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Phytoplankton Response to Anthropogenic and Recreational Activities in The Watershed of a Resort Centre in Edo State, Southern Nigeria

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ABSTRACT

The aesthetic value of a water body is affected by anthropogenic activities which lead to increased nutrients and ultimately, changes in the physico-chemical properties of the water. This study assessed the influence of anthropogenic and recreational activities on the phytoplankton species of River Ule in Owan West Local Government Area of Edo State, from November 2015 to June 2016. Samples of phytoplankton species and physico-chemical parameters were collected at two stations using a 55 µm mesh phytoplankton net and 1 litre plastic container for physico-chemical parameters. Palmer pollution index was employed in the assessment of the level of pollution of the water body. The results from this investigation showed that nutrient concentrations in this study were low with no discernible trend across seasons. There was no significant difference in the physico-chemical parameters in both stations. A total of 54 individual phytoplankton species comprising 2 classes; Bacillariophyceae and Chlorophyceae were recorded with Bacillariophyceae being the most dominant. Lack of organic pollution was also observed in the study. In conclusion, the anthropogenic and recreational activities in the watershed of the study stations did not affect the aesthetic value of Olomo beach and had no stress on the phytoplankton composition. More so, the level of productivity in this investigation is low as a result of lack of abundant nutrient and low phytoplankton abundance in the catchment area. Hence, may not be suitable for fish production.

Keywords: Phytoplankton, aesthetic, physico-chemical, anthropogenic.

Introduction

Recreation is an activity of leisure for pleasure, enjoyment or amusement for the purpose of refreshing the mind and body after work.[1] Recreation which is an important part of human life is of different types depending on the interest of an individual.[2] Recreational activities can be solitary or communal, passive or active, indoors or outdoors, harmful or healthy and useful or detrimental. They include reading, watching movies, sports, listening and playing music, swimming, fishing, cycling, running and travelling. However, some recreational activities like gambling and recreational drug use go against the law while most outdoor recreational activities have been found to be physically and socially rewarding.[3] Arising from the several health benefits of physical recreational activities which include reduction in risk of osteoporosis, cancer and obesity,[4] many recreational centres organized by public institutions, agencies and private groups also preserve the ecological and historical integrity of such centres while also making money in the process. Good examples of this are national parks, monuments and resorts.

It is however interesting to note that in the course of carrying out most outdoor physical recreational activities which involve contact with the water like swimming, canoeing, sport fishing, etc, the phytoplankton, which are the small free-floating plants that drift in water[5] are affected (i.e. in recreational centres where there is a water body). Apart from the direct effect of man's activities on these organisms in water, products of some recreational activities in the surrounding watershed in the resort or park like refuse disposal, litters and food left overs find their way into the water body (if there is any) within the centre. Dissolved nutrients (nitrate and phosphate) in these materials are absorbed by these plant organisms in the water, which increase in number and eventually turn the water body into a nuisance which is capable of repelling tourists.

Phytoplankton are in abundance in aquatic environments like lakes, rivers and streams and are important primary producers.[6] Their growth in the water body is a reflection of the quality of water. Excessive growth of these algae can affect the aesthetic value of the water as well as the health of the user. Outside the possibility of organic pollution in a recreational water body, physical pollution can also affect the phytoplankton. When pollutants like litters find their way into the water by wind or through careless water users who turn the water into a refuse dump or soil particles resulting from turbulence in the course of swimming, there is tendency for light penetration to be reduced if not cut off. This affects the photosynthetic activities of the phytoplankton species.

The effects of several anthropogenic activities like washing of clothes and cars, farming and commercial activities on phytoplankton algae have been documented by several authors. These include the investigations of Anyinkeng *et al.*[6] on water bodies exposed to anthropogenic pressures in Cameroun; Wassie and Melese[7] on Selemeko reservoir Ethiopia; Elenwo and Akankali[8] on marine pollution on Nigeria coastal resources; Ikpeme *et al.*[9] on Njaba River, Imo State, Nigeria and Adeyemi *et al.*[10] on Osere stream, Illorin, Nigeria.

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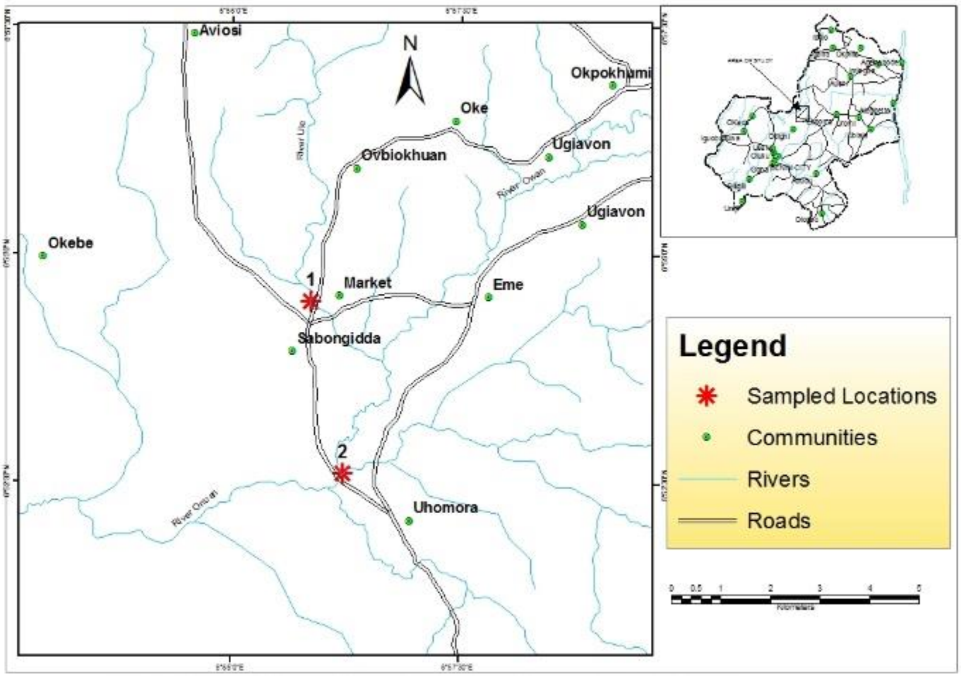

Figure 1: Map of River Ule showing the sampled stations.

The aim of this investigation was to:
(i.) ascertain the impact of recreational and anthropogenic activities on the phytoplankton species of a resort centre in Owan West Local Government Area in Edo State, Southern Nigeria.
(ii.) determine the pollution status of the river arising from the anthropogenic and recreational activities.
(iii.) determine the level of productivity of the water body and
(iv) give ecological information on the community structure of the phytoplankton species in the water body.

Study area
Owan West is a Local Government Area of Edo State, Southern Nigeria. It is one of the six Local Governments of Edo North which are collectively referred to as Afemai. It has a tropical climate characterized by two distinct seasons; wet season (April to October) and dry season (November to March).
Station I is located along River Ule, close to Sabongida-Ora main market. Dumping of refuse, bathing, washing of clothes take place at this station.
Station II is located at a recreational resort center, Olomo beach. It is created out of the existing River Ule. There are palm trees by the side of the river to give a beach feel. Swimming activities as well as different activities of fun seekers take place in the environment at this station.

Materials and Methods

Sample collection for Physico-chemical parameters
Water samples for physico-chemical analysis were collected from surface water in both stations using a 1 litre plastic container on monthly basis for a period of 8 months from November 2015 to June 2016, covering wet and dry seasons respectively. Samples were taken to the Phycology laboratory, University of Benin, Benin City, for physico-chemical analysis. Parameters analyzed are: dissolved oxygen, electrical conductivity, turbidity, total dissolved solids (TDS), nitrate, phosphate, sulphate, total hardness and pH.
Total dissolved solids (TDS) and conductivity were determined using TDS and conductivity meter, HACH Co 150 model. Turbidity was measured using HACH DR2000 model spectrophotometer at a wavelength of 450nm. pH of water samples was determined with a pH (HANNA instrument) meter calibrated with buffer of pH 4 and pH 9. Other parameters were determined following standard methods of [11].

Phytoplankton collection
Samples for phytoplankton studies were collected by filtering 50 Litres of water (using a 10 litre bucket) through a phytoplankton mesh net of 55 µm. Net catches were transferred into a 500 mL plastic container in the field and preserved with 4% formalin solution. This was done for phytoplankton collections at both stations and taken to the Phycology laboratory, Ambrose Alli University, Ekpoma for analysis.
Examinations of phytoplankton algae were done using a Lietz Orthoplan Research microscope. Identification was carried out with references to published works of Opute (2000)[12] and Prescott (1975).[13] Counting was done following the methods of Lackey[14] whereby phytoplankton samples were concentrated to 10 mL from which 2 drops were used for microscopic examination. Five mounts were examined, counted and an average counted computed which gave a relative number of organisms per mL of the water sample.

Organic pollution analysis
Algal genus pollution index proposed by Palmer[15] was employed in assessing the water samples for low or high organic pollution. In doing this, pollution tolerant genera of phytoplankton were recorded from sampled stations and scored in line with the Palmer pollution index for genus. The pollution status of the sampled stations of River Ule was determined by comparing the total score of each station with numerical values for Palmer pollution classification.

Table 1: Algal genus pollution index [15]

Genus	Pollution index	Genus	Pollution index
Anacystis	1	*Micractinium*	1
Ankistrodesmus	2	*Navicula*	3
Chlamydomonas	4	*Nitzschia*	3
Chlorella	3	*Oscillatoria*	5
Closterium	1	*Pandorina*	1
Cyclotella	1	*Phacus*	2
Euglena	5	*Phormidium*	1
Gomphonema	1	*Scenedesmus*	4
Lepocinclis	1	*Stigeoclonium*	2
Melosira	1	*Synedra*	2

Numerical values for pollution classification;
0-10 = Lack of organic pollution
10-15 = Moderate pollution
15-20 = Probable high organic pollution
20 or more = Confirms high organic pollution.

Statistical Analysis
Statistical analysis was done with statistical package for social science (SPSS) 16.0. past.exe statistical package was employed in the analysis of data for diversity indices.

Results and Discussion

Physico-chemical parameters
Results obtained from the study reveal that there were fluctuations in the physico-chemical parameters studied with little or no discernible trend across seasons (Figures 2 to 10). Nitrate however showed a decline in concentrations from dry to wet season while pH values for both stations were relatively constant with a mean of 6.575 ± 0.137 mg/L in station I and 6.638 ± 0.127 mg/L in station II. Electrical conductivity values were low for both stations from November 2015 to April 2016 with increase in concentrations from May to June 2016. Total Dissolved Solids (TDS) followed a similar trend. Dissolved oxygen fluctuated throughout the period of study but was high for both stations. Station I recorded a mean of 27.250 ± 8.149 mg/L and station II, 45.463 ± 9.117 mg/L. Relatively constant dissolved oxygen values were observed from December to April for station I. The month of February recorded the highest oxygen concentration of 96.00 mg/L. There was no significant difference in the parameters studied for both stations (Table 2).
From table 3, there was strong positive correlation between TDS and electrical conductivity (0.991) and a moderate positive correlation between TDS and sulphate (0.569). Nitrate and the class Chlorophyceae showed strong positive correlation (0.608). Strong negative correlation between pH and electrical conductivity was observed (0.701).

Phytoplankton
A total of 54 individual phytoplankton species comprising 2 classes, Bacillariophyceae and Chlorophyceae were recorded in the study. Station I accounted for 38 individual species while station II recorded 16 species (Table 4). The most abundant species in the study was *Synedra superba* (14 counts/mL) followed by *Hydrosera* sp (7 counts/mL) while members of the Chlorophyta division represented by *Closterium acerosum,Closterium pseudolunula,Cosmarium decoratum* and *Spirogyra majuscula* recorded 1 count/mL each. Apart from *Spirogyra majuscula* which was encountered in station I, other Chlorophyta species were observed in station II.
From table 5, the highest species richness was recorded for station II (3.246) and the lowest of 2.749 was recorded for station I. Dominance index (D) was low in the study, being less than 1 for both stations. A diversity index was higher in station II (2.187) than station I (2.141). Evenness was low in the study for both stations.
Seasonally, more phytoplankton species were recorded in station I (26) in the dry season than the wet season (12) while in station II, the reverse was the case where more phytoplankton species were observed in the wet season (11) than dry season (5) (Tables 6 and 7).
As shown in table 8, both stations lacked organic pollution when compared with Palmer pollution classification standard.
The low phytoplankton reported in this study is at variance with the findings of some other authors. Ogamba *et al*.[16] observed a total of 143 species in Elechi creek, Emmanuel and Onyema[17] documented 82 phytoplankton species from their work on Lagos Lagoon while Davies *et al*. [18] reported 169 species in Elechi creek as well. Bacillariophyceae was equally dominant just like in this present investigation. The dominance of the class Bacillariophyceae has been reported by the authors stated above in Nigerian Rivers in their findings. Margelef[19] reported that species could become dominant if they exhibit high self-sustaining mechanism of natural increase.
The low phytoplankton species composition, abundance and diversity recorded in this study is an indication of the low productivity of the water body. Davies *et al*.[18] stated that the productivity of a water body depends on the amount of phytoplankton species present as they are the major primary producers of the aquatic ecosystem. The low number of phytoplankton species encountered in stations I and II could be as a result of the low concentrations of nutrients (nitrate, phosphate and sulphate) in the river. It therefore means that even with the nearness of station I to the market and with all the attendant anthropogenic activities and inputs around the station in addition to the recreational activities around the beach, the wastes generated which found their way into the water at these stations were not high enough to increase nutrient concentrations and possibly establish a stress condition for the phytoplankton species throughout the season. This gives justification to the cleanliness of the environment particularly around station II.
Nutrients are important in determining community productive levels. These nutrients which are low in both stations gave a reflection of the low abundance of phytoplankton species recorded. This goes to buttress the role of nutrients in the productivity of rivers. The low phosphate concentrations recorded in this study is indicative of a lack of industrial effluent, agricultural run-off and domestic sewage (which are possible sources of phosphate) in the environment around the two stations while possible nitrate sources like industrial waste water, nitrogen chemicals, fertilizers and plant humus may have been lacking or reduced in the environment, hence, the low nitrate concentrations observed. [20]
The difference in the phytoplankton abundance observed in the two stations could be as a result of the local conditions peculiar to the two stations. Station I is close to the market area which makes it an immediate recipient of most waste materials generated in the market. Although nutrient concentrations in this study were low, higher values of phosphate and nitrate were observed in station I than station II with fluctuations in sulphate concentrations in both stations. The low phytoplankton abundance in this study is a reflection of the nutrient status at the stations. In relation to this, Abowei *et al.*[21] reported that availability of nutrients, penetration of light into the water, temperature and velocity of current can influence phytoplankton abundance. The lack of huge anthropogenic and recreational watershed operations around the two stations may have suggested the non-significant difference observed in the parameters studied in the two stations along the same length of fresh water body. Thus, phytoplankton can only respond to what is available. High nutrients level lead to increased phytoplankton growth and in extreme cases, eutrophication.
According to Davies *et al*.,[18] phytoplankton are excellent bio indicators of water pollution. Their abundance, diversity, composition and distribution are used to evaluate the state of the water body.[22] The absence of other classes of phytoplankton like, Cyanophyta, Euglenophyta, reveals the unpolluted environment of the water body. With the application of the Palmer pollution index, the water fell under the category of unpolluted water (lack of organic pollution) despite the presence of pollution indicator genera like *Placoneis (Navicula), Synedra* and *Closterium*. The high oxygen concentration observed in this investigation at both stations further attest to the integrity of the river and reflects a tendency towards productivity. Proper aeration of the water body is as a result of photosynthetic activity (with the release of oxygen) of the phytoplankton species, wind mixing, low temperature to enhance solubility of oxygen and a reduction or absence of decaying organic matter in the water body that will demand for oxygen consumption. The oxygen concentration observed in this study is a reflection of the aesthetic state of the river and its ability to attract and sustain tourists at the beach side.
Seasonally, station I recorded more phytoplankton species in the dry season (26) than station II (5). This could be as a result of direct penetration of light into the water in the dry periods for photosynthetic activity to take place as well as the peculiar proximity of station I to intermittent nutrient supply from the inhabitants of the area through washing of clothes, dumping of refuse, etc, which are not in operation in station II, being a resort centre where proper sanitary conditions are maintained to attract leisure seekers. However, the two stations have almost equal number of phytoplankton species in the wet season (station I, 12 and station II, 11). A condition brought about by flooding which may have caused physical pollution during the wet period as a result of the increase in TDS and electrical conductivity and hence reduces photosynthetic activity of the phytoplankton. More so, increased number of phytoplankton species observed in station II in the wet season, could be as a result of the drifting of phytoplankton species from station I. However, total phytoplankton abundance in the study was more in the dry season (31) than wet season (23). This is in line with some authors who have recorded similar findings in their investigations. Low dominance index in the study (station I,0.1482; station II, 0.125), gives an indication that two individuals from a population drawn at random belong to the same species. Low species evenness recorded (station I, 0.7737; station, II 0.8911) represents a condition in which all the phytoplankton species are not abundant equally. Margelef richness (d) was higher in station II (3.246) than station I (2.749), a reflection of high species number and relatively low number of individuals. Diversity index was higher in station II (2.187) than station I (2.141).

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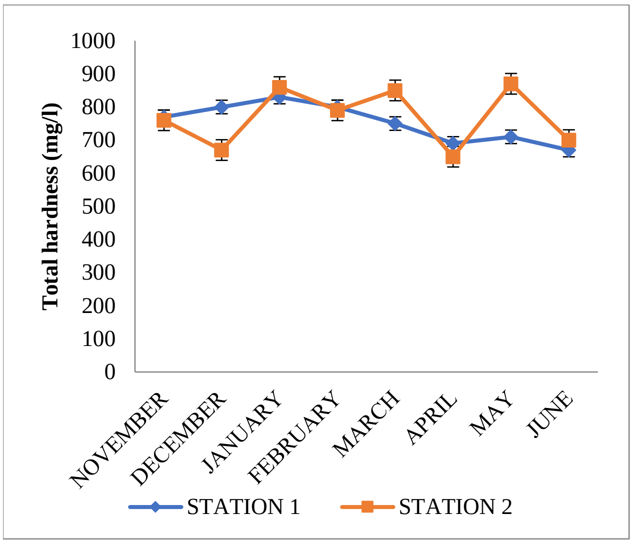

Figure 2: Monthly variations in total hardness concentrations of River Ule.

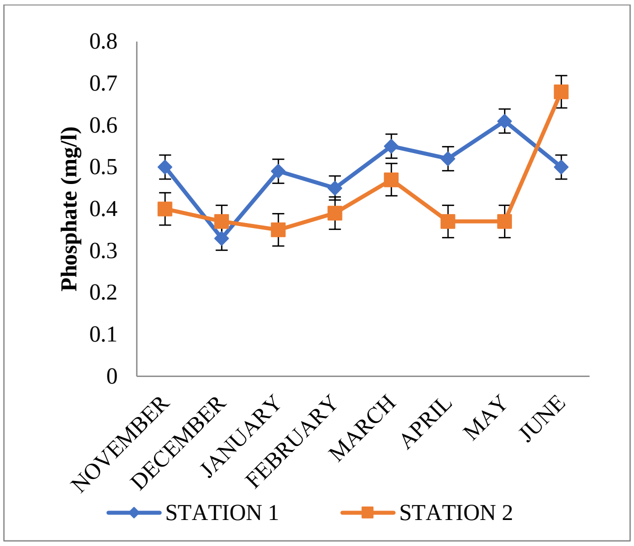

Figure 3: Monthly variations in phosphate concentrations of River Ule.

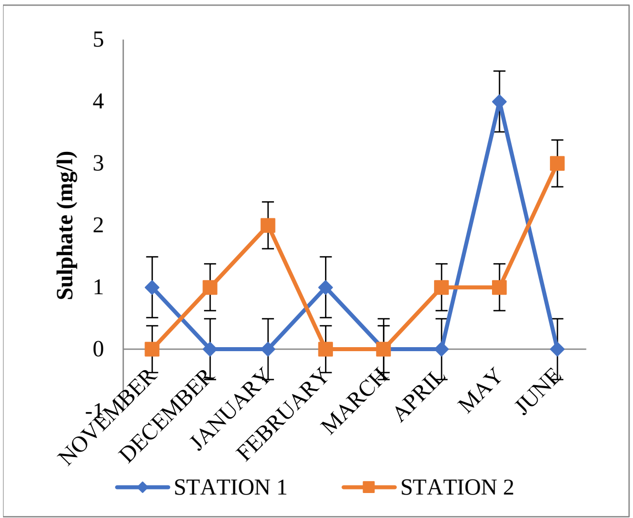

Figure 4: Monthly variations in sulphate concentrations of River Ule.

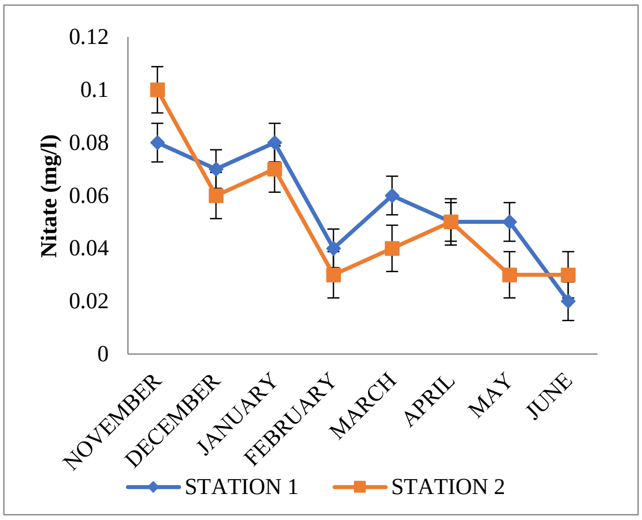

Figure 5: Monthly variations in nitrate concentrations of River Ule.

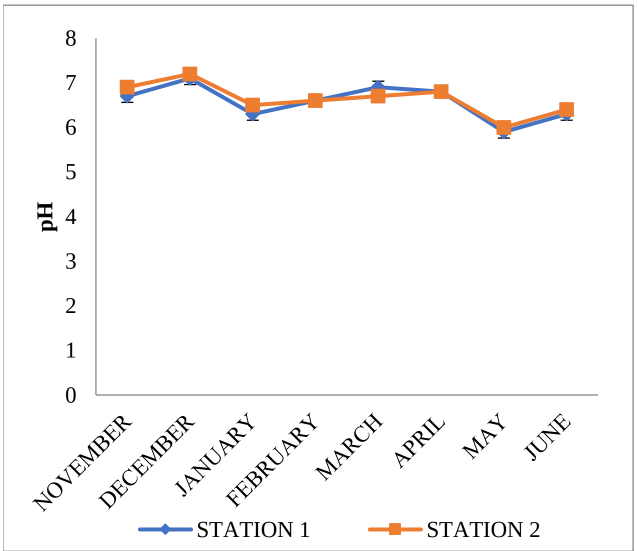

Figure 6: Monthly variations in pH values of River Ule.

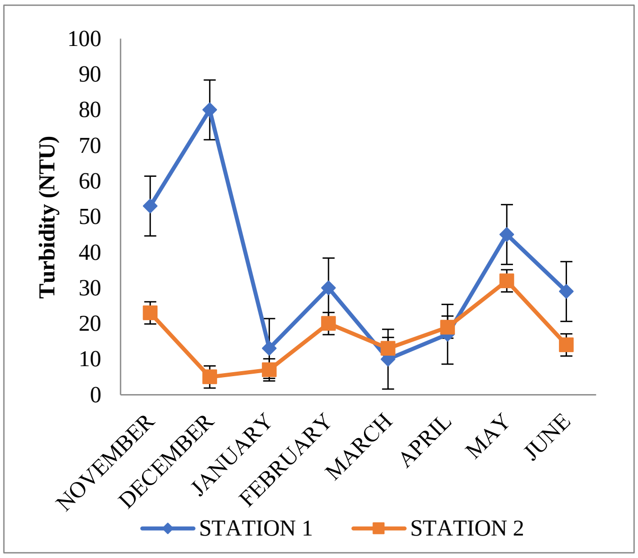

Figure 7: Monthly variations in turbidity concentrations of River Ule.

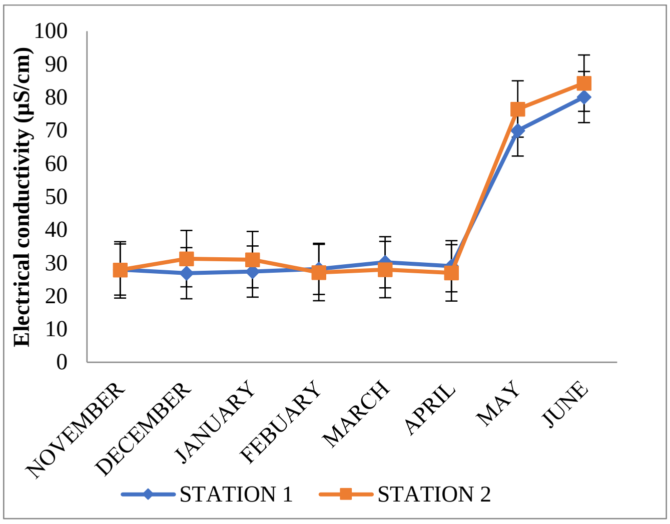

Figure 8: Monthly variations in electrical conductivity concentrations of River Ule.

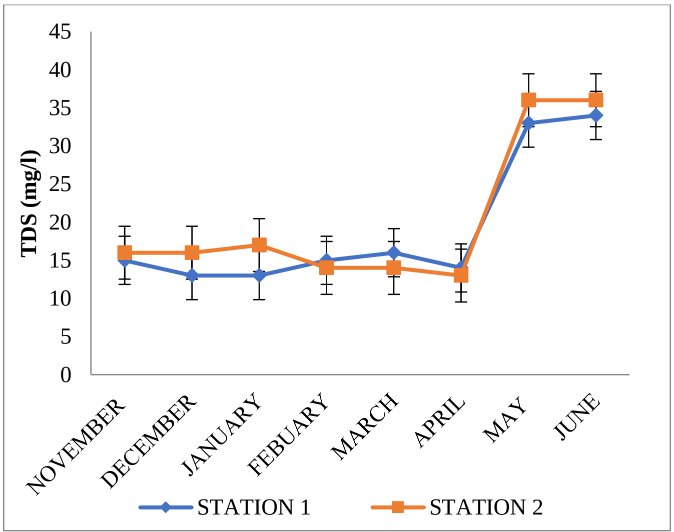

Figure 9: Monthly variations in total dissolve oxygen concentrations of River Ule.

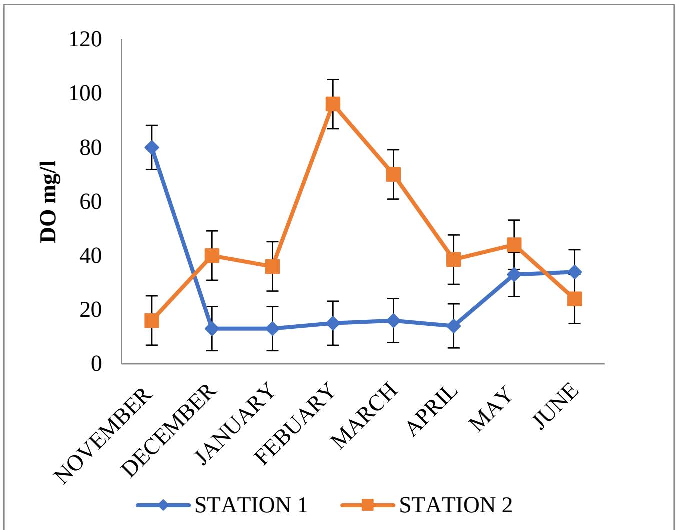

Figure 10: Monthly variations in dissolve oxygen concentrations of River Ule

Tiseer *et al.*[23] stated that abundance of species of Chlorophyta and Bacillariophyta in a water body represents relatively 'clean' water. The presence of three species of Desmids of the Chlorophyta division; *Closterium acerosum*, *Closterium pseudolunula* and *Cosmarium decoratum* gives an indication of a low nutrient water body. This is corroborated by the work of Kadiri[24] on desmids of Ikpoba River that desmids are characteristic of low nutrient water bodies.
The strong positive correlation of 0.608 between nitrate and class Chlorophyceae of phytoplankton indicates the influence of dissolved nutrients on the Chlorophyceae population.
The mean pH of the two stations (station I, 6.575 ± 0.137) and station II (6.638 ± 0.127) puts the water body within the acceptable range of 6.0 - 9.0 (NSDQW, 2007). This is in line with the reports of Adefemi *et al.*[25] in water samples from Ureje, Egbe and Ero dams, Southwest Nigeria and Chinedu *et al.*[26] on water quality in Canaanland, Ota, Southwest Nigeria. Prati *et al.*[27] stated that pH levels within this range are usual for tropical rivers which are not polluted. According to World Health Organisation,[28] pH has no health-based guideline value proposed for it. Although it has no direct impact on the consumer, it is one of the most important operational water quality parameters.

Table 2: Summary result table for physico-chemical parameters for the two stations

Parameter	**Station 1** $\bar{X}$ ± S.E	**Station 2** $\bar{X}$ ± S.E	**Significance Level**
Total Dissolved Solids	19.125±3.159	20.250±3.468	P>0.05
Nitrate (mg/L)	0.056±0.007	0.051±0.009	P>0.05
pH	6.575±0.137	6.638±0.127	P>0.05
Turbidity	34.625±8.389	16.625±3.111	P>0.05
Electrical conductivity (µS/cm)	39.975±7.721	41.638±8.510	P>0.05
Dissolved oxygen (mg/L)	27.250±8.149	45.563±9.117	P>0.05
Total hardness (mg/L)	752.500±20.419	768.750±31.136	P>0.05
Phosphate (mg/L)	0.494±0.029	0.425±0.039	P>0.05
Sulphate (mg/L)	2.000±1.000	1.333±0.333	P>0.05

P > 0.05 Indicates no significant difference.

Conclusion

From this study, there was no change in physico-chemical and biological components of the river across the seasons. Which means that the two classes of phytoplankton observed in this investigation gives clear information on the physico-chemical state of the water body in the two seasons. The anthropogenic and recreational activities around the water body at these two stations have not affected the aesthetic value of Olomo beach and as such there is no stress on the phytoplankton composition. This is emphasized by the low nutrient levels recorded. The water body is also not polluted going by the Palmer pollution index. However, with the presence of pollution indicator species, care and proper maintenance of the scenery around the beach must be enacted in other to prevent deterioration of water quality. More so, products of anthropogenic activities and other municipal wastes which find their way into station I (which later flows to station II) arising from its closeness to the market must be reduced if not stopped completely, as this will eventually increase the nutrient and biological loads at the beach station. The level of productivity in this investigation is low due to lack of abundant nutrient in the catchment area and may not be suitable for fish production. It is therefore recommended that a continuous environmental and water quality assessment be carried out regularly in order to maintain the biological integrity of the water and sustain the interest of tourists who use the place for leisure.

Table 3: Correlation analysis of physico-chemical parameters with phytoplankton classes.

	TDS (NTU)	**NO_3 (mg/L)**	**pH**	**Turbidity (mg/L)**	**Electrical conductivity (µS/cm)**	**DO (mg/L)**	**Total hardness (mg/L)**	**Phosphate PO_4 (mg/L)**	**Sulphate SO_4 (mg/L)**	**CHLOROPHYCEAE**	**BACILLARIOPHYCEAE**
Total Dissolved Solids (TDS) (NTU)	1										
Nitrate (mg/l)	**-0.5466007**	1									
pH	**-0.7225402**	0.4117706	1								
Turbidity (mg/l)	0.0684749	0.1321063	-0.024955765	1							
Electrical conductivity (µS/cm)	**0.9919877**	**-0.587447**	**-0.701614784**	0.066939	1						
Dissolved oxygen (mg/l)	-0.0656032	-0.260417	-0.072587446	-0.00441	-0.07939	1					
Total hardness (mg/l)	-0.1577691	0.1644819	-0.218614834	0.09583	-0.20895	0.179415	1				
Phosphate (mg/l)	0.4671616	-0.243468	-0.399040983	-0.11884	0.495608	-0.15736	-0.338291	1			
Sulphate (mg/l)	**0.5691665**	-0.156052	**-0.517589507**	0.045832	**0.534746**	-0.03521	-0.1748483	0.449715966	1		
CHLOROPHYCEAE	-0.0673911	**0.6082303**	0.286148442	-0.24699	-0.12792	-0.39517	-0.1388709	0.033707859	-0.22972	1	
BACILLARIOPHYCEAE	-0.0518775	0.1345346	-0.223936358	-0.20018	0.04973	-0.43243	-0.1298636	0.006035167	-0.14462	0.095871	1

Bold values indicate variables that are significantly correlated at $P<0.05$. Df = 10, r(0.05) = 0.497.

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Table 4: Phytoplankton abundance of River Ule.

S/N	ORGANISMS	STATION 1	STATION 2	TOTAL
	BACILLARIOPHYCEAE			
1	*Eunotia monodon* Ehrenberg.	2	-	2
2	*Eunotia pectnalis*(Kutz) Rabenh	1	-	1
3	*Fragilariforma javanica* (Hustedt) C.E.Wetzel, E.Morales&L.Ector	4	1	5
4	*Frustulia rhomboides* (Ehrenberg) De.Toni	2	-	2
5	*Hydrosera* sp	5	2	7
6	*Placoneis elginensis*(W.Gregory) E.J.Cox	3	3	6
7	*Pinnularia cardinaliculus* Cleve	2	-	2
8	*Pinnularia gibba* Ehr.	-	1	1
9	*Pinnularia viridis* (Nitzsch) Ehrenberg.	-	1	1
10	*Sirirella elegans* Ehrenberg.	2	-	2
11	*Synedra superba* Kutzing	11	3	14
12	*Terpsinoe musica* Ehrenberg.	5	2	7
	CHLOROPHYCEAE			
13	*Closterium acerosum* (Schroeder) Ehrenberg.	-	1	1
14	*Closterium pseudolunula* O.Borge var *concavum* K.Foster and F.Eckert	-	1	1
15	*Cosmarium decoratum* W. and G.S West	-	1	1
16	*Spirogyra majuscula* Kutzing	1	-	1
TOTAL		38	16	54

Table 5: Diversity indices of phytoplankton community structure.

PHYTOPLANKTON	STATION 1	STATION 2
Taxa S	11	10
Individuals	38	16
Dominance D	0.1482	0.125
Shannon H	2.141	2.187
Evenness e^H/S	0.7737	0.8911
Margalef (d)	2.749	3.246

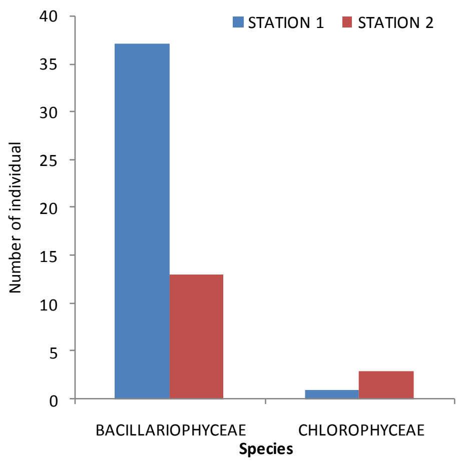

Figure 11: Bacillariophyceae class as the most abundant in the study.

Table 6: Seasonal phytoplankton composition in station I from November 2016 to June, 2017.

S/N	ORGANISMS	DRY	WET	TOTAL
	BACILLARIOPHYCEAE			
1	*Eunotia monodon* Ehrenberg.	2	-	2
2	*Eunotia pectnalis*(Kutz) Rabenh	1	-	1
3	*Fragilariforma javanica* (Hustedt) C.E.Wetzel, E.Morales&L.Ector	2	2	4
4	*Frustulia rhomboids* (Ehrenberg) De.Toni	-	2	2
5	*Hydrosera* sp	3	2	5
6	*Placoneis elginensis* (W.Gregory) E.J.Cox	3	-	3
7	*Pinnularia cardinaliculus* Cleve	2	-	2
8	*Sirirella elegans* Ehrenberg.	1	1	2
9	*Synedra superba* Kutzing	9	2	11
10	*Terpsinoe musica* Ehrenberg.	3	2	5
	CHLOROPHYCEAE			
11	*Spirogyra majuscula* Kutzing		1	1
TOTAL		26	12	38

Table 7: Seasonal phytoplankton composition in station II from November 2016 to June 2017.

S/N	ORGANISMS	DRY	WET	TOTAL
	BACILLARIOPHYCEAE			
1	*Fragilariforma javanica* (Hustedt) C.E.Wetzel, E.Morales & L.Ector	-	1	1
2	*Hydrosera* sp	1	1	2
3	*Placoneis elginensis* (W.Gregory) E.J.Cox	1	2	3
4	*Pinnularia gibba* Ehr.	-	1	1
5	*Pinnularia viridis*(Nitzsch) Ehrenberg.	-	1	1
6	*Synedra superba* Kutzing	2	1	3
7	*Terpsinoe musica* Ehrenberg.	1	1	2
	CHLOROPHYCEAE			
8	*Closterium acerosum* (Schroeder) Ehrenberg.	-	1	1
9	*Closterium pseudolunula* O.Borge var *concavum* K.Foster and F.Eckert	-	1	1
10	*Cosmarium decoratum* W. and G.S West	-	1	1
TOTAL		5	11	16

Table 8: Algal genus pollution index scores of the different stations.

Algal genera	**Stations**		
Bacillariophyceae	**1**	**2**	**Pollution index**
Navicula (Navicula anglica synonym of *Placoneis elginensis)*	3	3	3
Synedra	2	2	2
Chlorophyceae			
Closterium	1	1	1
Total score	6	6	

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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References

1. Yukic TC. Fundamentals of research, (2nd Edition) Harpers and Row. Library of Congress1970; 70-80: 646 p.
2. Daniels BC. Puritans at play. Leisure and recreation in colonial new England. St Martin's press, New York. 1995. 11 p.
3. Rolston H. Environmental ethics: Duties to and values in the natural world. Philadephia, PA: Temple university press. science publishers, London. 1988. 530 p.
4. Smith EL, Raab DM. Osteoporosis and physical activity. Acta Med Scand Suppl. 1986; 711:149-156.
5. Dimowo BO. The phytoplankton species composition and abundance of Ogun River, Abeokuta, Southwest Nigeria, Int J Aquacult. 2013; 3(2):4-7.
6. Anyinkeng N, Mih AM, Suh TA, Awah CC. Phytoplankton diversity and abundance in water bodies as affected by anthropogenic activities within the Buea municipality, Cameroon. J Ecol Nat Environ. 2016; 8(7):99-114.
7. Wassie TA, Melese AW. Impact of physico-chemical parameters on phytoplankton compositions and abundance in Selemeko manmade reservoir, Dedre Tabor, South Gondar, Ethiopia. Appl. Water Sci. 2017; 7:1791-1798.
8. Elenwo EI, Akankali JA. The effects of marine pollution on Nigeria coastal resources. J Sust Dev Stud. 2015; 8(1):209-224.
9. Ikpeme EM, Uttah, C, Uttah, EC. The effect of crude oil spill at Izombe, Imo State, Nigeria, on plankton diversity and abundance. Austr J Basic Appl Sci. 2013; 7(6):178-183.
10. Adeyemi-Ale OA, Aladesida AA, Esenowo IK. The effect of detergent effluent on the physico-chemical characteristics and plankton diversity of Osere stream, Illorin, Kwara State, Nigeria. J Appl Sci Environ. Manage. 2004; 18(1):99-103.

11. APHA. American Public Health Association. Standard methods for the analysis of water and waste water. New York, 1998. 1287 p.
12. Opute FI. Contribution to the knowledge of Algae of Nigeria I. Desmids from the Warri/Forcados Estuaries. Part II. The elongate baculiform desmids. J Limnol. 2000; 59(2):131-155.
13. Prescott GW. How to know fresh water algae. Brown and company publishers, IOWA. 1975. 348 p.
14. Lackey JB. The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. U.S. Public Health Reports. 1938; 53:2080-2093.
15. Palmer CM. Composite rating of algae tolerating organic pollution. J Phycol. 1969; 5:78-82.
16. Ogamba EN, Chindah AC, Ekweozor, IKE, Onwuteaka JN. Water quality of phytoplankton distribution in Elechi creek complex of the Niger Delta. J Nig Environ Soc. 2004; 2(2):121-130.
17. Emmanuel BE, Onyema IC. The plankton and fishes of a tropical creek in South Western Nigeria. Turk J Fish Aquatic Sci. 2007; 7:105-113.
18. Davies AO, Abowei JFN, Tawari CC. Phytoplankton community of Elechi Creek, Niger Delta, Nigeria. Am J Sci Res. 2009; 2: 20-30.
19. Margelef R. Perspectives in Ecological Theory. University of Chicago Press, Illinois, 1968. 111 p.
20. Xue Y, Song J, Zhang Y, Kong F. Wen M, Zhang G. Nitrate pollution and preliminary source identification of surface water in a semi-arid river basin, using isotopic and hydrochemical approaches. Water 2016; 8:328.
21. Abowei JFN, Ezekiel EN, Hansen U. Effects of water pollution on phytoplankton species composition in Koluama area, Niger Delta area, Nigeria. Int J Fisheries Aqua Sci. 2012; 1(2):134-139.
22. Townsend CR, Harper JL, Bagon M. Essentials of ecology. 3rd Ed. Blackwell. 2000.
23. Tiseer FA, Tanimu Y, Chia AM. Seasonal occurrence of algae and physico-chemical parameters of Samaru stream, Zaria, Nigeria. Asian J Earth Sci. 2008; 1(1):31-37.
24. Kadiri MO. More desmids from Ikpoba Reservoir (Nigeria) compared with other records from Africa. Algolog Stud. 1996; 80:87-98.
25. Adefemi OS, Asaolu SS, Olaofe O. Assessment of the physico-chemical status of water samples from major dams in Ekiti State, Nigeria. Pak Nutr. 2007; 6(6):657-659.
26. Chinedu SN, Nwinyi OB, Oluwadamisi AY, Eze VN. Assessment of water quality in Canaan land, Ota, Southwest Nigeria. Agric Biol J North Am. 2011; 2(4):577-583.
27. Prati L, Pavenello R, Pesarin P. Assessment of water quality by a single index of pollution. Water Research, 1974; 5:74-81.
28. World Health Organisation (WHO). Guidelines for drinking water quality. Fourth edition. Incorporating the first addendum. 2017; 541 p.