellinger and Sigee, (2010), Opute and Kadiri, (2013).

Statistical Analysis

The data obtained were analysed using the descriptive statistics, correlation and regression analysis and cluster analysis.

RESULTS

Taxonomic composition and outline classification of recorded phytoplankton

From the investigated sampling stations, a total of one hundred and forty-three (143) species of phytoplankton were recorded belonging to sixty-four (64) genera, forty (40) families, twenty-eight (28) orders, ten (10) classes and seven (7) Divisions of Algae as summarized in (Table 1).

Description/ diagnosis of species

The species described have been photographed, and the photomicrographs are shown within the text. The following abbreviations have been used; L= length of cell; W= maximum width of cell. All dimensions are given in micrometer (µm)

***Cyclotella comma* (Plate 1a):** Cells are short and drum-shaped; valves usually are circular with a diameter ranging 3.1 - 3.4 ɥm with differential ornamentation between central and marginal area. The central area is flat to tangentially undulate; while single rimoportula is positioned on a costal.

Table 1: Outline classification and taxa composition of the phytoplankton flora.

Division	Class	Order	Family	Genus	Species
Bacillariophyta (Diatoms)	3	14	22	33	64
Charophyta (Stoneworts/ Brittleworts)	1	2	4	11	40
Chlorophyta (Green Algae)	1	3	7	8	10
Cyanophyta (Blue-green Algae)	1	5	6	6	12
Ochrophyta(Yellow-green Algae)	2	2	2	2	2
Chrysophyta (Golden-Brown Algae)	1	1	1	1	1
Euglenophyta (Euglenoids)	1	1	2	3	14
Total	10	28	44	64	143

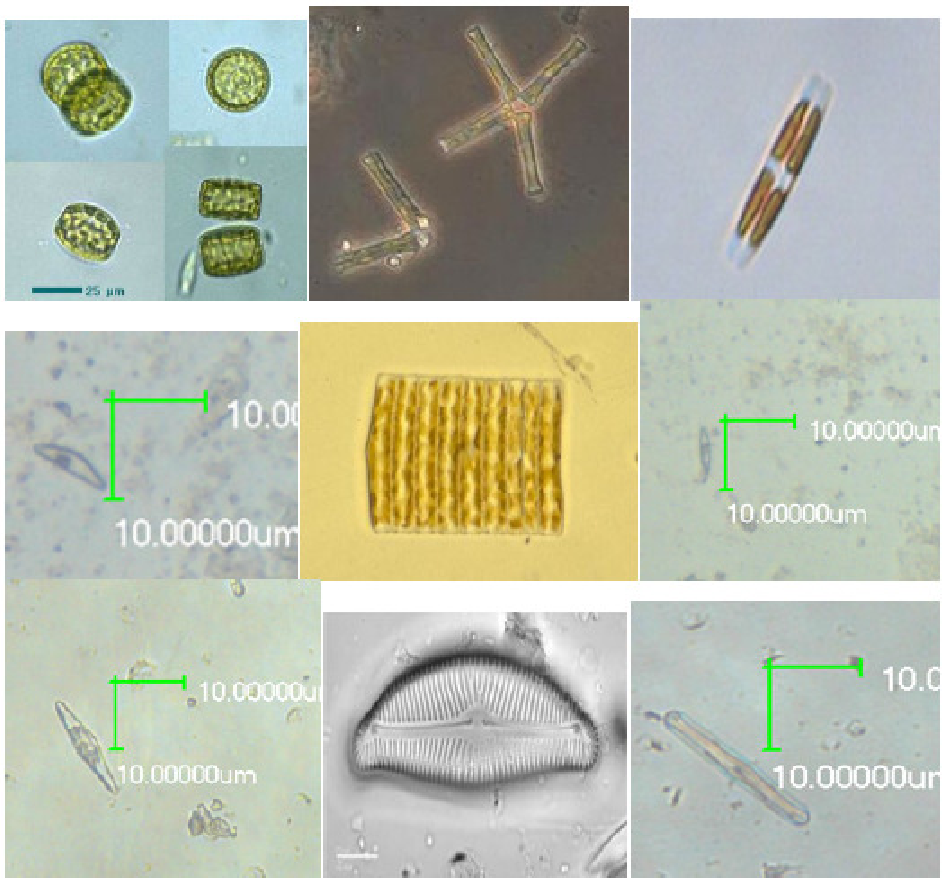

Plate 1: Identified Phytoplankton species I: (a) *Cyclotella comma* (b) *Asterionella gracillima* (c) *Bacillaria sp* (d*) Cymbella lanceolata* (e) *Diatoma hiemale* (f)*Pinnularia microstaura* (g) *Brachysira styriaca* (h) *Encyonema auerswaldii* (i) *Rhopalodia gibba.*

***Asterionella gracillima* (Plate 1b):** L: 60-85 µm; W: 2-4 µm. Valve linear-lanceolate with capitate apices; Spines present on valve margin; central sternum very narrow and may not be distinguishable; striae uniserate and irregularly spaced while cells are linked by mucilage pads forming characteristic stellate colonies and single rimoportula at headpole and/or footpole.

***Bacillaria* sp (Plate 1c):** L.68-102 µm; W.5.5-6.5 µm. Cells are elongated and motile, sliding along each other in stacked colonies, raphe fibulate, central; striae are distinct and relatively coarse. Living cells form colonies and were joined by silica hooks near the keel; these silica hooks allowed the cells to slide past one another in coordinated movements.

***Cymbella lanceolata (*Plate 1d):** L: 60-220µm; W: 18-32µm. Cells show slight to pronounced dorsiventrallity, with ends rounded to sub-capitate. Raphe central or slightly ventral, curved or slightly sinuous. 6-9 stigmata on ventral side of the central area; Striae pores clearly lineate; Single chloroplast with several lobes projecting from a central axis.

***Diatoma hiemale* (Plate 1e):** L: 25-80µm; W: 7-13µm. Valves linear to lanceolate, with apices rounded to narrowly rounded. Costae distinct mostly extend across the entire width of the valve. Striae indistinct; central sternum distinct, more or less straight.

***Pinnularia microstauron* (Plate 1f):** L: 28-81 µm; W: 7.2-12.2 µm. Valves linear with parallel or slightly convex sides.apices are rostrate (much narrower than valves). Central area is a rhombus; slightly curved raphe lateral. Striae strongly radiate near valve center, becoming strongly convergent near apices.

***Brachysira styriaca* (Plate 1g):** L: 16-37 µm; W: 4.9-7.1 µm. Valves lanceolate with rounded, unprotracted apices, axial area narrow. Central area elliptical apically elongated, with a middle constriction in larger valves. Proximal raphe ends weakly expanded and close in small valves. Striae radiate. Areolae transapically elliptic near axial area and bacilliform towards valve margins. Areolae irregularly spaced, creating a pattern of undulating longitudinal lines.

***Encyonema auerswaldii* (Plate 1h**): L: 23-33 µm; W: 20µm. Valvesstrongly arched dorsally and slightly tumid ventrally, with rounded ends. Dorsal striae parallel near the center, becoming radiate near the ends. Ventral striae are slightly radiate. The axial area is slightly lanceolate; raphe broad and lateral. Proximal raphe ends dorsally deflected, while the distal raphe ends ventrally deflected. Living cells form mucilage tubes, they live as colonies inside the tubes.

***Rhopalodia gibba* (Plate 1i): L**: 75-205µm.**W**: 8-11µm. Valves linear and usually seen in girdle view, raphe positioned in a canal along dorsal margin, and proximal raphe ends and helictoglossae not evident. Costae prominent and extend across the valve face. 2 and 3 rows of punctate striae. Costae number 5-8 in 10 µ.

Abundance and distribution

The abundance of major phytoplankton groups in the reservoir are presented in (Tables 5a to 5d). In February, 2017, Station 1S has the lowest abundance of Bacillariophyta (900 Org/m^3), and Chlorophyta (2513 Org/m^3) Chrysophyta (1979 Org/m$^{3)}$, Cyanobacteria (2244 Org/m^3), Euglenophyta (2378 Org/m^3) Charophyta (3050 Org/m^3) had the highest abundance of species. The highest mean abundance (638Org/m^3) was recorded for Charophyta while the lowest mean abundance 240Org/m^3 was recorded for Bacillariophyta. In April, 2017, Station 2L1 has the highest abundance of Charophyta (1800 Org/m^3), Chlorophyta (1138Org/m^3),Chrysophyta (1469Org/m^3),Cyanobacteria (1303Org/m^3) Euglenophyta (1386 Org/m^3) Charophyta (1800 Org/m^3)having the highest abundance of species. The table also revealed that the highest mean abundance 423Org/m^3 was recorded for Charophyta while the lowest mean abundance 217Org/m^3 was recorded for Bacillariophyta which followed the same trend with the result obtained in Feburary. During July, 2017, Station 3S has the highest abundance of Bacillariophyta (2675 Org/m^3) Charophyta (375Org/m^3) Chlorophyta (950Org/m^3) Chrysophyta (1238Org/m^3) Cyanobacteria (1094 Org/m^3) Euglenophyta (1166, Org/m^3) Chrysophyta (1238 Org/m^3) was found to be the most abundant species. During this period the table revealed that there was no record of any of the observed phytoplankton at 2L1, 2L2, 3L1 and 3L2 respectively. The highest mean abundance 599Org/m^3 was recorded for Bacillariophyta while the lowest mean abundance 130Org/m^3 was recorded for Charophyta. During October, 2017 which was the last sampling month, Station S1 was also recorded as the month that has the highest abundance of Bacillariophyta (1175Org/m^3) Charophyta (875Org/m^3) Chlorophyta (1025Org/m^3) Chrysophyta (988Org/m^3) Cyanobacteria (969Org/m^3) Euglenophyta (978Org/m^3) Bacillariophyta (1175Org/m^3) had the highest abundance of species. During this period the table revealed that there was no record of any of the observed phytoplanktons at 2L1, 2L2, 3L1 and 3L2 respectively. The highest mean abundance 276 Org/m^3 was recorded for Bacillariophyta while the lowest mean abundance 146Org/m^3 was recorded for Charophyta, result for this month followed similar trend with the result of July, 2017.

General abundance of phytoplanktons structure of Esa-Odo reservoir from February to October 2011

The result of the general phytoplankton of water is presented in the (Table 2). The recorded values of Bacillariophyta and Charophyta of Esa-Odo Reservoir during the study period were in the range of 0.0 to 4700 Org/m^3 and 0.0 to 4400 Org/m^3 with overall Mean ± S.E.M of 289.0± 9.8Org/m^{3}and 253.8± 11.1Org/m^3, median value of 25 Org/m^3 and 26 Org/m^3. In (Table 4), the minimum and maximum values of Chlorophyta and Chrysophyta were recorded 0.0 – 4900 Org/m^3 and 0.0 and 0.0 - 5900 Org/m^3. It was found with an overall mean ± S.E values (158.0± 10.0 Org/m^3 and 151.0 ± 11.5 Org/m^3) (Table 4). The values of sample Cyanobacteria, Euglenophyta and Ochrophyta during the period of study were in the range of 0.0 Org/m^3 to 11800 Org/m^3, 0.0 Org/m^3 to 650 Org/m^3, and 0.0 Org/m^3 to 1600 Org/m^3 with an overall mean ±S.E of 429.0 ±24.4 Org/m^3, 13.0±1.30 Org/m^3 and 32.4±3.10 Org/m^3 (Table 2).

Spatial (Horizontal) and seasonal variation in the mean abundance of net phytoplankton (Org/m^3)

The horizontal pattern of variation showed an increase in

Table 2: Descriptive statistics of the general phytoplankton abundance (Org/m^3) of Esa-Odo Reservoir from February to October, 2017.

Taxonomic groups	N	Min	Max	Median	Mean	Std. error	Std. Deviation	Skewness	Kurtosis
Bacillariophyta	52	0.0	4700	25	289	9	71.2	5.0	2.9
Charophyta	52	0.0	4400	26	253	11	80.5	4.4	1.9
Chlorophyta	52	0.0	4900	0	158	10	71.0	6.4	4.2
Chrysophyta	52	0.0	5900	118.5	151	11	83.4	6.7	4.6
Cyanobacteria	52	0.0	11800	79.2	429	24	17.2	6.1	4.0
Euglenophyta	52	0.0	650	1.8	13	1	9.1	7.1	5.0
Ochrophyta	52	0.0	1600	6.9	32	3	2.2	7.1	5.0

Table 3a: ANOVA statistics of horizontal variation in the abundance (Org/m^3) of Net phytoplankton of Esa-Odo, February to October, 2017.

Taxonomic group	Upper		Middle		Lower		Anova	
	Min-Max	Mean±Sem	Min-Max	Mean±Sem	Min-Max	Mean±Sem	F	P
Bacillariophyta	0-1550	290.0±76.2	0-1050	177.5±26.7	0-4700	400±23.5	0.477	0.623
Charophyta	0-950	133.3±44.2	0-4400	290.0±21.9	0-3700	290±19.0	0.169	0.845
Chlorophyta	0-11800.	459.0±48.5	0-1250	110.5±26.4	0-400	37.5±12.1	1.336	0.273
Chrysophyta	0-650	541.6±25.6	0-1250	65.0±3.05	0-50	25.5±2.5	1.790	0.178
Cyanobacteria	50-4900	1381.8±59.0	0-2500	218.4±13.4	0-1000	105±5.4	2.273	0.114
Euglenophyta	0-0	59.0±1.52	0-0	0.0±0.0	0-0	0±0	1.833	0.171
Ochrophyta	0-5900	0.0±0.0	0-1600	80.0±12.0	0-50	25.5±2.5	0.737	0.484

Table 3b: ANOVA statistics of seasonal variation in the abundance (Org/m^3) of Net phytoplankton of Esa-Odo, February to October, 2017.

	Dry season		Rainy Season		Anova		Overall	
Taxonomic group	Min-Max	Mean±Sem	Min-Max	Mean±Sem	F	P	Min- Max	Mean±Sem
Bacillariophyta	0-1000	138.4±15.0	0-4700	439.6±18.8	2.385	0.129	0-4700	289.0±9.8
Charophyta	0-4400	361.5±21.4	0-1300	146.1±6.36	0.928	0.340	0-4400	253.8±11.7
Chlorophyta	0-4900	280.7±21.5	0-400	25±1.7	1.639	0.207	0-4900	158±10.0
Chrysophyta	0-5900	300±23.0	0-50	1.9±1.92	1.679	0.201	0-5900	150.9±11.5
Cyanobacteria	0-11800	813.4±46.1	0-50	12.5±4.5	2.773	0.102	0-1180	429±24.4
Euglenophyta	0-0	0±0	0-650	25±2.5	0.922	0.342	0-650	13±0.5
Ochrophyta	0-1600	64±6.4	0-50	1.92±1.92	0.978	0.327	0-1600	32.3±3.1

the mean abundance of Cyanobacteria and Chlorophyta at the upper basin with 1381.8±59.0 and 459.0±48.5Org/m^3, whereas Euglenophyta showed a decreased trend from the upper basin towards the lower basin. At the lower basin, Bacillariophyta was found with highest abundance of net phytoplankton with mean (400±23.5Org/m^3). Bacillariophyta, Charophyta and Cyanobacteria had the highest mean value of177.5±26.7, 290.0±21.9 and 218.4±13.4Org/m respectively at the middle basin of the reservoir as shown in (Table 3a). There was no significant difference (p>0.05) in all the net phytoplankton across the horizontal variation of the reservoir.

Spatial (Horizontal) and seasonal variation in the mean abundance of total phytoplankton (Org/m^3)

The horizontal pattern of variation showed an increase in the mean abundance of Bacillariophyta, Charophyta, Euglenophyta and Chrysophyta at the upper basin with the mean values (641.6±26.4Org/m^3), (583.3±19.9Org/m^3), (325±14.4Org/m^3) and (191.6±8.27Org/m^3) respectively, whereas Ochrophyta showed a decrease from the upper basin towards the lower basin. At the lower basin, Bacillariophyta had the highest abundance of162.5±6.72Org/m^3 of net phytoplankton. Charophyta, Bacillariophyta and Euglenophyta were observed with the highest mean value of715±23.4, 435±8.68 and 125±5.74Org/m^3 respectively at the middle basin of the reservoir as shown in (Table 4a). There was no significant difference (p>0.05) in the total phytoplankton variation across horizontal plane (upper, middle and lower basin) of the reservoir. Seasonal variation analysis of total plankton's abundance is showed in (Table 4a) which revealed that Charophyta had the minimum and maximum abundance with 0-3450Org/m^3 during dry season also found with an overall mean of 517.3±10.9Org/m^3 throughout the period of study. During the rainy period, Bacillariophyta and Charophyta were recorded to have the highest Mean±S.E (436.5±13.5 and 253.8±51.17Org/m^3). Irrespective of observed total phytoplankton, the result revealed that there was no significant seasonal difference (p<0.05) between abundance of taxa during the dry and rainy season (Table 4b).

Table 4a: ANOVA statistics of horizontal variation in the abundance Org/m3 of Total phytoplankton of Esa-Odo, February to October, 2017
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Taxonomic group (Org/m³)	Upper		Middle		Lower		Anova	
	Min-Max	Mean±Sem	Min-Max	Mean±Sem	Min-Max	Mean±Sem	F	P
Bacillariophyta	0-2700	641.6±26.4	0-1200	435±8.68	0-1250	162.5±6.72	3.234	0.048*
Charophyta	0-1750	583.3±19.9	0-3450	715±23.4	0-1300	280±10.2	1.597	0.213
Chlorophyta	0-50	4.1±0.4	0-100	10±0.68	0-850	92.5±5.81	1.660	0.201
Chrysophyta	0-650	191.6±8.27	0-450	75±3.0	0-100	22.5±0.92	4.139	0.022*
Cyanophyta	0-700	145.8±7.57	0-400	62.5±2.68	0-250	40±1.68	1.884	0.163
Euglenophyta	0-1200	325±14.4	0-850	125±5.74	0-750	115±5.0	1.929	0.156
Ochrophyta	0-0	0.0±0.0	0-0	0.0±0.0	0-1000	120±6.79	2.478	0.094

P <0.05 significant difference

Table 4 b: ANOVA statistics of seasonal variation in the abundance (Org/m³) of total phytoplankton of Esa-Odo, February to Oct . 2017

	Dry season		Rainy Season		Anova		Overall	
Taxonomic group	MinMax	Mean±Sem	Min-Max	Mean±Sem	F	P	Min-Max	Mean±Sem
Bacillariophyta	0-1200	319.2±7.43	0-2700	436.5±13.5	2.385	0.129	0-2700	377.8±7.68
Charophyta	0-3450	780.7±19.1	0-1750	253.8±51.17	0.928	0.34	0-3450	517.3±10.9
Chlorophyta	0-850	73.0±4.51	0-100	7.6±0.45	1.639	0.207	0-850	40.3±2.29
Chrysophyta	0-650	157.6±4.27	0-50	5.7±8.17	1.679	0.201	0-650	81.7±2.37
Cyanophyta	0-700	130.7±7.30	0-100	15.3±7.30	2.773	0.102	0-700	73.0±2.51
Euglenophyta	0-1200	334.6±16.7	0-0	0.0±0.0	0.922	0.342	0-1200	167.3±4.48
Ochrophyta	0-1000	92.3±4.61	0-0	0.0±0.0	0.978	0.327	0-1000	46.15±2.69

Table 5a: Abundance of major net phytoplankton Taxa in Esa-Odo Reservoir in February, 2017 (Org/m³).

Station	Bacillariophyta	Charophyta	Chlorophyta	Chrysophyta	Cyanobacteria	Euglenophyta	Ochrophyta	Total	Mean abundance	S.E
S1	0	0	0	0	0	0	0	0	0	0.0
1S	900	3050	1975	2513	2244	2378	2311	15370	3842	1660.8
1B	175	650	413	531	472	502	487	3229	807	349.2
2S	375	925	650	788	719	753	736	4945	1236	532.7
2M	0	0	0	0	0	0	0	0	0	0.0
2B	175	150	163	156	159	158	159	1120	280	120.0
3S	0	75	38	56	47	52	49	316	79	34.7
3M	150	150	150	150	150	150	150	1050	262	112.5
3B	350	0	175	88	131	109	120	973	243	110.0
2L1	250	1750	1000	1375	1188	1281	1234	8078	2019	878.5
2L2	600	850	725	788	756	772	764	5255	1313	563.6
3L1	100	50	75	63	69	66	67	489	122	52.6
3L2	50	650	350	500	425	463	444	2881	720	314.5
Mean Abundance	240	638	439	539	489	51	501			
S.E	73.4	247.3	154.4	200.4	177.2	188.7	182.9			

DISCUSSION

A total of one hundred and forty-three (143) species of phytoplankton belonging to sixty-four (64) Genera, forty (40) Families, twenty-eight (28) Orders, ten (10) Classes and seven (7) Divisions of Algae were recorded. Most of the phytoplankton species recorded in this study) are common to many African freshwaters and have been documented to occur most especially in Nigerian reservoirs (Atobatele, 2013; Offem *et al.,* 2011; Edward and Ugwumba, 2010). The high diversity of desmids in Esa-Odo reservoir may be an indication that the water body is nutrient poor (Ganai *et al.,* 2010), since desmids are hardly or not to be expected in polluted waters and could also be traced to diluted freshwater influenced largely by high rainfall regime (Kabir, 1992). Cynaobacteria was found with the highest percentage (48 %) composition while Ochrophyta was found with the lowest percentage (1%) which was similar to the result of net phytoplankton. This composition is typical of waters contained in some of the reservoirs found in Nigeria (Akin-oriola, 2003). The composition is similar to the

Table 5b: Abundance of major net phytoplankton taxa in Esa-Odo Reservoir in April, 2017 (Org/m^3).

Station	Bacillariophyta	Charophyta	Chlorophyta	Chrysophyta	Cyanobacteria	Euglenophyta	Ochrophyta	Total	Mean Abundance	S.E
S1	0	0	0	0	0	0	0	0	0	0.0
1S	425	600	513	556	534	545	540	3713	2385	1855.0
1B	250	725	488	606	547	577	562	3754	873	339.9
2S	375	300	338	319	328	323	326	2309	906	576.9
2M	0	0	0	0	0	0	0	0	0	0.0
2B	400	275	338	306	322	314	318	2273	424	100.2
3S	75	0	38	19	28	23	26	209	65	36.6
3M	0	150	75	113	94	103	98	633	210	120.9
3B	0	0	0	0	0	0	0	0	121	121.6
2L1	475	1800	1138	1469	1303	1386	1345	8915	2124	860.9
2L2	600	950	775	863	819	841	830	5677	1366	556.6
3L1	75	50	63	56	59	58	59	420	113	53.7
3L2	150	650	400	525	463	494	478	3159	755	307.8
Mean Abundance	217	423	320	371	345	358	352			
S.E	59.3	145.8	96.8	120.6	108.5	114.5	111.5			

Table 5c: Abundance of major net phytoplankton Taxa in Esa-Odo Reservoir in July, 2017 (Org/m^3).

Station	Bacillariophyta	Charophyta	Chlorophyta	Chrysophyta	Cyanobacteria	Euglenophyta	Ochrophyta	Total	Mean Abundance	S.E
S1	2125	25	1075	550	813	681	747	6016	859	243.3
1S	65	25	45	35	40	38	39	286	41	4.6
1B	250	25	138	81	109	95	102	801	114	26.1
2S	850	325	588	456	522	489	505	3735	533	60.9
2M	250	50	150	100	125	113	119	906	129	23.2
2B	275	125	200	163	181	172	177	1292	184	17.4
3S	2675	375	1525	950	1238	1094	1166	9022	1289	266.5
3M	100	50	75	63	69	66	67	489	70	5.8
3B	1200	700	950	825	888	856	872	6291	898	57.9
2L1	0	0	0	0	0	0	0	0	0	0.0
2L2	0	0	0	0	0	0	0	0	0	0.0
3L1	0	0	0	0	0	0	0	0	0	0.0
3L2	0	0	0	0	0	0	0	0	0	0.0
Mean Abundance	599	130	365	247	306	277	291			
S.E	245.2	58.6	140.6	92.8	116.0	104.1	110.0			

Table 5d: Abundance of major net phytoplankton Taxa in Esa-Odo Reservoir in October, 2017 (Org/m^3).

	Bacillariophyta	Charophyta	Chlorophyta	Chrysophyta	Cyanobacteria	Euglenophyta	Ochrophyta	Total	Mean Abundance	S.E
S1	1175	875	1025	950	988	969	978	6959	944	34.8
1S	75	50	63	56	59	58	59	420	60	2.9
1B	150	0	75	38	56	47	52	417	59	17.4
2S	925	350	638	494	566	530	548	4049	578	66.6
2M	375	225	300	263	281	272	277	1992	284	17.4
2B	200	125	163	144	153	148	151	1084	154	8.7
3S	200	75	138	106	122	114	118	873	124	14.5
3M	200	25	113	69	91	80	85	662	94	20.3
3B	300	175	238	206	222	214	218	1573	224	14.5
2L1	0	0	0	0	0	0	0	0	0	0.0
2L2	0	0	0	0	0	0	0	0	0	0.0
3L1	0	0	0	0	0	0	0	0	0	0.0
3L2	0	0	0	0	0	0	0	0	0	0.0
Mean Abundance	276	146	211	17	195	187	191			
S.E	101.8	67.8	83.6	75.2	79.4	77.3	78.3			

findings of Abdullahi (1997), Abubakar (2007) and Abubakar et al. (2012). The Cynaobacteria is one of the most diverse and widely occurring groups of phytoplankton. The phytoplankton was sensitive to pollution as indicated by their fluctuation in relation to pollution level and water quality.

Conclusion

In conclusion, the phytoplankton flora and primary productivity of Esa-Odo reservoir were studied over the period of February, 2017 to October, 2017 covering both the dry and rainy seasons of the annual cycle. Hence, it can be concluded that most of the phytoplankton species recorded in this study (which include *Cyclotella comma*, *Asterionella gracillima,Cymbella lanceolata,Pinnularia microstaura* Rhopalodia *gibba, Eunotia naegelii, Eunotia obliquestriata,* Eunotia*sp, Flagilariacrotonensis,* Flagilaria *sp, Geissleria sp, Gyrosigma acuminatum,*and Amphora *bicapitata*) are common to many African freshwaters. However, Cynaobacteria was the phytoplankton group found with the highest percentage for the total phytoplanktons observed while Ochrophyta had the lowest.

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