Macro-invertebrates as Indicator of Water Quality of Egbe Reservoir, Egbe-Ekiti, Nigeria.

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Abstract: A study of the macro-invertebrates and physico-chemical parameters was conducted in Egbe-Reservoir from May – July, 2009. Physico-chemical parameters of the water samples were determined using standard methods. Sampling of macro-invertebrates was done by Kick sampling method and the macro-invertebrates found were identified under light microscope using 10x - 40x magnification. The Macro-invertebrates obtained from the reservoir composed; *Melanoids tuberculata* which has 53.3% by number of total macro-invertebrates, *Biophalaria pfeifferi* 6.7%, *Lymnae natalensis* 22.5%, Leeches 13.3%, Earthworm with 2.5% and Dragon fly larvae with 1.7% by number of total macro-invertebrates. The result showed variation in the physico-chemical parameters at different sampling stations in the reservoir. Temperature ranged from 27.2 to 29.7^{o}C, pH ranged from 4.7 – 8.7, Alkalinity ranged from 5.1 - 14.1 mg$CaCO_3$/L, Biochemical Oxygen Demand, BOD_5 ranged from 2.2 – 6.6 mg/L, Total Suspended Solids, 0.04 – 0.06 mg/L and Total Dissolved Solids, 0.37 – 0.62 mg/L. Statistical analysis of the result showed that there were significant correlations between Biochemical Oxygen Demand and Dissolved Oxygen. Also, there was a significant correlation between Earthworm and pH. The water of Egbe Reservoir was found to be fairly clean and good for consumption from the result recorded during the period of study. It must however be well treated before consumption. The physico-chemical parameters was also found to influence the distribution of macro-invertebrates of the reservoir, hence, they could be used as bio-indicators.

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1. Introduction

The aquatic environment occupies about 79 % of the world's surface. These include ponds, rivers, lakes, seas, and oceans. According to the aquatic ecosystem by Olaniyan (1978) there are three types of ecosystem the marine, brackish and freshwater environment. This classification is based principally on the salinity of the environment. Sharma (1979) stated that for marine, the salinity is 36% while freshwater has less than 1% salinity. Most water bodies in Nigeria are of the freshwater type and many are artificially created in form of reservoir predominantly in the regions where large natural lakes are sparse or unsuitable for human exploitation. Bottom deposits water in a reservoir make significant contribution to the composition of the surface water. Also, the hydrochemistry of a river is governed by the nature of the soil and sedimentary rock constituting the basin. Therefore the abundance and species diversity of the benthic organization could vary with the nature of the soil and sedimentary rock constituting the basin (Palamarchuk and Denisora, 1996). Benthic macro-invertebrates include organisms such as worms, crayfish or the larva stage of many insects that reside near the bottom of streams or lakes. Within the lake and watershed, many different types of macro-invertebrates can be found. These organisms are good indicators of water quality, since they vary in their tolerance to pollution level. Caddisfly, mayfly, stonefly larva, for example have been recognized as indicators of good water quality, since they are unable to survive in polluted water (Darlington, 1977), whereas midge larvae and blood worms can live in areas of poor water quality. The presence of blood worms may not necessary mean that the water is poor but their presence coupled with the absence of mayfly could. Species such as those that help determine the health of an ecosystem are referred to as biological indicator species (Darlington, 1977). Macro-invertebrates organisms form an integral part of an aquatic environment and are of ecological and economic importance as they maintain various levels of interaction between the community and the environment (Anderson and Sedell, 1979). According to Carlisle *et al*. (2007) macro-invertebrate populations in streams and rivers can assist in the assessment of the overall health of the stream. Marques *et al*. (2003) reported that knowledge of the structure of the benthic macro-invertebrates community provides precise and local information on recent events, which can be seen in their structuring. Their abundance and distribution can be influenced by the water quality. Therefore, it is important to study what macro-invertebrates are, their nature in the aquatic and the link between them and the physico-chemical parameters.

2. Material and Methods

Study Area

Geographically, Egbe Reservoir is located in Egbe-Ekiti, Ekiti State. The reservoir serves as a major source of water for the people of Gbonyin Local Government Area of Ekiti State and the Akoko parts of Ondo State. It is also serves as a source of irrigation to farmlands in the suburbs and supports medium-scaled fisheries for local fishermen who depend mainly on the fishery resources of the reservoir.

The reservoir was formed by damming the Osse River, a major river that takes it source from Kwara State and runs through Ekiti to Ondo State. The reservoir was constructed in 1975 and commission in 1989. The transverse survey is 272.5 hectares and the depth of the reservoir is 5.6m. The reservoir is located on an undulating plane and is surrounded by highlands from which runoffs also feed the reservoir during raining seasons. The reservoir lies between latitudes 7^0 36^0 N and 35^0 E of the equator.

The reservoir is surrounded on each side by a stretch of forest made-up of trees like *Chloromora excels* (African teak "Iroko"), *Terminaba superba* (Limba "Afara"), *Senna occidentalis* floating plants include *Certophylum Submersum, Mormodica balsamina* (Balsam Pear), *Commelina diffusa* (water side commelina), *Cyperus articulatus* (Sedge) and *Pista stratiotes*. Weeds at the bank of the reservoir include *Chromolaena odorata* (siam weed), *Aspilia africana* (Bush marigold) and *Cynodon plectostachyum*.

The reservoir also supports a commercial fishery of about twenty fishermen. Fishing daily with traps sets and casts nets, hook and line. Fish species in the reservoir include *Tilapia zilli*, *Oreochromis iniloticus*, *Channa obscura*, *Clarias* species, *Hepsetus odoe* and *Sardinella* species.

Sampling Method

Five sampling stations were selected on the reservoir. Stations 1 was very close to the darn, 2 and 3 were at the extreme edges while station 4 was close to the base of a hill and 5 was at the middle of the reservoir as shown in the map (Figure 1). Sampling was carried out monthly between 8am and 11am in the morning. For the months, May to July 2009.

Field and laboratory determination of physico-chemical parameters of Egbe-Reservoir. The physico-chemical parameters of water determined were Temperature, Dissolved Oxygen (DO_2), Hydrogen-ion Concentration (pH), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS).

Hydrogen ion Concentration (pH)

The materials used were universal paper indicators and pH meter. The paper indicator was used in the determination of pH at the field. The paper indicator was dipped into the water sample and matched against the universal pH colour range on the indicator. The pH value obtained with the paper indicator was later validated in the laboratory using pH meter. The glass electrode was immersed in the water samples collected and the potential difference between them measured (Fredrick, 1972).

Temperature (°C)

The temperature of the surface water at each station was measured with mercury in glass thermometer graduated in degree Celsius (°C). The thermometer was allowed to stabilize for 5 minutes in surface water and the readings were taken while still in water.

Dissolved Oxygen (DO_2)

Determination of dissolved oxygen content of the water were carried out in the laboratory using titrimetric method described by Mackereth (1963); 2 m1 of concentrated hydrochloric acid (HCL) were added to the water samples already fixed with the Winkler's solution. The bottles were shaken thoroughly to dissolved the precipitate formed 50 ml of this solution was placed in a conical flask and titrated with 0.01 m sodium thiosulphate solution from a burette. Three drops of starch solution was added as indicator and titration continues until the blue-black colouration of the starch disappeared. The procedure was repeated twice to obtain the mean (x) volume used. The concentration of dissolved Oxygen was then calculated as follows:

$$\frac{0.056 \text{ x X x } 1000}{50}$$

Where x = volume of thiosulphate used.

Biochemical Oxygen Demand (BOD)

The materials and the same titrimetric method in (DO_2) were used, but the titration was carried out on the fifth day. If the samples for the DO_2 is D_1 (mg/L), the incubated samples contain D_1 -D_5 mg/L.

Total Dissolved Solid (TDS)

Total dissolved solids was obtained by the difference between total solids and total suspended solids (TDS = TS — TSS).

Total Solids (TS)

The total solids (TS) are made up to dissolved solids (DS) and suspended Solid (SS).

TS=DS+SS

A day clean dish was placed in an oven at 103°C and was weighed to a constant weight. It was later cooled down to room temperature in a desiccators and the weight was recorded. 250 m1 of thoroughly mixed water sample was pipetted into a dish and evaporated to dryness on a steam bath. The residue was dried in an oven for about an hour at 103°C. The dish was quickly transferred to a desiccator, cooled to room temperature and weighed and weight was recorded, the dish was returned to the oven, dried further for 20 mins, reweighed after cooling to room temperature.

The procedure was repeated until the weighed of the dish plus residue was constant to within 0.05 mg. The weight of the dish was subtracted from the total weight (i.e. the weight of dish plus residue) to obtain the weight of the total solids.

$$\text{Total solids (mg/L)} = \frac{\text{mg total solids x 1000}}{\text{ML sample}}$$

Total Suspended Solid (TSS)

Ashless filter paper was dried in oven at 103°C to constant weight, and it was cooled down to room temperature in a desiccator and weigh was noted. The filter was placed into the Gooch funnel carefully with the aid of a pair of tongues. The water sample was mixed thoroughly and 250 m1 was withdrawn with a pipette, filtered, and the filter paper was removed, using a pair of tongues from the Gooch funnel. It was then dried in an oven at 103°C to a constant weight. The weight of the filter paper was subtracted from the weight of filter paper plus residue to obtain the weight of the suspended solids.

$$\text{TSS (mg/L)} = \frac{\text{mg. SS x 1000}}{\text{ml sample}}$$

Alkalinity

2 drops of methyl orange was added to 50m1 of water sample in a clean conical flask. It was shook and titrated with 0.02% of HC1 until the colour changed to orange from yellow

The Alkalinity was calculated as:

$$\text{Total alkalinity mg/L} = \frac{V_t \text{ x m x 1000}}{\text{ml sample}}$$

Where V_t = Total volume of acid used for the titration

M = Concentration of the acid

ml sample = volume of the water sample

Collection and Identification of Macro-invertebrate of the Egbe Reservoir

Samples were collected by Kick sampling method. The sediment was collected and sieved out through 1 mm x 1 mm size to collect benthos and was spread on the white tray, after which the macro-invertebrate found were collected and later preserved with 4% formalin in a collecting vial.

The sorting, counting and identification was later done in the laboratory. The identification was done using the manuals of Pennak (1978) and the key to the fresh water snail of West Africa (APHA, 1985). The identification was done using light microscope under the magnification of 10x - 40x.

Data Analysis

Physico-chernical parameters

- The mean and standard error of each of the physicochemical parameters were calculated.
- Correlation coefficient was used to determine interdependence of the parameters.
- Physico-chemical parameters were correlated with the abundance of macro-benthos.

Biological Parameters

1. The monthly percentage occurrence of macro-benthos for each station were calculated.
2. Diversity of the benthic form was determined using Margalef's diversity, Shanon-Wiener and Equitability index (Ajao, 1990 and Zar, 1984).

Shanon-Wiener index is expressed as:

$$Hs = \sum \frac{Ni}{N} \frac{Ni}{\log N}$$

It is a measure of heterogeneity

Margalef index:

This is a measure of species richness and it is expressed as

$$d = \frac{s = 1}{\log_e N}$$

Equitability Index:

This is a measure of how evenly distributed the species are in a sample community. It is expressed as:

$$J = \frac{Hs}{\text{Log}_2 S}$$

Where,

S = Number of species

N = Total number of individuals of species in the sample

N; = Number of individuals of species in the sample

d = Margalef value

Hs = Shanon-Wiener information

J = Equitability measure.

3. Results

Total temperature in the five locations on Egbe Reservoir ranged between 27.2°C at station 3 in May 2009 and 29.72°C at station 4 in June 2009 (Table 1). Temperature was observed to have no significant correlation at 5 % level of probability with any of the measured physico-chemical and biological (macro-invertebrate) parameters. On the other hand, pH of the five locations on Egbe Reservoir range between 4.7 at station 2 in June 2009 and 8.7 at station 4 in July 2009 and showed a positive significant ($p < 0.05$, r 0.616) correlation with biochemical oxygen demand and negative but significant ($p<0.05$, r -0.665) correlation with alkalinity (Table 2). It also exhibits a negative but significant correlation ($p< 0.05$, r - 0.536) with earthworm (Table 3b).

Alkalinity in the five locations on Egbe Reservoir ranged between 149.2 $mgCaCO_3/L$ at station 1 in June 2009 and 102.8 $mgCaCO_3/L$ at station 2 in May 2009. Alkalinity had a mean value of 169.3±66 mgCaCO3/L (Table 1) and had a positive significant ($p<0.05$, $r = 0.653$) correlation with biochemical oxygen demand. It also showed a negative but significant correlation ($p<0.05$, $r = -0.665$) with temperature (Table 2). There was no significant ($p<0.05$) correlation with any of the macro-invertebrates.

Dissolved Oxygen in the five locations on Egbe Reservoir ranged between 5.1 mg/L at station 3 in May 2009, and 14.1 at station 5 with a mean value of 8.4 ±1.2 (Table 1). Dissolved Oxygen had a positive significant ($p<0.05$, $r=0.555$) correlation with only Biochemical Oxygen Demand. No significant ($p<0.05$) correlation was observed between dissolved oxygen and any of the identified macro-invertebrates. Biochemical Oxygen Demand in the five stations on Egbe Reservoir ranged between 2.2 mg/L at station 2 in June 2009 and 6.6 mg/L at station 3 (Table 1) Biochemical Oxygen Demand had a positive significant correlations (p<0.0S, r = 0.6 16, r = 0.653, r = 0.555) with pH, Alkalinity, and dissolved oxygen (Table 2), while it had no significant ($p<0.05$) correlation with any of the identified macro-invertebrates while Total Suspended Solid in the five locations on Egbe Reservoir ranged between 0.04 at station 4 in July 2009 and 0.06 at station 3 in July 2009 with the mean of 0.05±0.1. There was no significant correlation ($p<0.05$) with any of the measured physico-chernical parameters and identified macro-invertebrates. Also, Total Dissolved Solid in the five locations on Egbe Reservoir ranged between 0.37 at station 3 in July 2009 and 0.62 at station 1 in June 2009. It had a mean value of 0.53±0.59 (Table 1). Total Dissolved Solids also had no significant ($p<0.05$) correlation with any of the measured physico-chemical parameters and identified macro invertebrates.

Spatial distributions of the benthic macro invertebrates

The checklist, abundance and percentage composition of macro-invertebrates identified in Egbe Reservior are listed in Table 6. Six (6) macro-invertebrates of the reservoir were dominated by the gastropods with 82.5% of the total number of macro-invertebrates (figure 1). Amongst them, *Melanoides tuberculata* had the highest percentage composition (53.3%), followed by *L. natalensis* (22.5%). The lowest abundant gastropod was *B. pfefferi* which made up 6.7% of the total number of macro invertebrates *M. tuberculata* was not found in station 2 and 3 in May and June respectively and also *B. pfefferi* was not found in station 4 in May and station 3 in July. *L. natalensis* were not found in station 2 and 5 of May and June respectively.

Leeches contributed 13.3% percentage abundance by number of the total macro-invertebrates. Leeches were not found in station 3 and 2 of May and July respectively. Earthworm, the only annelid encountered had 2.5% percentage composition by number of the total macro-invertebrates. Earthworm was not found in station 3 in May and 1 in July. Insect larvae were represented by Dragon fly larvae with the percentage composition of 1.7% by number of the total macro-invertebrates. Dragon fly larvae were not found in stations 2 and 4 in May, station 1 in June and station 3 in July.

It was observed that only earthworm had a negative significant ($p<0.05$, $r = -0.536$) with pH. There was no significant ($p<0.05$) correlation between the identified macro-invertebrates (Table 3a).

Table 1: Monthly mean of physico-chemical of Egbe Reservoir July, 2009

Physico-chemical Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Mean	Standard Error	Range	WHO/FEPA
Temperature °C	28.4	28.3	28.0	28.8	28.3	28.4	±0.3	27.2-29.7	30-32
pH	7.4	7.0	7.6	7.8	7.5			4.7-8.7	7.0-8.5
Alkalinity mg/L	176.5	167.3	170.4	173.4	159.2	169.3	± 6.6	149.2-192.8	20-200
DO_2	8.8	6.3	8.8	8.7	9.3	8.4	± 1.2	5.1-14.1	≥ 5
BOD mg/L	5.3	3.2	5.4	4.3	4.4	4.5	± 0.8	2.2-6.6	≤ 5
TSS	0.05	0.05	0.04	0.04	0.05	0.05	± 0.1	0.04-0.06	≤ 5
TDS	0.56	0.42	0.37	0.40	0.51	0.45	±0.39	0.37-0.62	≤ 200

Table 2: Correlation co-efficients (r) of physico-chemical of Egbe Reservior between the period of May – July 2009

Physic-chemical Parameters	Temperature (°C)	pH	Alkalinity (mgcaco₃L)	Do₂ (mg/L)	BOD (mg/L)	TSS	TDS
Temperature (°C)	1.000	-0.213	-0.132	0.087	-0.033	-0.241	-0.151
PH		1.000	-0.665*	0.126	0.616*	0.497	-0.160
Alkalinity (mgCaC0₃/L)			1.000	0.338	0.653*	0.171	0.249
DO₂(mg/L)				1.000	0.555*	-0.207	-0.049
BOD (mg/L)					1.000	0.307	0.103
TSS						1.000	-0.322
TDS							1.000

Table 3a: Correlation co-efficients (r) between Biological parameters of Egbe Reservior between the period of (May – July 2009)

	M. tuberculata	*Biomphalaria pfeifferi*	Leeches	Earthworm	*L. natalensis*	Dragon fly larva
M. tuberculata	1.000	-0.084	0.082	0.510	0.614*	-0. 502
Biomphalaria pfeifferi		1.000	0.127	0.443	0.138	0.000
Leeches			1.000	0.443	0.138	0.211
Earthworm				1.000	0.031	-0.900
L. natalensis					1.000	-0.500
Dragon fly larva						1.000

Table 3b: Correlation co-efficient (r) value between physico-chemical and biological parameter of Egbe Reservoir.

	M. tuberculata	*Biomphalaria pfeifferi*	Leeches	Earthworm	*L. natalensis*	Dragon fly larva
Temperature (^{0}C)	-0.159	-0.030	0.421	0.436	-0.305	0.107
PH	-0.200	-0.070	-0.507	-0.536*	-0.144	0.105
Alkalinity (mgCaC0$_3$/L)	-0.055	-0.161	-0.021	-0.230	0.022	0.215
DO$_2$(mg/L)	0.218	-0.489	-0.240	0.141	0.086	0.098
BOD (mg/L)	-0.084	-0.241	-0.334	-0.444	0.086	0.016
TSS	-0.126	0.278	-0.056	-0.433	-0.108	0.338
TDS	-0.088	0.289	0.186	-0.227	0.359	-0.135

*Correlation is significant at 0.05 level.

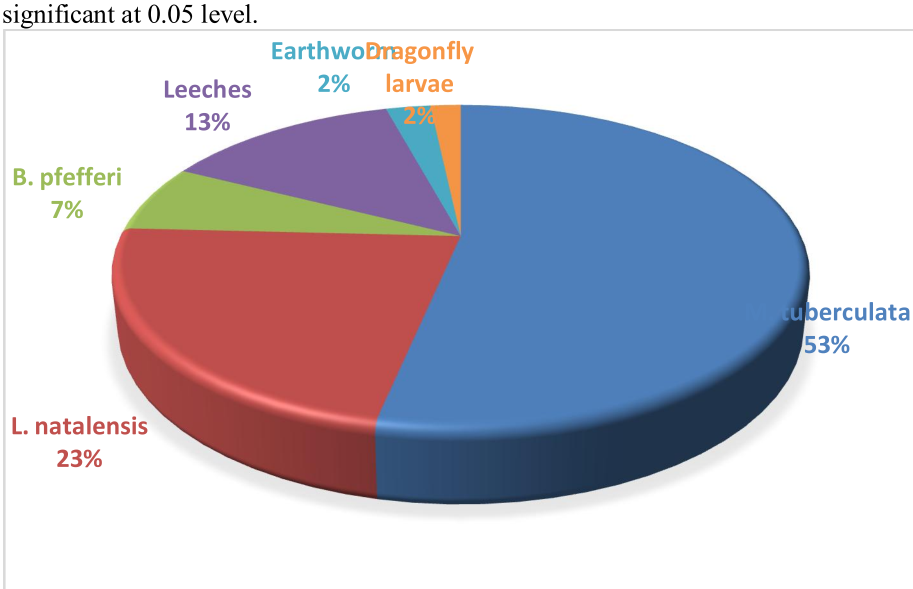

Figure 1: Chat showing the percentage abundance of macro-invertebrates of Egbe Reservoir

Table 4: Shanon-Wiener's index values of macro-invertebrates from the various sampling stations in Egbe Reservior.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
May	0.459	0.440	0.425	0.334	0.572
June	0.552	0.522	0.571	0.524	0.614
July	0.661	0.381	0.302	0.553	0.506

Table 5: Margalef's index values of macro-invertebrates from the various sampling stations in Egbe Reservoir.

Month	Station 1	Station 2	Station 3	Station 4	Station 5
May	0.966	1.019	0.971	0.821	1.610
June	1.033	1.272	1.559	0.259	1.154
July	0.285	0.164	0.151	0.213	0.253

Table 6: Equitability values of macro-invertebrates from the various sampling stations in Egbe Reservoir

Month	Station 1	Station 2	Station 3	Station 4	Station 5
May	0.198	0.220	0.213	0.169	0.246
June	0.238	0.202	0.246	0.226	0.264
July	0.186	0.164	0.251	0.262	0.203

Table 7: Species Diversity of the overall mean of various sampling stations in Egbe Reservoir

Month	Station 1	Station 2	Station 3	Station 4	Station 5
Shanon-Wiener values	1.623	1.340	1.287	1.412	1.689
Margalef values	2.276	2.405	2.679	1.391	2.918
Equitability values	0.726	1.391	0.574	0.604	0.768

Species Diversity and Equitability

Monthly changes in the species diversity of the macro-invertebrates community in the various sampling stations were given in Table 4-6. The tables show that there were no marked changes in species diversity in all the sampling stations. The highest Shanon-Wiener index calculated was in station 1 in July (0.66) while the lowest index was recorded in station 3 (0.30) also in July (Table 4). The Margalef's value was highest in May (1.61) at station 5 and lowest was recorded in station 3 in July (0.15) (Table 5). Table 6 shows that equitability value in station 3 in July (0.15).

The species diversity of the overall mean abundance of macro-invertebrates in all the sampling stations was shown in Table 7, where the highest Shanon-Wiener index was recorded in station 5(1.689), and lowest was recorded in station 3 (1.287). The highest Margalef index was recorded in station 5 (2.918) and the lowest was recorded in station 4 (1.39 1). The lowest equitability value was recorded in station 3 (0.574). Also, the highest equitability index was recorded in station 2 (1.391).

Discussion

Physicochemical Parameters

The monthly mean temperature of Egbe Reservoir ranges from 29. 2 °C - 29.7 °C during the study period and it falls within optimal limit sited by Boyd (1979). Site 4 of the reservoir has the highest temperature of 28. 7 °C, this could be as a result of the fact that the site is close to the site of discharge of waste waters and washouts of the water treatment department of the reservoir. It could also be as a result of absence of trees that can form shade at the sides of the water body. The temperature range in Egbe Reservoir (27.2°C - 29.7°C) falls below WHO/FEPA temperature range during the period of study and this may be due to the cooling effects of the rain as the study period falls within the raining season. Temperature levels that were higher than 32°C exceeded the optimal maximum for fish production as given by Boyd (1979) and WHO. In tropical waters, most organisms live within their temperature tolerance range (30-32°C) and so moderate increases above their optimum temperature would put such population under stress (Ajao, 1990). According to Mason (1991), United States Environmental Protection Agency, USEPA (2009), temperature affects many other parameters in water, including the amount of dissolved oxygen available, the types of plants and animals present, and the susceptibility of organisms to parasites, pollution and diseases. High Dissolved Oxygen levels were recorded in the reservoir during the period of study. This could be due to rigorous aeration of the water due to rapidity of water flow, concomitant with the flood from the rains. This may indicate some relationship between temperature and dissolved oxygen. Aguigwo (1998) also reported a direct relationship between temperature and dissolved oxygen in a productive Nigerian stream while Ugwumba (1990) and Oben (2000) affirmed that there is usually an inverse relationship between temperature and dissolved oxygen. This increase in dissolved oxygen observed in Egbe Reservoir could be due to reduced phytoplankton bloom and reduced decomposition of organic materials taking place at these times of the year. Any observed depression in dissolved oxygen could be due to chemical and biological oxidation process in the water. Lewis (2000) regarded factors that work against oxygen retention in tropical water as the poorer ability of water to hold oxygen at higher temperature than at lower temperature and to the higher rates of microbial metabolism at higher temperature. The dissolved oxygen range in Egbe Reservoir (5.1 mg/L - 14.lmg/L) falls within the WHO/FEPA optimal range for a productive freshwater (5.0) and this shows that Egbe Reservoir is highly productive.

Biochemical oxygen demand values were high during the period of investigation and this supports high organic enrichment of the reservoir (Mason 1990, 1991). The BOD gave a good indication of the effect of the effluent on water. According to Mason (1992), the BOD provides a broad measurement of the effects of organic pollution on a receiving water, because it is a measure of organic matter in water that can be degraded by biochemical reaction (APHA, 1992). The PH. value of the reservoir were within the optimum ranges (7.0-8.5) (WHO / FEPA) and reservoir could be described as having waters of neutral PH with slight fluctuation to alkaline condition and this may be attributable to the cooling and diluting effects of the rains and is typical of tropical waters (Holden and Green, 1960, Egborge, 1970, Adebisi 1981) similar observation were made by Ugwumba (1990) for Awba Lake, Idowu and Ugwumba (2005) and Ayoade et al. (2006). This suggests that Egbe Reservoir is good for fish production. Accumulation of free carbon dioxide due to little photosynthetic activities of phytoplankton will lower the pH value of the water while intense photosynthetic activities of phytoplankton will reduce the free carbon dioxide content resulting in increased pH values (Egborge, 1994; Gupta and Gupta, 2006). Adebisi (1981) stated that pH decreases with rainfall. This may suggest why significant lower mean pH was recorded during the period of study in Egbe Reservoir. The alkalinity obtained for all the five sites fall within 149.2-192.8 $mgCaCO_3/L$. This is also within the optimal range for fish production (20 - 300rngcaco3/L) as classified by Boyd and Lichtkoppler (1979). Also the alkalinity value obtained in Egbe reservoir during the study period fell with WHO/FEPA range for productive freshwater. According to Boyd (1979), the total titrable bases in a water expressed as equivalent CaCO3 as referred to as total alkalinity and for natural waters, values may range from less than 5mg/L to several hundreds mg/L. Natural waters which contain 4O mg/L or more total alkalinity as equivalent calcium carbonate are considered for biological purposes by limnologists as "hard" water, while water with lower alkalinities are said to be "soft" (Moyle, 1945; Boyd, 1976). By the above classification therefore, the reservoir studied can be grouped as hard water since none of the sites in the reservoir had alkalinity levels of below 50 mg/L. Moyle (1946) described hard waters as generally more productive than soft water. Also, waters having hardness values of 1.5Nppm or above according to (Gupta and Gupta 2006) is said to be satisfactory for the growth of fish while values less than 5 ppm CaCO3 equivalent cause show growth, distress and eventual death of fish. The total suspended solids of the studies stations ranges from 0.04 - 0.06 mg/L throughout the period of study total suspended solids in Egbe reservoir still falls with WHO/FEPA range for productive water. Suspended solids are the portions of solids that are retained on a filter paper (Ashless filter paper) under specific condition the TSS of Egbe Reservoir was found to be moderate. Water with high suspended solids is unsatisfactory for bathing, industrial and other purposes (Frondork, 2001). TDS is the term applied to the solids that are in dissolved state in solution. The TDS of Egbe Reservoir was also found to be moderate as the TDS ranges from 0.37 - 0.62 mg/L. This can be due to the fact that these period coincide with the raining season. Water with high dissolved solids generally are of inferior palatability and may induce an unfavourable physiological reaction in the transient consume (Wetzel, 1983).

Qualitative Analysis of Macro-invertebrates

The benthic fauna of the reservoir were observed to be dominated by molluscs of which *M. tuberculata* and *L. natalensis* accounted for the highest percentage. These gastropods were also reported as the dominant molluscs in some studies. Adeleke (1982) recorded *M. tuberculata, L. natalensis* to be dominant in Ibadan (Eleyele reservoir). Idowu and Ugwumba (2005) found M tuberculata to be the dominated molluscs in Eleyele reservoir, Ibadan Adeleke (1982). It has however been reported that molluscs are in tolerant of heavy metal pollution (Murphy, 1979). The result of this study on macroinvertebrate composition and abundance also shows that most of the species are known to be resistant to pollution e.g. Oligochaetae and Hirudinae were poor in representation and their presence coupled with that of mayfly which is a clean water indicator shows that the rate of pollution is low since molluscs could survive in a broad range• of habitats within the reservoir which have been shown to be free or moderately under stress of pollution, it may be concluded that the molluscan populations appeared selected for competitive success. Such was the conclusion drawn from a similar situation in the sites studied by Ajao (1990), Mason (1991), Oben (2000) and Barbour and Gerritsen (2006).

Indices of Benthic Community Structure.

The Shanon-Wiener diversity indices in the locations of the reservoir fell between 0.30 - 0.66. This value according to the classification of Wilhm and Doris (1966) are indicative of not polluted water conditions. They were however closer to the lower end of the range which means they may be tending towards moderately polluted conditions. Equitability values were low, ranging from 0.15 - 0.29 and this indicated the uneven distribution of individual numbers among the species. These low values indicated that the location status in terms of benthic fauna, ranged from not polluted to moderately polluted. The equitability distribution also indicated that the communities in these locations exhibited low dominance also with a small number of species. The varying degrees of species composition in this reservoir also denoted the instability of the environments which suggests a certain degree of pollution (Laws, 1982).

Due to positive significant correlation between physico-chemical parameters and macro-invertebrate, it can be concluded that physico-chemical factors influenced the distribution and abundance of macro-invertebrates to some extent.

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