HYDROCHEMISTRY AND PLANKTON DYNAMICS OF EUTROPHIC TROPICAL LAGOON

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Abstract: The hydrochemistry and plankton dynamics of the Ologe lagoon was investigated between February, 2002 and January, 2004. Whereas the lagoon remained freshwater (S%o < 0.5%o) and acidic to alkaline conditions (pH 5.8-8.1), all through the sampling period, the dissolved oxygen (DO) and biochemical oxygen demand (BOD5) values (0-28mg/l) indicated stress. Although nutrient levels at the lagoon were high (NO3-N >1.02mg/L; PO4-P < 1.5mg/L), heavy metal values were low (Fe < 0.99 mg/L, Cu < 0.06 mg/L, Zinc < 0.03 ). The occurrence of Melosira granulata, Nitzschia palea, Cyclotella meneghiniana, Gomphonema parvulum, Pinnularia major , P. ambiguа (diatoms), Euglena viridis, Lepocinclis sp, Phacus acuminateus (euglenoids), Microcystis aeruginosa, M. flos-aquae (cyanobacteria), Brachionus angularis, B. calicyflous, B. urceolaris (rotifers) in high numbers may highlight pollution stress in the lagoon. The proliferation of the cyanophyta and other plankton species encountered were controlled by the nutrient level. The physico-chemical characteristics, Margalef, Shannon and Wiener and Equitability indices indicated pollutions stress and dominance by a few species. [Nature and Science 2010;8(9):140-149]. (ISSN: 1545-0740).

Keywords: hydrochemistry; plankton dynamics; Ologe; physico-chemical characteristics

1. INTRODUCTION
According to Kjerfve (1994), a coastal lagoon is an inland body of water, usually oriented parallel to the coast, separated from the ocean by a barrier, connected to the ocean by one or more restricted inlets, and having depths which seldom exceed a couple of meters. Lagoons vary in size and shape in relation to geomorphology and are known to experience forcing from river input, tides, precipitation, wind stress, evaporation and surface heat balance and they respond differently to these forcing functions (Kirk and Lauder, 2000; Suzuki et al., 2002; Nwankwo, 2004 b).

According to Lawson and John (1982), lagoons can be classified as open, closed and semi-closed depending on whether they retain a permanent connection to the sea, an annual or less frequent connection, or an artificially restricted and hence 2004a). Phytoplankton is free floating and mostly microscopic plants that contain chlorophyll and grow by photosynthesis and lack roots, stems (non-vascular) and leaves (Lee, 1999; Nwankwo, 2004a).

They absorb nutrients (carbon dioxide, nitrates, ammonium, phosphate and other nutrient forms and micronutrients) from the water or sediments, add oxygen to the water as by-products and are usually the major source of organic matter at the base of the food web in aquatic environment (Smith, 1950; Lawson and John, 1987; Lee, 1999). Chlorophyll a concentrations are an indicator of phytoplankton intermittently closed connection to the sea. Lagoons are important in water transportation, energy generation, exploitation and exploration of some mineral resources including sand, provide natural food resources rich in protein, fish and fisheries farming sites as well as sites for the disposal of both domestic and industrial wastes (FAO, 1969; Kirk and Lauder, 2000; Onyema et al., 2003, 2007; Chukwu and Nwankwo, 2004).

Algae are thalophytes (plants lacking roots, stems and leaves), which have chlorophyll as their primary photosynthetic pigment and which lack a sterile covering of cells around the reproductive cells (Smith, 1950; Bold, 1957; Lee, 1999; Nwankwo, 2004a). Algae are primary producers in many habitats and have been described as the “grass of many waters” (Bold, 1957; Lee, 1999; Nwankwo, abundance and biomass in the aquatic environment (Smith, 1950; Lee, 1999; Suzuki et al., 2002).

Over the years, ecological studies have shown that there is a good relationship between water quality or environmental characteristics and plankton community structure (Palmer, 1969; Odiete, 1999; Onyema and Nwankwo, 2006). Similarly, (Dakshini and Soni, 1982; Nwankwo and Akinsoji, 1988; Nwankwo and Onitiri, 1992; Nwankwo et al., 1994 and Chindah et al., 1993, Nwankwo, 2004) indicated that plankton and have been diagnostic in assessing water quality and hydrological status.

According to Odiete, 1999; Chukwu, 2002; Nwankwo, 2004; increasing urbanization and industrialization in the coastal zone of Nigeria, have increased anthropogenic stressors which eventually impacts negatively on the aquatic environment. There is need therefore, for a good understanding of the nature, dynamics and history of our coastal lagoons as they possess innumerable scientific, ecological and economic implications both now and for the future (Lawson and John, 1982, 1987).

There are no previous in-depth biological investigations of the Ologe lagoon system, its hydrological regimes, characteristics and plankton dynamics. Unfortunately, this sensitivity environment serves as a sink for surrounding facilities, especially Agbara industrial effluents and is gradually being transformed from a physically controlled to a biologically controlled environment. Hence there is a need to investigate the plankton diversity and biomass distribution of the lagoon and relate the observed changes to environmental factors.

2 Materials and Methods
2.1 Description of study site
The coastal water of south-western Nigeria lies within the rainforest belt that experiences a bimodal rainfall pattern that is concentrated into one season (May – October) and a dry season that spans between November and April. The tidal regime is semi-diurnal with tidal heights that decrease inland. The Ologe lagoon (Fig. 1) transverses Lagos state and Ogun states, in Nigeria and is one of the nine lagoons in South-western Nigeria (Webb, 1958a; Nwankwo, 2004b). It is located between Latitude 6° 27'N, Longitude 3° 01'E and Latitude 6° 30'N, Longitude 30° 06' E at the distal end of Badagry creek (Webb, 1958a).

It is presumably the smallest lagoons in south-western Nigeria with a surface area of 9.4Km2. The major sources of water are River Owo, Ore, and Oponu in Ogun State (Akanni, 1992; Odewunmi, 1995). The entire area of the lagoon is riparian by swamp rainforest dominated by raphia palms except confluence points with Badagry creek where few mangroves are prominent. The effluents and organic wastes from Agbara industrial and residential estates are discharged all year round into the lagoon.

The main body of the lagoon lies within Badagry Local Government Area and it opens up to the Atlantic ocean via the Lagos Harbour and Dahomey in the Republic of Benin. The major source of water are River Owo with a source in a town called Toto Owo where River Ore and Illo form a confluent with River Opon in Ogun State created within the lagoon. Water samples for physico-chemical analysis were collected 0.50m below the water surface in four litre plastic containers, properly labeled and stored in ice chests in the field. In the laboratory, the water samples were transferred into refrigerator (t = 4 °C) and analyzed within 24 h of collection. Water samples for biochemical oxygen demand (BOD₅) were collected in 200 ml light and dark bottles.

Plankton samples were collected using a 55 µm mesh size standard plankton net tied unto a motorized boat and towed horizontally at low speed (< 4 knots) for 10 min. The concentrated samples were stored in 200 ml well labeled containers with screw caps and preserved in 4% unbuffered formalin.

2.2 Physical and chemical parameters
The surface water temperature was measured with an ordinary mercury thermometer to the nearest °C and transparency estimated with a 20 cm diameter white and black painted Secchi disc. Total suspended solids (TSS) were determined by evaporating 100ml aliquot of the sample, while total dissolved solids (TDS) were determined by evaporating 100 ml of the filtrate in preweighed evaporating dish at 100 °C. Conductivity of the surface water was measured with a conductivity meter (model H18733) and salinity determined with a refractometer (model S100). Dissolved oxygen (DO) was measured with a Griffin oxygen meter (model 40) and the five-day BOD₅ determined according to the method described in A.P.H.A (1985). The pH was determined using a Griffin digital pH meter (model 80), while nitrate-nitrogen and phosphate-phosphorus were determined by the phenol-disulphuric acid and molybdenum blue methods respectively. The concentration of copper, iron and lead were determined using an atomic absorption spectrophotometer (A.A.S Unicam 99 model).

2.3 Biological parameters
Plankton analysis was done using the microtransect drop count method described by drop count method described by Lackey (1938). For each aliquot sample, five drops were thoroughly investigated under an M II Wild binocular microscope with a calibrated eye piece. For each drop, at least five transects were investigated and the organisms identified recorded as number per ml. Three indices were used to obtain the estimate of species diversity. The species richness were estimated according to Margalef (1951), 

\[ d = \frac{(S - 1)}{\ln N} \]

The Shannon and Wiener’s (1949) diversity index (\[ H = \sum \pi \ln \pi = \left(\frac{1}{\ln 2}\right) \sum \frac{N_i}{N} \ln \frac{N_i}{N} \]) and Pielon’s (1966) evenness index (\[ J = \frac{E}{H_{\text{max}}} = \frac{H}{\ln S} = \frac{H}{\ln 2/\ln S} \]) were calculated.

3.0 Results
The minimum and maximum values obtained for the estimates of environmental factors, their means and standard deviation are presents in Table 1. Also in Table 1 is whether each parameter recorded higher values in the wet or dry season for the two (2) years of study. Fig. 2 showed seasonal variations in some environmental factors among stations at the Ologe lagoon from Feb., 2002 to Jan., 2004.

Air temperature values ranged between 27°C to 33.5°C among all the sampled stations within the study period. The highest air temperature (33.5°C) was recorded at station OL1 (Idolowu) in March 2002, while the lowest was recorded at station OL14.
(center of lagoon between Otto-Ijaniki and OL6) in August the same year. The lowest surface water temperature estimated was 25.2°C (August, 2002), the highest value obtained was 31.8°C (March, 2002). The highest transparency value (76cm) was recorded at station OL8 (between Ibiye and Obele) in March 2002, while the lowest values (24cm) was recorded at stations OL16 and OL10 (Asepe Mushin) in the months of August and September 2003. Total dissolved solids ranged between 48 to 294mg/l, with the lowest value recorded in station OL5 (confluence between Owo River and Ologe lagoon) in September 2003. The highest total dissolved solids value (294mg/l) value was recorded at station OL1 (Idolowu) in March 2002. Total suspended solids valued ranged between 10 to 378mg/l,10 (OL3-Otto jetty in March 2003) and 378mg/l (OL10-Asepe Mushin in September 2003). Rainfall volumes showed both monthly changes and varied from one year to the next. In the first year the highest rainfall volume was recorded: highest rainfall volume (372.1mm) was recorded in June 2002 and the lowest (0.6mm) was in December 2003.

Hydrogen ion concentration (pH) values ranged between 5.8 (station OL4-Owo River point effluent discharge in the month of July 2002) to 8.16 (station OL8 (between Ibiye and Obele) in September 2003). Iron levels ranged between106 (station OL8 (between Ibiye and Obele) in September 2003) and 76mg/l (station OL1 (Idolowu) in the month of March 2002). Copper values was between 23.1 (station OL8 (between Ibiye and Obele) in September 2003) and 9.54mg/l (OL11 (Gbanko) in the month of May 2003). Calcium levels were between 34mg/l (station OL6 and OL8 (between Ibiye and Obele) in September and October 2003 respectively) to 228mg/l (station OL1 (Idolowu) in April 2002). Magnesium estimates were between 10 (at station OL8 (between Ibiye and Obele) in September 2003) and 76mg/l (station OL1 (Idolowu) in the month of April 2002). Copper values was between 23.1 (station OL8 (between Ibiye and Obele) in July 2003) to 56.9µg/l (station OL11 (Gbanko) in the month of March 2002). Iron levels ranged between106 (station OL17 in the month of September 2002) and 987µg/l (station OL4 (point of effluent discharge) in the month of March 2002). Zinc values ranged between 2.62 (station OL7 (Ibiye) in August 2003) and 30.88µg/l (station OL4 (Owo river end receiving effluent) in the month of March 2002).

Dissolved Oxygen values ranged between 7 (station OL6 in March 2003) to 12.7mg/l (station OL14 - centre of Ologe lagoon between Otto-Ijaniki and OL6 in the month of June 2002). Biological Oxygen Demand values ranged between 3 (stations OL12 (Ajido) and OL13 (between Ajido and Idolowu) in September and October 2003 respectively) to 28mg/l (station OL3 (Otto jetty) in April 2002). Nitrate-nitrogen values were between (0.01 station OL4 (Owo river- point of effluent discharge) in January 2003) to 1.02mg/l (station OL3 (Otto jetty) in June 2003). Phosphate-phosphorus recorded between 0.03 (station OL17 in the month of March 2002) to 1.79mg/l (station OL10 in the month of June 2003). Silica values fell between 2.05 (station OL15 (between Ibiye and Idolowu) in March 2002) and 9.54mg/l (OL11 (Gbanko) in the month of May 2003). Calcium levels were between 34mg/l (station OL6 and OL8 (between Ibiye and Obele) in September and October, 2003 respectively) to 228mg/l (station OL1 (Idolowu) in April 2002). Magnesium estimates were between 10 (at station OL8 (between Ibiye and Obele) in September 2003) and 76mg/l (station OL1 (Idolowu) in the month of April 2002). Copper values was between 23.1 (station OL8 (between Ibiye and Obele) in July 2003) to 56.9µg/l (station OL11 (Gbanko) in the month of March 2002). Iron levels ranged between106 (station OL17 in the month of September 2002) and 987µg/l (station OL4 (point of effluent discharge) in the month of March 2002). Zinc values ranged between 2.62 (station OL7 (Ibiye) in August 2003) and 30.88µg/l (station OL4 (Owo river end receiving effluent) in the month of March 2002).

Table 1: A summary of the minimum, maximum and mean estimated values for environmental factors from the Ologe lagoon (February, 2002 – January, 2004).

<table>
<thead>
<tr>
<th>Parameter/Unit</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Mean value ± S.D.</th>
<th>Higher values reported in the---</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Air temperature (oC)</td>
<td>27</td>
<td>34</td>
<td>31.10 ± 0.22</td>
<td>Dry season</td>
</tr>
<tr>
<td>2 Water temperature (oC)</td>
<td>25.2</td>
<td>31.8</td>
<td>29.01 ± 0.47</td>
<td>Dry season</td>
</tr>
<tr>
<td>3 Transparency (cm)</td>
<td>24</td>
<td>76</td>
<td>51.54 ± 5.65</td>
<td>Dry season</td>
</tr>
<tr>
<td>4 Depth (m)</td>
<td>3.2</td>
<td>7</td>
<td>4.4</td>
<td>Wet season</td>
</tr>
<tr>
<td>5 Total Dissolved Solids (mgl-1)</td>
<td>48</td>
<td>294</td>
<td>139.23 ± 17.89</td>
<td>Dry season</td>
</tr>
<tr>
<td>6 Total Suspended Solids (mgl-1)</td>
<td>7</td>
<td>378</td>
<td>184.36 ± 14.90</td>
<td>Wet season</td>
</tr>
<tr>
<td>7 Rainfall (mm)</td>
<td>0.6</td>
<td>383</td>
<td>137.37</td>
<td>Wet season</td>
</tr>
<tr>
<td>8 Total hardness (mgl-1)</td>
<td>62</td>
<td>342</td>
<td>146.38 ± 26.52</td>
<td>Dry season</td>
</tr>
<tr>
<td>9 pH</td>
<td>5.8</td>
<td>8.1</td>
<td>6.92 ± 0.14</td>
<td>Dry season</td>
</tr>
</tbody>
</table>
The Plankton Flora of the Ologe Lagoon

Five major algal groups were represented in the microflora of sampled areas of the Ologe lagoon. These were the Bacillariophyceae, Cyanophyceae, Euglenophyceae, Chlorophyceae, and Dinophyceae. A total of 119 species from 49 genera were recorded. Diatoms were the most abundant group making up a total of forty-eight species belonging to eighteen genera. This was followed by green algae, with twenty-three species from eleven genera, euglenoids with seventeen species from five genera, while the dinoflagellates had one species. The inter and intra-annual variations in phytoplankton assemblages was dominated by diatom species. There were more prevalence of pennate diatoms and green algae during the wet season than the dry season, while the euglenoids were more prevalent during the dry season.

The more dominant phytoplankton taxa included Melosira granulata and its varieties and forms, Cyclotella meneghiniana, Nitzschia palea, Gomphonema parvulum, Pinnularia major, P. ambiguа (diatoms) (diatoms), Chlorellococcus humicolum, Scenedesmus obliquus, S. quadricauda, C. microscoporum (green algae), Euglena viridis, Lepocinclis sp, Phacus acuminate (euglenoid), Microcystis aeruginosa, M. flos-aquae, M. wesenbergii (blue-green algae). Table 2 shows a checklist of Ologe lagoon phytoplankton species and their classification. Species that are first reports for South-western Nigeria with regard to existing checklists (Nwankwo, 1988; Nwankwo et al., 2003a, b; Nwankwo and Onyema, 2004; Wujek et al., 2004) are preceeded by an asterick on the list.

Six major phyla groups were represented in the microfaunal of sampled areas of the Ologe lagoon (table 3). These are the Arthropoda, Rotifer, Mollusca, Nematoda, Chordata and Annelida. The dominant zooplankton forms included Arthropoda-Cyclops sp, Eucyclop sp, Eurytemora sp, Evadne sp and Copepod nauplius, while rotifers are – Branchionus sp and Keratella sp. Both Margalef’s species richness (d), Shannon and Wiener’s diversity index and equitability index of phytoplankton species were higher in the dry months than in the wet months. Among the zooplankton, similar observations were also observed among the diversity indices.

| Conductivity (µS/cm) | 83 | 621 | 256.59 ± 36.65 | Dry season |
| Salinity (%) | 0.0 | 0.5 | 0.10 ± 0.03 | Dry season |
| Alkalinity (mgl-1) | 42 | 162 | 100.20 ± 9.37 | Dry season |
| Dissolved oxygen (mgl-1) | 7 | 12.7 | 9.08 ± 0.42 | Wet season |
| Biological oxygen demand (mgl-1) | 0 | 28 | 13.11 ± 1.79 | Dry season |
| Chemical oxygen demand (mgl-1) | 6 | 39 | 21.34 ± 2.52 | Dry season |
| Nitrate – nitrogen (mgl-1) | 0.02 | 1.02 | 0.44 ± 0.08 | Wet season |
| Phosphate – phosphorus (mgl-1) | 0.03 | 1.79 | 0.80 ± 0.10 | Wet season |
| Silica (mgl-1) | 2.05 | 9.54 | 5.07 ± 0.45 | Wet season |
| Sodium (mgl-1) | 2.6 | 22.7 | 30.82 ± 6.13 | Dry season |
| Potassium (mgl-1) | 0.1 | 7.6 | 8.71 ± 1.78 | Dry season |
| Calcium (mgl-1) | 34 | 227 | 91.27 ± 17.89 | Dry season |
| Magnesium (mgl-1) | 0.01 | 7.6 | 2.64 ± 0.62 | Dry season |
| Copper (mgl-1) | 0.02 | 0.06 | 0.03 ± 0.001 | Dry season |
| Iron (mgl-1) | 0.12 | 0.99 | 0.35 ± 0.04 | Dry season |
| Zinc (mgl-1) | 0.002 | 0.03 | 0.01 ± 0.001 | Dry season |
| Chromium (mgl-1) | 0.001 | 0.04 | 0.02 ± 0.002 | Dry season |
| Chlorophyll – a (µg/L) | 0.1 | 64.5 | 16.99 ± 7.83 | Dry season |
Stephanocyclus sp
Cyclotella meneghiniana (Kutzing)
  C. striata (Kutz.) Grunow
  C. stelligera Cleve ex Grunow
Coscinodiscus centralis Ehrenberg
  C. eccentricus Ehrenberg
Melosira varians Agargh
Actinoptychus sp
  N. vermicularis Hantzsch
Pinnularia major (Kutz.) Cleve
  P. interrupta W.M.Smith
  P. laevis (Ehr.) Compere
  P. hemiptera (Kutz.) Rabenh.
  P. ambigua Cleve
Pinnularia sp
Navicula oblonga Ehrenberg
  N. radiosa Kutzing
  N. gracilis Ehrenberg
  N. mutica Kutzing
  N. cuspidata Meist
Coconoeis placenta (Ehr.) Cleve
  C. Disculum (Schum) Cleve
*Epithemia sp
Cymbella affinis Kutzing
  C. minuta Hisle ex. Rabenh
Eunotia gracilis Meister
  E. lunaris (Ehr.) Grunow
  E. monodon Ehrenberg
Surirella elegans Ehrenberg
  S. ovata Kutzing
Fragilaria construens Ehrenberg
*Gomphonema parvulum Kutzing

DIVISION: CHLOROPHYTA
CLASS: CHLOROCOCCALES
Pediastrum simplex (Meyer) Lemm
  P. simplex var. echinulatum (Witr.) Lemm
  P. duplex Meyer
  P. duplex var. gracillimum (W. West) Thinmark
  P. tetras (Ehr.) Ralfs
  P. tetras var. tetraodon (Corda) Rabenhorst
  P. boyanum (Turpin) Meneghini
Scenedesmus acuminatus (Lagerh.) Chordat
  S. quadriacuada (Turp.) Breb.
  *S. dimorphus (Turp.) Kutzing
  S. apiculatus (W.et G.S.West) Chordat
  S. arcuatus Lemm.
Ankistrodesmus acicularis (A.Braun) Korsh.
  A. falcatus (Corda) Ralfs.
Tetraedron sp

ORDER II: VOLOLVOCALES
Volvox aureus Ehrenberg

Biddulphia laevis Ehrenberg

ORDER 11: PENNALES
Synedra ulna (Nitzschia) Ehr
  S. acus Kutzing
Nitzschia palea (Kutz) W.M.Smith
  N. closterium (Ehr.) W.M.Smith
  N. acicularis (Kutz.) W.M.Smith
  V. africana Ehrenberg
Eudorina elegans Ehrenberg

ORDER III: ZEGNEMATALES
Staurastrum leptocladium Nordst
Staurastrum paradoxum Meyen
Staurastrum sp
Desmidium swartzi Ag
Microsterias sp
Spirogyra africana (Fritsch) Czurda
Zygnema sp
Closterium ehrenbergii Menegh
  C. aciculare T.West
  C. kuetzingii Breb.
  C. intermidium Ralfs
Spondylosom sp
Cosmarium sp

DIVISION: EUGLENOPHYTA
CLASS: EUGLENOPHICEAE
ORDER: EUGLENALES
Euglena acus Ehrenberg
  E. caudat Hubner
  E. convoluta Korishikor
  E. viridis
  E. polymorpha Dangeard
Euglena spirogyra Ehrenberg
Lepocinolis sp
Phacus accuminatus Stokes
  P. longicauda Duj.
  P. orbicularis Hubner
  P. curvicauda Swir
  P. tortus (Lemm) Skvort
Trachelomonas caudata stein
  T. hispida Lemm
  T. armata (Ehr.) Stein
  T. acanthostoma (St) Deft
Eutreptia sp

DIVISION: CYANOPHYTA
CLASS: CYANOPHICEAE
ORDER I: CHROOCOCCALES
Microcystis aeruginosa Kutzing
  M. flos-aquae Kirchn.
  M. wesenbergii Komark
**Table 3.** A checklist of zooplankton at the Ologe lagoon during the period of (February, 2002 – January, 2004).

<table>
<thead>
<tr>
<th>Phylum/Division</th>
<th>Group/Class</th>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nematoda</td>
<td>------</td>
<td>------</td>
<td>Nematode larvae</td>
</tr>
<tr>
<td>Arthropoda/Crustacea</td>
<td>Cladocera</td>
<td>------</td>
<td>Moina sp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bosminidae</td>
<td>Bosmina longirostris</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holopedidae</td>
<td>Latonopsis occidentalis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polyphemidae</td>
<td>Evadne spinifera, Evadne tergestina, Polyphemus sp</td>
</tr>
<tr>
<td></td>
<td>Cladocera</td>
<td>------</td>
<td>Copepod nauplius, Onchocamptus sp, Harpicticus sp</td>
</tr>
<tr>
<td></td>
<td>Acaritidae</td>
<td>Acartia sp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calanidae</td>
<td>Limnocalanus sp, Sinocalanus dorrii</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cyclopidae</td>
<td>Cyclopina longicornis, Cyclops strenuus, Cyclops varicans, Cyclops vicinus, Eucyclops agilis, Eucyclops bicolor, Eucyclops serrutalus, Eucyclops varicans, Macrocyclops distintus, Mesocyclops sp, Microcyclops sp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diaptomidae</td>
<td>Diaptomus forbesi, Diaptomus wardi, Diaptomus wilsonae</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oithonidae</td>
<td>Limnoithona sinensis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temoridae</td>
<td>Eurytemora affinis, Eurytemora lacustris, Eurytemora lacustris, Temora sp</td>
<td></td>
</tr>
</tbody>
</table>
Mollusca
Gastropoda
---------
Gastropod larvae

Rotifer
Monogononta
----------
Monostyla lunaris
Branchionidae
Branchionus angularis
Branchionus falcatus
Branchionus sp
Keratella quadrata
Keratella sp
Keratella valga

Chordata
Pisces
--------
Fish larvae

Annelida
Polychaeta
--------
Polychaete larvae


<table>
<thead>
<tr>
<th>Indices</th>
<th>Feb-02</th>
<th>Mar-02</th>
<th>Apr-02</th>
<th>May-02</th>
<th>Jun-02</th>
<th>Jul-02</th>
<th>Aug-02</th>
<th>Sep-02</th>
<th>Oct-02</th>
<th>Nov-02</th>
<th>Dec-02</th>
<th>Jan-03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species richness index (d)</td>
<td>1.49</td>
<td>1.23</td>
<td>1.54</td>
<td>1.54</td>
<td>1.50</td>
<td>1.48</td>
<td>1.43</td>
<td>1.35</td>
<td>1.28</td>
<td>1.33</td>
<td>1.40</td>
<td>1.46</td>
</tr>
<tr>
<td>Shannon-Wiener's Index (Hs)</td>
<td>0.67</td>
<td>0.45</td>
<td>0.53</td>
<td>0.50</td>
<td>0.44</td>
<td>0.42</td>
<td>0.49</td>
<td>0.42</td>
<td>0.34</td>
<td>0.39</td>
<td>0.45</td>
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4. Discussion
The modification of the areas around the Ologe lagoon, mainly by way of discharge of effluents may have created eutrophic conditions experienced in the lagoon. According to Nwankwo (1996a), environmental modification creates new environments and in some cases nutrient traps that may induce blooms. The pH of the Ologe lagoon falls within the values recorded for some Nigerian water bodies. For instance, in Kainji lake, 6.3 – 8.4 was recorded by Adeniyi (1978); 5.78 ± 0.83 for Oguta lake Nwadiaro and Umenam (1985), 5.1 – 6.3 for Nworie stream (King and Nkata, 1991). A range of 6.0 – 7.5 was reported by Visser and Villeneuve.
(1975) for West African waters. pH values of the lagoon were essentially slightly alkaline for a good part of the study. Values lower than 7.0 were observed only seldomly in the wet season and at stations closer to Owo River. Chinda and Braide (2003) also recorded alkaline pH for studies in the lower Bonny River.

The low transparency may be connected to the high algal cell counts recorded in the lagoon as well as to biodegradation waste disposed into the lagoon. According to Nwankwo (1996b) seasonal variation in transparency in the coastal water of south-western Nigeria is linked to the rainfall pattern and associated floods from adjoining rivers. Low DO and high BOD$_5$ values recorded in the lagoon all through the sampling period may be due to sewage and other biodegradable waste effect on oxygen consumption during organic matter decomposition. Similar observation was reported by Saad and Antione (1983) in the Ashar canal Iraq. The relatively lower DO values and higher BOD$_5$ in the dry months may be due to elevation of water temperature in the dry season and increased the rate of bacterial decomposition of organic matter in a small man-made West African lake.

Hynes (1960) reported that BOD$_5$ values between 1 mg/L – 2 mg/L or less represent clean water 4 mg/L – 7 mg/L represent slightly polluted water and more than 8 mg/L represent severe pollution. Based on the above criteria, the Ologe lagoon is severely polluted. However according to Odiete et al (2003), chemical measurements reflects water quality at a given time while biological assessment reflects conditions that have exited in a given environment over a long period of time.

The total phytoplankton population in the lagoon was lower in the wet months possibly due to the dilution effect of storm water which diluted ion concentration in water and modified the water chemistry. The occurrence of such species as Nitzschia palea, Gomphonema parvulum, Microcystis aeruginosa, M. flos-aquae, M. wesenbergii (blue-green algae), Scenedesmus obliquus, S. quadricanda (green algae), and Euglena sp(Euglenoids) may be an indication of the level of pollution of the lagoon. It is possible that wastes from surrounding areas may be a major pollution problem particularly in turning the site into a nutrient trap and in prompting the excessive algal growth experienced.

Cholnory (1968) reported that N. palea and C. meneghiniana are nitrogen heterotrophs and that N. palea is a very good indicator of pollution. The observed high level of nutrients and the low heavy metal levels in the lagoon may in part have contributed to the predominance of M. aeruginosa and M. flos-aquae(Gerloff et al. 1952). Furthermore, the prevalence of euglenoids notably E. viridis, E. oxyuris, Lepocinclis texta and P. pyrum may be a further indication of organic contamination. The frequency of rotifers alongside other organisms could be an additional pointer to the level of contamination.

From the data presented in this paper, there is no doubt that the Ologe lagoon is under pollution stress and needs restoration.

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References

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