



Aquatic Macro-Invertebrate Diversity and Abundance in Eleyele Lake, Ibadan, Oyo State, Nigeria

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Abstract

The availability and quality of water system in 21st century plays a vital role in the growth and survival of all living organisms. Eleyele Lake is a general-purpose water body which supplies water to various communities in Ibadan metropolis. This research aimed to investigate the quality of the water using physico-chemical parameters and their influence on the diversity, abundance and distribution of aquatic macro-invertebrates of the lake. Monthly, sample of water and macro-invertebrates from April to September, 2021 at eight sampling points were done, using standard APHA and Winkler's methods. Macro-invertebrates collected were identified using standard identification guides. Relationship between physico-chemical parameters and aquatic macro-invertebrates was determined using Pearson's correlation coefficient (r). Species diversity, taxa richness, evenness and similarity were determined using Simpson, Shannon-Weiner, Margalef, Evenness and Equitability. A total number of 670 macro-invertebrates belonging to 7 orders namely, Hemiptera (47%), Odonata (20%), Diptera, Coleoptera, Lepidoptera, Trombidiformes and Hygrophila were collected and identified during the study period. Positive correlations occurs between BOD, EC, TDS, Nitrate and Phosphate and *Chironomus sp.* Also, pH was positively correlated with *Lestes sp.* and *Aeshna sp.* while DO have negative correlation with *Lethocerus sp.*, *Physa sp.* and *Lymnaea sp.* The physico-chemical parameters and the diversity indices of macro-invertebrates encountered indicated that the lake was moderately polluted and tends toward degradation as a result of indiscriminate discharge of domestic, agricultural and industrial effluents into the Lake. Therefore, proper management of the lake is required to prevent further deterioration.

Keywords: Eleyele Lake, Agricultural and industrial effluents, Aquatic macro-invertebrates, Lake, Physio-chemical.

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INTRODUCTION

The aquatic macro-invertebrates react to modifications in the quality of water (Adeyemo *et al.*, 2008); because they rarely

move around and extended residency period in a given aquatic habitat, therefore, they are index of pollution of aquatic ecosystem thus allowing the integration of past, present and future health condition of the water body (EPA, 2002). The incorporation of index of pollution and physico-chemical assessment has proven to be a more accurate and complete method of evaluating the effect of

pollutants in an aquatic ecosystem (Oliveira and Cortes, 2006).

The important of water cannot be over emphasized considering their usefulness in human activities such as drinking, manufacturing, cultivation of crops and fisheries. Freshwater bodies are faced with environmental pollution making them unhealthy for aquatic organisms and unfit for human use. Anthropogenic such as agricultural activities lead to discharge of domestic wastes, run-off of fertilizers and pesticides into water leading to pollution (Olayinka *et al.*, 2017). Water quality determination for years have been via standard physico-chemical studies because it provides information on the health status of a water body at a given period and not historical information on water quality like biological monitoring.

For a full evaluation of water bodies physico-chemical analysis needs to be conducted along with bio-monitoring tools in order to determine the health status of fresh water ecosystems (Subramanian and Sivaramkrishna, 2007). The biota composition of every aquatic ecosystem is greatly affected by the physico-chemical contents and this goes a long way to affect their diversity. (Ugwumba and Ugwumba, 1993; Mustapha, 2008). The abundance, distribution and diversity of macro-invertebrates' community largely depend on the physico-chemical properties of the water body (Sharma *et al.*, 2004). Habitat destruction and change in climatic conditions are the major parameters responsible for biodiversity loss in freshwater (Abell, 2002; Saunder *et al.*, 2002). Eleyele Lake is a multipurpose lake situated in Ibadan metropolis that provides water for all its surrounding communities for domestic, industrial, agricultural, transportation and fisheries purposes. Unfortunately, the lake is being degraded as a result of indiscriminate

discharge of domestic wastes, industrial and agricultural effluents into the lake. These anthropogenic pollutants have debilitating effect on the biotic community of the lake and also render the water unfit for human use.

This study was conducted to assess the health status of the Eleyele lake using various physico-chemical parameters and their influence on the diversity and abundance of aquatic macro-invertebrates as bio-indicator of the current health status of the water body. Some earlier studies had established the utilization of abundance of macro-invertebrates as index of pollution in freshwater ecosystem (Komolafe and Imoobe, 2015; Albert *et al.*, 2016).

MATERIALS AND METHODS

Description of study area

The study area spread across Eleyele Lake found in Ibadan, Oyo State, Nigeria. Eleyele lake is located in the North-West of Ibadan City and surrounded by Apete in the East, Awotan in the North and Ologuneru in the North-West. In 1939 when River Ona was dam this give rise to the construction of Eleyele lake. It has an altitude of 125m above sea level and lies between Latitude 7°25'30"-7°26'30" N and Longitude 3°51'30"-3°52'30" E. (Imevbore, 1967). The lake has an average depth of 6.0 m and covers a total area of about 14.4 km with elevation range of 166 m and 127 m, respectively. The water body is reach in macro-faunas such as water spider, freshwater snail and tilapia fish Others are snout fish and white little egret. Tall well populated vegetation surrounds the lake. Anthropogenic activities occurring in and around the lake, includes car washing, block making, cloth washing, bathing, automobile repairing, fishing, agriculture and boat transportation.

Sample Collection

Water sample collection and analysis

Monthly water sampling was done from April 2021– September 2021 using 8 sampling points marked A to H (Figure 1) using 1L plastic containers. Sampling was done between the hours of 8 am to 12 noon at each point of the lake. However, samples were not collected in August due to overgrown aquatic weeds that covered the surface of the Lake during the period. The water samples collected were transported to the laboratory for immediate analysis in order to preserve

physico-chemical properties. The water temperature and transparency were determined in-situ using mercury-in-glass thermometer and Secchi disc respectively. Dissolved Oxygen (DO), Hydrogen ion concentration (pH), Electrical Conductivity (EC) and Total Dissolved Solid (TDS) were determined ex-situ using Hanna Portable Meter, while Biological Oxygen Demand (BOD) was determined using standard Titrimetric method. Nitrate, phosphate and sulphate were analyzed using UV Spectrophotometer

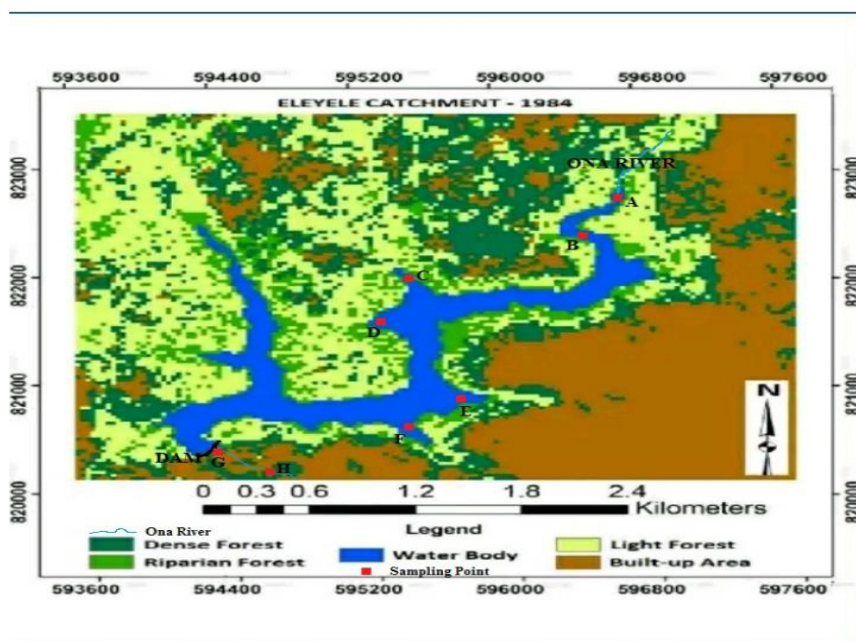


Fig 1: Map of Eleyele Lake with the eight sampling points (A-H).

Data Analysis

Aquatic Macro-invertebrates Collection and Identification

Aquatic macro-invertebrates were collected from water surface at each sampling points using a dip-net of 500- μ m mesh size at different sampling points and swirled for about 2-3 minutes to allow for the entrance of adult and immature stages of the macro-invertebrates. Sweep net of 250- μ m mesh size was also used to collect macro-invertebrates

like adult odonates from riparian vegetation around the lake. The net was swept over the vegetation for 2-3 minutes and all collected macro-invertebrates were sorted and preserved in pre-labelled specimen jars containing 40% alcohol. All samples collected were taken to Entomology Laboratory Department of Zoology, University of Ibadan for analysis.

Benthic Macro-Fauna Collection

Van Veen Grab with a surface area of 66.6 m² was used in the collection of micro-invertebrates from sediment, the samples were emptied into a pre-labelled polythene bag and taken to the laboratory for washing and sorting using sieves of mesh size of 0.1mm and 0.5 mm to remove detritus from the macro-invertebrates. The sorted macro-invertebrates were stored into 40% alcohol solution. All the collected samples were identified using standard aquatic identification keys of Yule and Yong, 2004; Subramanian and Shivaramkrishnan, 2007; Merritt and Cummins, 2008; Thorp and Roger, 2011.

Statistical Analysis

Data were managed using SPSS 2017. Analysis of Variance (ANOVA) was used to test for the statistical differences between the means of the physico-chemical parameters of the eight sampling points. Duncan Multiple Range Test (DMRT) was used for the multiple comparisons of the means of the physico-chemical parameters in order to determine the similarities between the sampling points. Pearson Correlation Coefficient (r) was used to determine the relationship between physico-chemical parameters and also to determine the relationship between aquatic macro-invertebrates and physico-chemical parameters of the water. Ecological indices were determined using PAST 4.0. Species abundance, diversity, distribution and similarities were determined using Shannon-

Weiner index (H), Simpson (D), Margalef index (d), Pielou's Evenness (E) and Jaccard similarity index (J) respectively.

RESULTS

Physico-chemical parameters of water sample

The mean, minimum and maximum, values of the physico-chemical parameters of each sampling point of Eleyele Lake is presented in Table 1. The trend in the pattern of each physico-chemical parameters was similar across the eight sampling points. The highest mean value of temperature and transparency were recorded at point C (Lake Midpoint), while the highest mean value for the DO and BOD was recorded at point G (Lake Outlet). The highest level of pH, TDS, EC, nitrate and sulphate were recorded at point A (Lake Inlet). The lowest value for transparency and EC were observed at point E (Lake midpoint) and G (Lake outlet) respectively.

Analysis of Variance of the physico-chemical parameters revealed that all the parameters were not significantly different ($p>0.05$) across all the sampling points as shown in Table 2. Pearson's correlation coefficient (r) shows the relationship between the physico-chemical parameters recorded in Eleyele Lake as presented in Table 3. The result revealed that DO and temperature correlated negatively, $r = 0.648$. TDS also had inverse relationship with transparency, $r = 0.599$ while nitrate and phosphate had direct correlation with TDS.

Table 1. Mean variation values of physico-chemical parameters measured at the eight sampling points along Eleyele Lake between April to September, 2021

Parameters	Inlet		Mid point			Outlet			F – Value
	Point A	Point B	Point C	Point D	Point E	Point F	Point G	Point H	
Temperature (°C)	24.80± 0.91 (24.00- 26.25)	24.60± 1.47 (22.50 - 26.50)	25.20± 1.07 (24.00-26.50)	24.90± 0.94 (24.00 - 26.25)	24.95± 0.89 (24.25 - 26.50)	25.05± 1.00 (24.00 - 26.50)	25.05± 0.97 (24.00 - 26.50)	25.30± 0.81 (24.50- 26.25)	0.23
Transparency (m)	3.85± 2.64 (1.50 - 8.25)	4.45± 2.68 (1.75 - 8.50)	4.55± 2.30 (1.75 - 7.25)	4.85± 2.12 (2.75 - 7.25)	2.75±0.82 (1.75 - 4.00)	2.70± 0.73 (1.75 - 3.75)	2.85± 1.24 (1.50 - 4.50)	4.40± 2.57 (1.75 - 7.75)	0.96
PH	6.93± 0.16 (6.75- 7.19)	7.04± 0.43 (6.70- 7.78)	6.95± 0.24 (6.65-7.20)	6.94± 0.27 (6.50- 7.20)	7.09± 0.38 (6.60- 7.60)	6.87± 0.32 (6.4- 7.23)	6.93± 0.43 (6.57- 7.70)	6.99± 0.19 (6.75- 7.19)	0.23
DO (mg/L)	2.85± 1.24 (1.25- 4.44)	2.46± 1.39 (0.60- 4.44)	2.19± 0.61 (1.35-2.81)	3.07± 1.2 (1.40- 4.43)	3.43± 3.03 (0.55- 8.05)	3.02± 2.12 (0.40- 5.26)	3.57± 2.85 (0.91- 8.46)	2.80± 1.04 (1.60- 4.43)	0.3
BOD (mg/L)	1.09± 1.11 (0.24- 2.95)	0.84±0.64 (0.28- 1.63)	0.65± 0.73 (0.10-1.85)	1.07± 0.78 (0.25- 2.20)	1.82± 2.54 (0.27- 6.27)	0.97± 1.16 (0.10- 2.82)	1.60± 2.18 (0.01- 5.10)	1.09± 0.75 (0.27- 2.30)	0.37
EC (µs/cm)	331.80± 25.12 (309.00- 370.00)	320.00± 31.47 (290.00- 370.00)	319.0±32.68 (285.00- 370.00)	322.50± 26.25 (300.00- 360.00)	323.40± 28.28 (295.00- 370.00)	320.80± 30.96 (390.00- 370.00)	318.20± 21.42 (290.00- 350.00)	320.40± 31.27 (285.00- 370.0)	0.11
TDS (ppm)	207.80± 51.17 (156.00- 272.50)	205.20± 49.60 (156.00- 269.00)	202.8± 49.65 (155.50- 267.00)	202.80± 48.93 (154.00- 262.00)	206.50± 48.89 (156.50- 268.00)	203.50± 47.22 (155.50- 265.00)	201.00± 41.16 (158.50- 250.00)	201.10± 45.24 (155.00- 260.00)	0.13
Nitrate (mg/L)	21.71± 2.67 (18.82- 24.06)	22.15± 2.14 (18.61- 23.91)	19.78± 4.82 (11.96-23.73)	19.38± 4.66 (11.73- 22.74)	20.14± 4.87 (11.97- 23.78)	19.78± 4.56 (11.88- 22.95)	19.73± 5.16 (11.28- 23.76)	19.60± 4.95 (11.57- 23.50)	0.28
Phosphate (mg/L)	0.54± 0.21 (0.34- 0.81)	0.54± 0.22 (0.32- 0.83)	0.58± 0.16 (0.39-0.79)	0.59± 0.14 (0.46- 0.80)	0.57± 0.15 (0.42- 0.78)	0.53± 0.13 (0.36- 0.79)	0.58± 0.19 (0.35- 0.79)	0.59± 0.18 (0.40- 0.79)	0.81
Sulphate (mg/L)	0.22± 0.23 (0.01- 0.61)	0.31± 0.26 (0.01- 0.66)	0.07± 0.87 (0.01-0.21)	0.10± 0.10 (0.01- 0.25)	0.08± 0.13 (0.00- 0.32)	0.13± 0.13 (0.01- 0.32)	0.12± 0.15 (0.01- 0.35)	0.09± 0.09 (0.00- 0.21)	1.26

Note: Values are Mean ± Standard Deviation (Range in Parenthesis).

Table 2. Physico-chemical Parameter of Water Samples from Eleyele Lake Sampled between April to September, 2021

Parameters	Inlet			Mid-point			Outlet	
	Point A	Point B	Point C	Point D	Point E	Point F	Point G	Point H
Temperature(°C)	24.85 ^a	24.60 ^a	25.25 ^a	24.90 ^a	24.95 ^a	24.95	25.05 ^a	25.05 ^a
Transparency(m)	3.85 ^a	4.45 ^a	4.55 ^a	4.85 ^a	2.75 ^a	2.70 ^a	2.85 ^a	4.40 ^a
pH	6.93 ^a	7.04 ^a	6.95 ^a	6.94 ^a	7.09 ^a	6.87 ^a	6.93 ^a	6.99 ^a
DO (mg/L)	2.85 ^a	2.46 ^a	2.19 ^a	3.07 ^a	3.43 ^a	3.02 ^a	3.57 ^a	2.80 ^a
BOD (mg/L)	1.09 ^a	0.84 ^a	0.65 ^a	1.07 ^a	1.82 ^a	0.97 ^a	1.60 ^a	1.09 ^a
EC	331.80 ^a	320.00 ^a	319.00 ^a	322.50 ^a	323.40 ^a	320.80 ^a	318.20 ^a	320.40 ^a
TDS (ppm)	207.80 ^a	205.20 ^a	202.80 ^a	202.80 ^a	206.50 ^a	203.50 ^a	201.00 ^a	201.10 ^a
Nitrate (mg/L)	21.72 ^a	22.15 ^a	19.78 ^a	19.38 ^a	20.14 ^a	19.78 ^a	19.73 ^a	19.60 ^a
Phosphate(mg/L)	0.54 ^a	0.54 ^a	0.58 ^a	0.59 ^a	0.57 ^a	0.53 ^a	0.58 ^a	0.59 ^a
Sulphate(mg/L)	0.22 ^a	0.31 ^a	0.78 ^a	0.10 ^a	0.86 ^a	0.13 ^a	0.12 ^a	0.99 ^a

Note: The similar superscript across the row shows that there is no significant difference ($p < 0.05$) indicated by Duncan Multiple Range Test.

Table 3. Pearson’s Correlation (r) values between the physico-chemical parameters within the sampled points in Eleyele Lake from April to September, 2021

Parameters	Tempt.	Transp.	pH	DO	BOD	EC	TDS	Nitrate	Phosphate	Sulphate
Temperature										
Transparency	-0.527									
PH	-0.322	0.444								
DO	-0.648*	0.550	0.688*							
BOD	-0.583*	0.414	0.630*	0.978*						
EC	-0.510	0.430	0.438	0.405	0.414					
TDS	0.182	-0.599*	-0.264	-0.579	-0.550	0.148				
Nitrate	0.448	-0.515	-0.467	-0.848*	-0.824*	0.009	0.875*			
Phosphate	0.766*	-0.815*	-0.334	-0.486	-0.347	-0.523	0.286	0.391		
Sulphate	-0.333	0.303	0.003	-0.140	-0.316	-0.308	0.012	0.030	-0.439	-

Note: significant relationship is asterisked; *- significant difference ($p < 0.05$); **- significant difference at ($p < 0.01$)

Aquatic Macro-invertebrates of Eleyele Lake

The macro-invertebrates collected from the sampling points were presented in Table 4. A total of 670 individual macro-invertebrate species belonging to seven (7) orders were collected and identified during the sampling period. The percentage composition of macro-invertebrates recorded were point A (22%), point B (10%), point C (14%), point D (8%), point E (10%), point F (11%), point G (12%) and F (13%) as shown in Figure 2. The Order Hemiptera had the highest percentage abundance (47%), followed by Odonata (20%) and Diptera (15%) as shown in Figure 3. Perason’s correlation coefficient between the physico-chemical parameters and the macro-invertebrates is shown in Table 5. The TDS

correlated positively with *Chironomus sp* and *Culex* among others. While, nitrate had positive correlation with *Diplonychus sp.*, and others species. DO, transparency and temperature performance can be vided in table 5 as well.

The ecological indices such as the diversity, taxa richness, dominance and evenness of the macro-invertebrate species collected across all the sampling points were shown in Table 6. The Shannon index showed that point G (Lake Outlet) had the highest species diversity, taxa richness and evenness, while, the Simpson index revealed that point A had the highest species dominance. The Equitability and Evenness indices showed that all the macro-invertebrates collected from each sampling point are equally and evenly distributed.

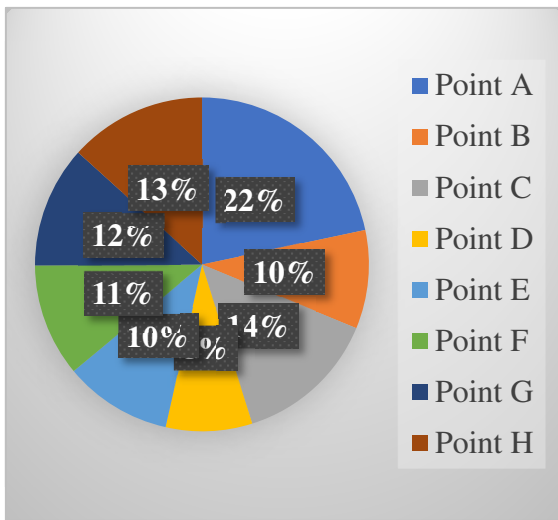


Figure 2. Percentage distribution density of Aquatic Macro-invertebrates recorded at Eleyele Lake from April to September, 2021.

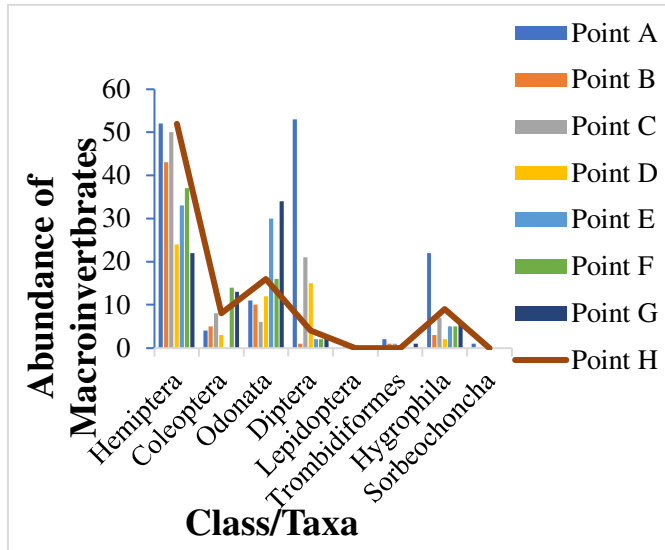


Figure 3: Distribution and abundance of aquatic macro-invertebrates in the study areas between April to September 2021.

Table 4. Composition and distribution of aquatic macro-invertebrates encountered in the sampling points in Eleyele Lake from April to September, 2021

	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)	G (%)	H (%)	TOTAL (%)
Hemiptera									
Notonectidae	12 (8.27)	-	12 (12.90)	3 (5.36)	8 (11.43)	1 (1.35)	5 (6.33)	1 (1.12)	42 (6.27)
Gerridae	5 (3.45)	3 (4.69)	6 (6.45)	2 (3.57)	-	2 (2.70)	1 (1.27)	-	19 (2.84)
Mesoveliidae	6 (4.14)	11 (17.19)	-	-	5 (7.14)	5 (6.76)	-	21 (23.59)	48 (7.16)
Belostomatidae	25 (17.24)	22 (34.37)	28 (30.10)	18 (32.14)	20 (25.13)	26 (35.14)	14 (17.72)	28 (31.46)	181 (27.01)
Velidae	-	4 (6.25)	-	-	-	-	2 (2.53)	-	6 (0.90)
Pleidae	4 (2.76)	-	-	-	-	-	-	-	4 (0.60)
Corixidae	-	-	2 (2.15)	1 (1.79)	-	-	-	1 (1.12)	4 (0.60)
Nepidae	-	1 (1.56)	-	-	-	-	-	-	1 (0.15)
Naucoridae	-	2 (3.16)	2 (2.15)	-	-	3 (4.05)	-	1 (1.12)	8 (1.19)
Coleoptera									
Noteridae	-	1 (1.56)	-	1 (1.79)	-	3 (4.05)	5 (6.33)	1 (1.12)	11 (1.64)
Hydrophilidae	1 (0.69)	2 (3.13)	2 (2.15)	2 (3.57)	-	9 (12.16)	1 (1.27)	4 (4.49)	aq (3.13)
Gyrinidae	1 (0.69)	2 (3.13)	5 (5.38)	-	-	-	5 (6.33)	2 (2.25)	16 (2.39)
Dytiscidae	2 (1.38)	-	1 (1.08)	-	-	-	2 (2.53)	1 (1.12)	6 (0.90)
Psephenidae	-	-	-	-	-	1 (1.35)	-	-	1 (0.15)
Odonata									
Coenagrionidae	6 (4.14)	10 (15.63)	3 (3.23)	8 (14.29)	15 (21.43)	13 (17.57)	26 (32.91)	12 (13.48)	93 (13.88)
Aeshnidae	3 (2.07)	-	1 (1.08)	1 (1.79)	9 (12.86)	-	-	-	14 (2.09)
Chlorocyphidae	1 (0.69)	-	-	-	-	-	-	-	1 (0.15)
Platynecmidae	-	-	1 (1.08)	-	-	-	-	-	1 (0.15)
Cordulidae	-	-	-	-	-	1 (1.35)	-	-	1 (0.15)
Gomphidae	-	-	1 (1.08)	1 (1.79)	2 (2.86)	2 (2.70)	1 (1.27)	-	7 (1.04)
Lestidae	1 (0.69)	-	-	2 (3.57)	1 (1.43)	-	3 (3.79)	-	7 (1.04)
Libellulidae	-	-	-	-	3 (4.29)	-	4 (5.06)	4 (4.49)	11 (1.64)
Diptera									
Chironomidae	52 (35.86)	1 (1.56)	21 (22.58)	15 (26.79)	2 (2.86)	2 (2.70)	3 (3.79)	4 (4.49)	100 (14.93)
Culicidae	1 (0.69)	-	-	-	-	-	-	-	1 (0.15)
Lepidoptera									
Nymphalidae	-	1 (1.56)	-	-	-	-	-	-	1 (0.15)
Trombidiformes									
Hydrachnidae	2 (1.38)	1 (1.56)	1 (1.08)	-	-	-	1 (1.27)	-	5 (0.75)
Hygrophila									
Planorbidae	12 (8.28)	1 (1.56)	1 (1.08)	-	3 (4.29)	2 (2.70)	4 (5.06)	7 (7.89)	30 (4.48)
Physidae	10 (6.89)	2 (3.13)	6 (6.45)	1 (1.79)	1 (1.42)	3 (4.05)	2 (2.53)	2 (2.25)	27 (4.03)

Table 5. Pearson correlation coefficient values (r) between the means of the physico-chemical parameters of water and aquatic macro-invertebrates encountered at Eleyele Lake from April to September, 2021

	Temp	Transp	pH	DO	BOD	EC	TDS	Nitrate	Phosphate	Sulphate
<i>Gerris sp.</i>	-0.577	0.513	0.186	0.513	0.535	0.825*	-0.200	-0.312	-0.647*	-0.362
<i>Neogris sp.</i>	-0.146	0.753*	0.547	0.464	0.394	0.417	-0.446	-0.300	-0.300	-0.054
<i>Mesovelia sp.</i>	0.261	-0.135	0.447	0.112	0.051	-0.167	0.123	-0.091	0.005	0.069
<i>Belostoma sp.</i>	0.097	0.083	-0.073	0.176	0.110	-0.572	-0.471	-0.523	-0.154	0.227
<i>Lethocerus sp.</i>	-0.064	0.325	0.321	-0.225	-0.324	0.546	0.457	0.529	-0.332	0.284
<i>Diplonychus sp.</i>	0.642*	-0.062	0.121	-0.019	0.042	0.075	-0.020	0.123	0.460	-0.658*
<i>Appasus sp.</i>	-0.378	0.518	0.284	0.102	-0.100	-0.154	-0.131	-0.158	-0.600*	0.931**
<i>Abedus sp.</i>	0.577	-0.078	-0.557	-0.454	-0.443	-0.354	0.029	0.363	0.442	-0.135
<i>Microvelia sp.</i>	-0.378	0.518	0.284	0.102	-0.100	-0.154	-0.131	-0.158	-0.600*	0.931**
<i>Rhagovelia sp.</i>	-0.577	0.096	0.186	0.235	0.138	-0.236	-0.010	-0.205	-0.237	0.747*
<i>Striduvelia sp.</i>	-0.378	-0.392	-0.041	0.206	0.280	-0.154	0.119	-0.111	0.290	0.047
<i>Neoplea sp.</i>	-0.378	0.427	0.608*	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Naucoris sp.</i>	0.146	0.472	-0.078	-0.131	-0.278	-0.417	-0.330	-0.044	-0.128	0.583
<i>Pelocoris sp.</i>	0.539	-0.538	-0.520	-0.514	-0.495	-0.293	0.596*	0.574	0.413	-0.152
<i>Ranatra sp.</i>	-0.378	0.518	0.284	0.102	-0.100	-0.154	-0.131	-0.158	-0.600*	0.931**
<i>Corixa sp.</i>	0.354	0.223	-0.076	0.223	0.262	-0.361	-0.806*	-0.567	0.187	-0.363
<i>Hydrocanthus sp.</i>	-0.227	-0.545	-0.413	-0.085	-0.036	-0.309	0.401	0.174	0.307	0.146
<i>Hydrophilus sp.</i>	0.000	0.617*	0.186	0.116	-0.031	-0.354	-0.582*	-0.330	-0.237	0.578*
<i>Tropisternus sp.</i>	-0.378	0.518	0.284	0.102	-0.100	-0.154	-0.131	-0.158	-0.600*	0.931**
<i>Derallus sp.</i>	0.389	-0.503	-0.598*	-0.449	-0.414	-0.177	0.591	0.536	0.313	-0.208
<i>Berosus sp.</i>	0.378	0.290	-0.041	0.050	0.060	-0.309	-0.631	-0.274	0.290	-0.174
<i>Dineutus sp.</i>	0.167	-0.080	0.000	0.226	0.291	-0.442	-0.496	-0.380	0.511	-0.192
<i>Gyrinus sp.</i>	-0.354	0.106	0.303	0.341	0.243	-0.217	0.023	-0.182	-0.061	0.516
<i>Coptotomus sp.</i>	-0.180	-0.197	0.366	0.555	0.647*	0.000	-0.169	-0.391	0.371	-0.360
<i>Thermonectus sp.</i>	-0.378	0.427	0.608*	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Psephenus sp.</i>	0.378	-0.392	-0.689*	-0.644	-0.641*	-0.154	0.668*	0.749*	0.290	-0.002
<i>Ceragrion sp.</i>	-0.473	-0.224	0.145	0.132	0.147	0.026	0.279	0.069	0.107	0.299
<i>Enallagma sp.</i>	0.378	-0.347	0.284	0.206	0.240	-0.309	-0.081	-0.291	0.290	-0.315
<i>Ischnura sp.</i>	-0.236	-0.443	-0.421	0.001	0.118	-0.270	-0.093	-0.201	0.202	-0.104
<i>Coenagrion sp.</i>	0.375	-0.380	-0.563	-0.739*	-0.705*	0.179	0.797*	0.915	0.228	-0.147
<i>Perinecmis sp.</i>	0.378	-0.347	-0.041	-0.592*	-0.540	0.000	0.318	0.494	0.290	-0.013
<i>Aeshna sp.</i>	-0.250	0.519	0.590*	0.513	0.516	0.816*	-0.091	-0.126	-0.279	-0.416
<i>Anax sp.</i>	0.378	-0.347	-0.041	-0.592*	-0.540	0.000	0.318	0.494	0.290	-0.013
<i>Coryphaesna sp.</i>	-0.378	0.245	-0.365	0.171	0.200	0.154	-0.381	-0.373	-0.469	-0.113
<i>Chlorocypha sp.</i>	-0.378	0.427	0.608	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Coeliccia sp.</i>	0.378	0.290	-0.041	0.050	0.060	-0.309	-0.631	-0.274	0.290	-0.174
<i>Dorocordulia sp.</i>	0.378	-0.392	-0.689*	-0.644*	-0.641*	-0.154	0.668*	0.749*	0.290	-0.002
<i>Ichtiogomphus sp.</i>	0.378	0.290	-0.041	0.050	0.060	-0.309	-0.631	-0.274	0.290	-0.174

<i>Lanthus sp.</i>	-0.378	-0.392	-0.041	0.206	0.280	-0.154	0.119	-0.111	0.290	0.047
<i>Hegenius sp.</i>	0.180	-0.214	-0.212	-0.481	-0.419	0.073	0.122	0.292	0.052	-0.065
<i>Ophiogomphus sp.</i>	0.378	-0.392	-0.689*	-0.644*	-0.641*	-0.154	0.668*	0.749*	0.290	-0.002
<i>Miniagiolestes sp.</i>	-0.180	0.068	-0.366	-0.118	-0.067	0.147	-0.211	-0.120	-0.309	-0.113
<i>Lestes sp.</i>	-0.500	-0.248	0.161	0.370	0.444	0.153	0.157	-0.122	0.162	-0.073
<i>Pachydiplax sp.</i>	-0.285	-0.481	0.031	0.259	0.342	-0.232	0.099	-0.185	0.364	-0.032
<i>Sympetrum sp.</i>	0.378	-0.347	0.284	0.206	0.240	-0.309	-0.081	-0.291	0.290	-0.315
<i>Croceipennis sp.</i>	0.378	-0.347	-0.041	-0.592*	-0.540	0.000	0.318	0.494	0.290	-0.013
<i>Erythemis sp.</i>	0.539	-0.495	0.096	-0.465	-0.400	-0.147	0.264	0.331	0.413	-0.162
<i>Chironomous sp.</i>	-0.320	0.573	0.506	0.579	0.597*	0.843*	-0.220	-0.249	-0.363	-0.491
<i>Culex sp.</i>	-0.378	0.427	0.608*	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Actinote sp.</i>	-0.378	0.518	0.284	0.102	-0.100	-0.154	-0.131	-0.158	-0.600	0.931**
<i>Planorbis sp.</i>	-0.190	0.164	0.722*	0.622*	0.638*	0.620*	0.086	-0.207	-0.128	-0.454
<i>Gyraulus sp.</i>	0.103	-0.443	0.407	-0.025	0.076	0.461	0.558	0.358	0.321	-0.451
<i>Menetus sp.</i>	-0.378	0.427	0.608*	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Physella sp.</i>	-0.158	0.500	0.576	0.528	0.515	0.613	-0.152	-0.170	-0.157	-0.349
<i>Physa sp.</i>	0.577	-0.565	-0.557	-0.944**	-0.902**	-0.118	0.754	0.949**	0.442	-0.011
<i>Lymnaea sp.</i>	0.000	-0.078	-0.309	-0.321	-0.260	0.118	-0.048	0.092	-0.137	-0.096
<i>Pleurocera sp.</i>	-0.378	0.427	0.608*	0.501	0.500	0.926**	0.119	-0.036	-0.378	-0.362
<i>Africallagma sp.</i>	-0.191	-0.355	-0.211	-0.382	-0.428	-0.312	0.510	0.428	0.132	0.659*
<i>Anisop sp.</i>	-0.180	0.543	0.558	0.500	0.504	0.733	-0.187	-0.164	-0.222	-0.427
<i>Enithares sp.</i>	-0.180	0.219	0.250	0.170	0.171	0.807*	0.430	0.322	-0.222	-0.345
<i>Notonecta sp.</i>	0.128	0.191	0.261	0.133	0.219	0.287	-0.345	-0.112	0.238	-0.451
<i>Rhagadotarsus sp.</i>	0.192	0.368	-0.103	-0.045	-0.117	-0.275	-0.308	-0.015	0.114	0.215
<i>Hydrachna sp.</i>	-0.324	0.520	0.264	0.533	0.061	-0.318	-0.210	0.214	0.153	-0.334

(Abbreviation meaning: Temp- Temperature, Trans- Transparency)

Significant correlations are asterisk, * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level

Table 6. Diversity and other indices of Aquatic Macro-invertebrate in the study areas of Eleyele Lake from April to September, 2021

	Point A	Point B	Point C	Point D	Point E	Point F	Point G	Point H
No. of Taxa	18	15	16	13	12	14	16	15
No. of Individuals	145	64	93	56	70	73	79	90
Simpson Dominance (D)	0.17	0.17	0.16	0.18	0.15	0.17	0.15	0.17
Shannon (H)	2.20	2.20	2.20	2.04	2.12	2.17	2.34	2.13
Taxa richness (d) Margalef	3.41	3.36	3.30	2.98	2.58	3.03	3.43	3.11
Evenness (E)	0.50	0.60	0.56	0.59	0.69	0.62	0.65	0.56
Equitability (J)	0.76	0.81	0.79	0.79	0.85	0.82	0.84	0.78

DISCUSSIONS

The values of water temperature recorded in this study ranged from 22.50°C and 26.5°C during the sampling period was within the temperature range of tropical freshwater reported by Komolafe and Imoobe (2020). The variation in the temperature recorded was as a result of the low intensity of sunlight radiating on the water surface across all the sampling points. Low ambient temperature and heavy rainfall that enters and mix with the water body may also contribute to the low values of temperature observed during the sampling period. The result of the temperature revealed that temperature plays an important role in the diversity and abundance of aquatic macro-invertebrates, as more species were collected in points (A, C, G and H) where temperature values were higher. Similar result was reported by Popoola and Otalekor (2011) during their study at Awba Reservoir. Analysis of the Pearson's correlation coefficient (r) between physico-chemical parameters showed that temperature correlated negatively with DO (r= -0.648). Pearson's correlation also revealed that temperature correlated positively with majority of the macro-invertebrates encountered. This is because the abundance, growth and reproduction of aquatic macro-invertebrates are at maximum when the temperature is optimum.

The highest transparency values observed at the reservoir midpoint (C and D) was as a result of the shallowness of these points as both sites were closer to the edge of the lake. This result was corroborated by the presence of high abundance of macrophytes observed at these points which receive sufficient sunlight for their growth compared to other points. The lowest transparency values recorded at the Lake midpoint (E and F) was due to high input of industrial wastes

from the plastic and palm oil factory, organic wastes from dumpsite and spent oil spillage from automobile workshop taking place at these two points.

The pH values recorded ranged from 6.60-7.60 which is slightly acidic to slightly alkaline. This result is in consonant with the study of Olagbemide (2017) during the assessment of quality index of Eleyele Lake. Pearson correlation revealed that *Chironomus* sp. and *Belostoma* sp. had inverse relationship with pH and this was confirmed by the high abundance of these species at the Lake inlet (point A) where the pH was low. This was because many tolerant species such as *Chironomus* sp. due to availability of hemoglobin in them are seldom affected by low water pH (Popoola and Otalekor, 2011).

The variation in the concentrations of DO was inversely related to variation in temperature. This was substantiated by the result of analysis of the Pearson correlation coefficient (r) which showed a significant negative relationship (r= - 0.648*) between DO and water temperature (P<0.05). This observation was in agreement with reports of Popoola and Otalekor (2011); and Rim-Rukeh (2013), who stated that high temperature causes reduction in the concentration of DO. The vital role of DO in the diversity and distribution of aquatic macro-invertebrates was strongly confirmed in this investigation. Highest species diversity and richness was recorded in the Lake outlet at point G where the concentration of DO was highest. The low level of DO recorded at the Lake inlet (point B) was as a result of influx of organic wastes from various anthropogenic activities such as discharge of spent oil from automobile workshop into this point which form films at the water surface that prevent atmospheric oxygen from diffusing into the water thus leading to deterioration of the water body. *Sympetrium* sp. and *Pachydiplax* sp. correlated positively with DO. This finding

was in line with what was reported earlier in a study in Aiba stream in Iwo where species in Family Lestidae correlated positively with DO.

The high phosphate level concentration observed in Lake outlet at Point H and Lake midpoint at point D may be attributed to the high impact of run-off from household sewage and agricultural wastes such as fertilizer and pesticide from nearby farms. . The dominance of *Chionomus sp.* at the Lake inlet (point A) is indicative of the high nutrient due to the input of organic wastes in the area. This is supported by the studies of Arimoro *et al.* (2007) and Popoola and Otalekor (2011) who reported that the abundance of *Chironmus sp.* is associated with heavy load of organic sewage discharged into water body.

Analysis of the diversity indices revealed that the point A (Lake inlet) had the highest number of individual species followed by the Lake midpoint (point C) and then point H (Lake outlet). The high species diversity observed in these points might be attributed to the availability of sufficient nutrients in these sites which promote good vegetative growth and in turn provide food source for the aquatic macro-invertebrates.

The result of the Simpson's index showed that all the points have low dominance since the values are much lesser than 1 and closer to 0 (Jorgensen *et al.*, 2005). The Shannon values of all the sampling points ranges from 2.04 – 2.34 which denotes medium or moderate diversity (Jorgensen *et al.*, 2005). The overall Evenness value across the points indicates an intermediate distribution which revealed that the macro-invertebrates are moderately distributed because the values recorded were average.

The Margalef index showed that point G (Lake Outlet) was more stable than other points and this corroborate the highest oxygen concentration recorded in this site. According

to Jorgensen *et al.*, (2005), Margalef value greater than 5 indicates an integrated/undisturbed species community; a value ranging from 2-5 denotes a semi-disturbed community while values less than 1 means the community is disturbed. The overall Margalef index in this study revealed that all the sampling points had Margalef values greater than 3 but less than 5 which indicated that the macro-invertebrate community of Eleyele Lake is fairly or moderately disturbed/stable. The higher values of Equitability observed across all the sampling points indicated that there was high uniformity in the composition of macro-invertebrates found across all the points.

CONCLUSION

The diversity, abundance and distribution of aquatic macro-invertebrates in Eleyele Lake is highly influenced by variation in the physico-chemical parameters observed and recorded during this study. With The Shannon value for the macro-invertebrates recorded indicates a moderate level of species diversity of the reservoir. Furthermore, the abundance of the macro-invertebrates perfectly depicts that the reservoir was fair or moderately polluted. This was because these species are those that can tolerate a fairly degraded water body..also the complete absence of some sensitive species confirmed the pollution status of the lake.

With reference to the results of the physico-chemical parameters and the diversity indices obtained in this investigation, it may be concluded that Eleyele water still remain as a sanctuary of macro-invertebrate. However, their population is being threatened by pollution. Owing to the pollution status of the lake, strict conservation measures should be put in place in order to prevent further deterioration of the water body

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