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 Olomore 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 water5 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.5 on water bodies exposed to anthropogenic pressures in Cameroon; Wassie and Melese7 on Selemeke reservoir Ethiopia; Elenwo and Akankali8 on marine pollution on Nigeria coastal resources; Ikpenye et al.9 on Njaba River, Imo State, Nigeria and Adeyemi et al.10 on Osere stream, Ilorin, Nigeria.

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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)15 and Prescott (1975).13 Counting was done following the methods of Lackey14 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 Palmer16 was employed in assessing the water samples for low or high organic pollution. In doing this, pollution tolerant genera of phytoplankton were recorded from 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

| 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               | Stigeoelonium| 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.
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 Chlorophyceae division represented by Closterium acerosum, Closterium pseudulina, 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 high in the study, being less than 1 for both stations. Evenness 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. Ongamba et al.16 observed a total of 143 species in Elechi creek, Emmanuel and Onyema17 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. Margel9 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 area and with all the attendant anthropogenic activities and discharges around the station, recreationals 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 show 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.23 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.22 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 whole length of the river 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.14 phytoplankton are excellent bio indicators of water pollution. Their abundance, diversity, composition and distribution are used to evaluate the state of the water body.24 The absence of other classes of phytoplankton like, Cyanophyta, Euglenophyta, reveals a less polluted environment in the study area.

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, 0.9111) represents a condition in which all the phytoplankton species are not abundant equally. Margalef 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).
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.
Table 2: Summary result table for physico-chemical parameters for the two stations

| Parameter                  | Station 1 ± S.E. | Station 2 ± 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   | 39.975±7.721     | 41.638±8.510     | P>0.05            |
| (µS/cm)                   |                  |                  |                   |
| Dissolved oxygen           | 27.250±8.149     | 45.563±9.117     | P>0.05            |
| (mg/L)                    |                  |                  |                   |
| 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. 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.

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 Kadiri24 on desmids of Ikpoba River that desmids are characteristic of low nutrient water bodies.

The composition of Olomo beach and as such there is no stress on the phytoplankton 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 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.
Table 3: Correlation analysis of physico-chemical parameters with phytoplankton classes.

|                              | TDS (NTU) | NO₃ (mg/L) | pH          | Turbidity (mg/L) | Electrical conductivity (μS/cm) | DO (mg/L) | Total hardness (mg/L) | Phosphate PO₄ (mg/L) | Sulphate SO₄ (mg/L) | CHLOROPHYCEAE | BACILLARIOPHYCEAE |
|------------------------------|-----------|------------|-------------|------------------|--------------------------------|-----------|----------------------|---------------------|-------------------|---------------|------------------|
| Total Dissolved Solids (TDS) (NTU) |           |            |             |                  |                                |           |                      |                     |                  |               |                  |
| 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.
Table 4: Phytoplankton abundance of River Ule.

| S/N | ORGANISMS                        | STATION 1 | STATION 2 | TOTAL |
|-----|----------------------------------|-----------|-----------|-------|
| 1   | Eunotia monodon Ehrenberg.       | 2         | -         | 2     |
| 2   | Eunotia pectinalis (Kutz) Rabenh. | 1         | -         | 1     |
| 3   | Fragilariforma javanica (Hustedt) | C.E.Wetzel, E.Morales&L.Ector | 4 | 1 | 5 |
| 4   | Frustulia rhomboids (Ehrenberg) De.Toni | 2 | - | 2 |
| 5   | Hydrosera sp                      | 5         | 2         | 7     |
| 6   | Placoecis elginensis (W.Gregory) E.J.Cox | 3 | 3 | 6 |
| 7   | Pinnularia cardinatus Cleve       | 2         | -         | 2     |
| 8   | Pinnularia gibba Ehrenberg.       | -         | 1         | 1     |
| 9   | Pinnularia viridis (Nitzsch) Ehrenberg. | - | 1 | 1 |
| 10  | Sirirella elegans Ehrenberg.      | 2         | -         | 2     |
| 11  | Syneodra superba Kutzin           | 11        | 3         | 14    |
| 12  | Terpsinoe musica Ehrenberg.       | 5         | 2         | 7     |

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     |       |
| Eveness 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 |
|-----|----------------------------------|-----|-----|-------|
| 1   | Eunotia monodon Ehrenberg.       | 2   | -   | 2     |
| 2   | Eunotia pectinalis (Kutz) Rabenh. | 1   | -   | 1     |
| 3   | Fragilariforma javanica (Hustedt) | C.E.Wetzel, E.Morales&L.Ector | 2 | 2 | 4 |
| 4   | Frustilia rhomboids (Ehrenberg) De.Toni | - | 2 | 2 |
| 5   | Hydrosera sp                      | 3   | 2   | 5     |
| 6   | Placoecis elginensis (W.Gregory) E.J.Cox | 3 | - | 3 |
| 7   | Pinnularia cardinatus Cleve       | 2   | -   | 2     |
| 8   | Sirirella elegans Ehrenberg.      | 1   | 1   | 2     |
| 9   | Syneodra superba Kutzin           | 9   | 2   | 11    |
| 10  | Terpsinoe musica Ehrenberg.       | 3   | 2   | 5     |
| 11  | Spirogyra majuscula Kutzin        | 1   | 1   |       |
| TOTAL|                                  | 26  | 12  | 38    |

CHLOROPHYCEAE
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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