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Spatio-Temporal Distribution and Abundance of Zooplankton Fauna in Relation to Physico-Chemical Characteristics of Ede-Erinle Reservoir

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Abstract- The study determined the seasonal and spatial variation in the species diversity and abundance of zooplankton fauna in Ede-Erinle reservoir. This was with the view to determining the effects of the physico-chemical characteristics of water on the zooplankton distribution and abundance in the reservoir. A total of 22,628 zooplankters comprising 101 species, 57 genera and five (5) groups (viz. rotifers, cladoceras, copepods, ostracods and dipterans) were collected and identified. The rotifers were the most specious (57 species) while the ostracods were the least (4 species). The copepods were the most abundant (44.8%) while the Dipteran larvae (0.20%) were the least abundant. All the classes of zooplankton occurred in all the stations monitored except the dipteran larvae which were not found in two stations. However, spatial distribution of species varied significantly ($p < 0.05$) within each class. In contrast, all zooplankton classes occurred in the two all seasons, but seasonal species distribution also differed significantly ($p < 0.05$). Conductivity, TDS, BOD_5, Ca^{2+}, SO_4^{2-} and pH correlated significantly ($p < 0.05$) with the abundance of some zooplankton species. The study concluded that the distribution of zooplankton species in Ede-Erinle reservoir was significantly ($p < 0.05$) influenced by some key physico-chemical factors.

Index Terms- Hydrobiology, Aquatic life, Zooplankton, Water quality, Biodiversity

I. Introduction

Zooplankton are microscopic drifting animal-like organisms found either at or near the surface of water bodies. Ovie (2011) defined zooplankton as the free-floating, aquatic invertebrates, which are microscopic because of their usual small sizes that range from a few to several micrometres, rarely exceeding a millimetre. Global aquatic ecosystem can be broadly classified using salinity into Freshwater ecosystem and salt water ecosystem, both of which support zooplankton growth. Freshwater ecosystems are inland waters in which reservoirs fall in to and they have low concentration of salts (< 599mg/L). The saltwater ecosystem has high concentration of salt (averaging about 3.5%) (Tideman, 2000). Freshwater habitats can be further divided into two broad groups, the lentic and lotic ecosystems based on the differences in the water residence time and flow velocity (Wetzel, 2001). Freshwater zooplanktons in the tropics comprise predominantly of rotifers, cladocerans, copepods and occasionally the ostracods and insects (Fernando, 2002).

In the hierarchy of the food web, the zooplanktons are the major mode of energy transfer between phytoplanktons and other aquatic animals including fish. They are, thus, the most important biotic components influencing all the functional aspects of all aquatic ecosystems, viz; food chains, food webs, energy flow/transfer and cycling of matter. Generally, they play an important role in fish nutrition, both in aquaculture and capture fisheries. Suresh *et al.* (2011) reported that different environmental factors that determine the characters of water have great importance upon the growth and abundance of zooplankton. Thus, water quality influences zooplankton abundance, clustering and biomass.

Most of the zooplankton species are cosmopolitan in distribution. Many zooplanktons, particularly the Cladocera, exhibit marked diurnal vertical migrations moving away from direct sunlight while the horizontal spatial distribution of zooplankton in lakes is often uneven and patchy (Wetzel, 2001). Pelagic zooplanktons such as cladocerans and copepods also migrate away from littoral areas (avoidance of shore movements) by behavioural swimming responses to angular light distributions. Non-random dispersion of zooplankton is caused by water movements.

The distribution of zooplankton communities depends on many factors, some of which are change of climatic conditions, physico-chemical parameters and vegetation cover. The change in water quality and limnological characteristics from riverine to middle transition and to lacustrine environments create distinct habitats which have bearing on the distribution and abundance of distinct biota inhabiting each zone (Sthapit *et al*., 2008). For example, calanoida are generally abundant in oligotrophic environments while cyclopoids and cladocerans dominate in eutrophic waters (Margaleff, 1983; Wetzel, 1990). Zooplankton abundances range from less than one individual per litre in most oligotrophic waters to up to 500 individuals per litre in eutrophic lakes (Goldman and Horne, 1983).

Zooplankton species succession and spatial distribution result from differences in ecological tolerance to various biotic and abiotic environmental parameters (Marneffe *et al*., 1998). Studies have shown that the zooplankton community is sensitive to extreme variation in flow; thus species composition is changed and the succession of taxa is redirected after flow recession (Tavernini, 2008). This results in different timing for the emergence of rotifers, cladocerans, and copepods from the inundated dry river beds (Jenkins *et* al., 1980; Boulton, 2003). Therefore, a subdivision of diversity in hierarchical scales in stream ecosystems will result from these factors, which represent the interaction of physical and biological processes. In such water bodies, specific adaptations and strategies are important to cope with the variable and commonly extreme conditions (Seminara *et al*., 2008), and such mechanisms may lead to the spatial and temporal segregation of the zooplankton fauna.

Among the factors that influence species distribution, abundance and composition of zooplankton, physical and chemical characteristics have been observed to be the most important (Sousa *et al*., 2008; Vieira *et al*., 2009). For example, temperature determines the distribution of zooplankton in water column of lakes. (Wetzel, 2001; Kubar *et al*., 2005) and also influence their densities (Masundire, 1994). Temperature is known to have a direct effect on zooplankton populations by influencing reproductive activity, the rate of moulting and the rate of egg development, (Wetzel, 1975; Hutchinson, 1967). These activities all increase as the temperature rises in the spring. Also, high water transparency increases the euphotic zone in an aquatic ecosystem which in turn favours phytoplankton growth and primary productivity. Any factor that enhances the production of phytoplankton is most likely going to enhance the production of zooplankton also, since the latter are nutritionally dependent on the former.

According to Rajagopal *et al*., (2011) zooplankton plays an integral role and serves as bio-indicator and it is a well-suited tool for understanding water pollution status. Zooplanktons play important role in bioremediation of heavy metals and other toxic materials, biomonitering of water pollution (Tyor *et al*., 2014) and act as biomarker for water quality assessment for fish production (Pradhan *et al*., 2008; Purushothama *et al*., 2011; Hoxmeier and Wahl, 2004). Zooplankton communities are typically diverse, occurring almost in all lakes and ponds and are highly sensitive to environmental variation. Hence, zooplankton can speak to condition of water body and can be used to assess overall lake health.

In order to properly manage reservoirs or lakes, monitoring of zooplankton communities is needed to predictively model the ecosystem (Deborah and Robert, 2009). This study was motivated by the need to establish an ecological relationship between the fluctuating physico-chemical water condition and the biotic component of Ede-Erinle reservoir, using its zooplankton fauna as an index.

II.MATERIALS AND METHODS

The Study Area

Erinle Lake is the largest of all water bodies in Osun State, Nigeria. It has many tributaries of which the major inflow rivers, Awon and Erinle, are the main sources of water. The lake basin which is about 342 km extends in width from Longitude 4° 24' E to 4° 35' E and in length from Latitude 7° 45' N to 7° 58' N. The lake itself is located at Longitude 4° 27' E and 7° 46' N (Fig. 1). The surrounding vegetation has a mixture of savannah, light and thick forest, with scattered cultivations due to various human activities (Akinbuwa, 1999). The substratum of the lake is muddy and sandy with scattered logs of wood. The surface area is about 1.25 km (Akinbuwa, 1999); the highest depth of 7.6m was recorded during the study. The sampling points on the lake are shown in (Figure 1).

Selection and Description of Sampling Stations

A reconnaissance survey of Ede-Erinle Reservoir was conducted to identify sampling stations based on important ecological landmarks. Eight sampling sites (Stations A-H) were established along the course of the Reservoir for investigation in this study. Four of the sampling sites (A-D) were established on the reservoir while the remaining four sampling sites (Stations E-H) were established on the two major inflows with Stations E and F located on River Erinle and Stations G and H located on River Awon. A Global positioning system (GPS) handset was used to determine the grid coordinates of the sampling sites.

Sample Collection and Field Determinations

Field collection from the sampling stations was conducted four times from September 2014 to June 2015, covering both the dry and rainy seasons. The samplings were conducted in September 2014 (rain season), December 2014 (early dry season), March 2015 (dry season) and June 2015 (early rainy season). Air temperature and water temperature (using mercury in glass thermometer), pH (using pH meter), conductivity (using conductimeter), water depth and transparency (using glossy white secchi disc) were each measured *in situ*. Samples for dissolved oxygen (DO) and five-day biochemical oxygen demand (BOD_5) were collected in transparent and amber 250 ml reagent bottles respectively. Dissolved oxygen samples were fixed in the field immediately on collection with Winkler's reagents (Manganate sulphate) and (Alkali iodide). BOD_5 samples were collected in black reagent bottles and kept in the dark cupboard at room temperature (about 27 $\pm$ 2ºC) for 5 days after which they were treated as described for oxygen determination. Water samples were collected in sterile capped containers (2.0 L plastic bottles) and returned to the laboratory for the analysis of other parameters using both instrumental and non-instrumental methods according to standard methods by APHA *et al*. (1998).

Zooplankton Sampling

Zooplankton distribution and abundance were assessed by straining 30 L of water through a 25 cm diameter zooplankton net with a 45 μm mesh size to a concentrated volume of 30 ml. This was preserved in 4% formalin. Zooplankton species in 3 ml concentrate subsample were identified and counted under the scanning (x40) and low power (x100) magnifications. Identification was done using the descriptive keys of Akinbuwa (1999); Alekseev (2002); Brooks (1959) and Edmondson (1959); Cander-Lund and Lund (1995); Durand and Lévêque 1980; Egborge (1994); Korinek (2002); Kutikova (2002); Jeje and Fernando (1982; 1986; 1991); Turner and Da Silva (1992); Victor (2002); Wilson and Yeatman (1959).

Community structure was assessed using the indices of species diversity, Simpson's dominance index (S). Abundance of each species was estimated based by multiplying the number in the final concentrate volume (30 ml for 30 Litres) by 1000 and expressed as Organism per m^3 (Org/m^3).

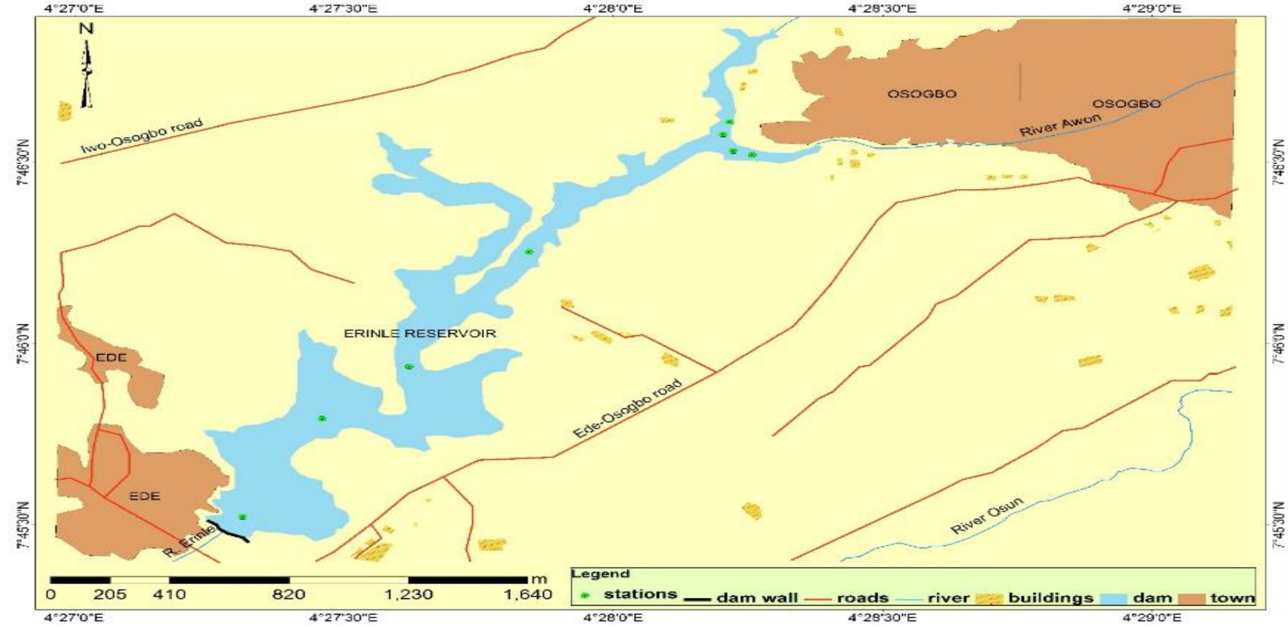

Figure 1: Map of study area showing sampling points

Statistical Analysis of Data

All the data obtained were subjected to appropriate statistical methods using SPSS version 17.0 software. Statistical methods such as Analysis of variance (ANOVA), Cluster Analysis (CA), Correlation and Regression analysis were used as applicable. Analysis of variance (ANOVA) was used to find and identify levels of significance and establish the spatio-temporal variation in water physicochemical parameters. Correlation and Cluster Analysis (CA) were used to show the relationship and association amongst the zooplankton fauna group and water quality parameters accordingly while Regression Analysis was used to show the effect of the physicochemical parameters on the zooplankton fauna.

III. RESULTS AND FINDINGS

The Spatio-Temporal Effect of Physical and Chemical Parameters on the Abundance of Zooplanktons in Ede-Erinle Reservoir

The results of a correlation and regression analyses of the relationship between the various physico-chemical parameters and abundance of zooplankton species are presented in Tables 4.43 and 4.44 respectively.

Abundance of Cladocera and copepod were both positively and significantly correlated with ambient air temperature, pH, conductivity, transparency, TDS and bicarbonate ions. Conversely, they were both negatively and significantly related with turbidity, organic matter, Mg^{2+}, sulphate, ($p < 0.05$) as shown in Table 4.43. Also, cladocera had a significant relationship with pH, total acidity, K^{+}, hardness ($p < 0.05$). Organic matter favoured the abundance of Diptera ($p < 0.05$). Phosphate, Ca^{2+}, hardness were found to be significantly related with ostracod and rotifers were discovered to be related with ambient air temperature, conductivity, transparency, BOD, TDS, TS, Ca^{2+} and sulphate ($p < 0.05$). Also observed, was the positive association between cladocera and copepods. Similar positive relationship was observed between rotifers and copepods too.

The regression analysis revealed that the predictors accounted for over 65% of the zooplankton's abundance in cladoceras, copepods and rotifers (Table 4.44). Also all the predictors significantly affect the abundance of the planktons at ($p < 0.05$).

4.1 Zooplankton Groups Abundance Relationship Using Cluster Analysis

Figure 4.5 shows the cluster plot of the relationship among zooplanktons groups abundance of Ede-Erinle Reservoir. There are two major clusters observed; the first comprised of dipteras, ostracods and cladoceras while the second comprised of copepods and rotifers.

The result of the cluster analysis showing the relationship among the zooplankton species abundance based on the sampling stations of Ede-Erinle reservoir during the study period is presented in figure 4.6 ($p = 0.05$). There are two major clusters in which the first comprises stations A, C, D, E, F, G and H while station B forms a single cluster.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e
A	1																														
B	0.339**	1																													
C	0.390**	0.065	1																												
D	0.311*	0.214	0.513**	1																											
E	0.144	-0.422**	0.393**	-0.058	1																										
F	0.083	-0.270*	0.455**	0.016	0.881**	1																									
G	-0.540**	-0.258*	-0.543**	-0.565**	-0.311*	-0.356**	1																								
H	-0.379**	-0.196	-0.327**	-0.375**	-0.205	-0.131	0.295*	1																							
I	-0.220	0.025	-0.338**	0.041	-0.467**	-0.384**	0.085	0.631**	1																						
J	0.009	0.222	-0.029	0.281*	-0.375**	-0.439**	-0.150	-0.110	0.184	1																					
K	-0.380**	-0.246	-0.125	-0.273*	-0.054	-0.103	0.291*	0.311*	0.084	-0.005	1																				
L	-0.039	0.293*	-0.342**	-0.122	-0.532**	-0.466**	0.313*	0.032	0.172	-0.155	0.073	1																			
M	0.172	-0.391**	0.429**	-0.032	0.996**	0.897**	-0.341**	-0.211	-0.472**	-0.410**	-0.069	-0.501**	1																		
N	-0.183	-0.096	-0.119	-0.252*	-0.069	-0.071	0.066	0.296*	0.197	0.000	0.137	0.019	-0.094	1																	
O	-0.013	-0.432**	0.220	-0.212	0.732**	0.623**	-0.204	0.070	-0.224	-0.301*	-0.005	-0.398**	0.714**	0.582**	1																
P	-0.188	-0.223	0.174	-0.044	0.268*	0.473**	-0.089	0.284*	0.048	-0.420**	0.120	-0.171	0.296*	-0.025	0.198	1															
Q	0.326**	0.331**	0.179	0.033	-0.068	0.082	-0.235	-0.089	0.059	-0.155	-0.118	0.248*	-0.024	0.097	0.028	0.265*	1														
R	-0.233	-0.510**	-0.072	-0.210	0.638**	0.403**	-0.018	-0.049	-0.223	0.093	0.050	-0.568**	0.575**	0.255*	0.657**	-0.076	-0.424**	1													
S	-0.047	0.099	-0.230	-0.292*	-0.515**	-0.592**	0.500**	0.138	0.050	0.286*	0.202	0.011	-0.553**	0.094	-0.357**	-0.281	-0.162	-0.109	1												
T	-0.622**	-0.155	-0.324**	-0.332**	-0.165	-0.076	0.316*	0.512**	0.264*	-0.200	0.426**	0.096	-0.172	0.397**	0.133	0.380**	-0.012	0.050	-0.017	1											
U	0.072	0.253*	0.276*	0.156	-0.037	0.233	-0.251*	0.108	0.114	-0.487**	-0.031	0.304*	0.037	-0.045	-0.041	0.543**	0.540**	-0.609**	-0.471**	0.309*	1										
V	0.334**	0.355**	-0.020	0.333**	-0.408**	-0.247*	-0.371**	-0.103	0.187	0.061	-0.245	0.282*	-0.383**	0.152	-0.221	-0.098	0.145	-0.438**	-0.108	-0.153	0.224	1									
W	-0.710**	-0.221	-0.639**	-0.529**	-0.472**	-0.500**	0.828**	0.442**	0.290*	0.112	0.382**	0.160	-0.523**	0.313*	-0.172	-0.077	-0.336**	0.126	0.593**	0.541**	-0.377**	-0.229	1								
X	-0.170	0.029	-0.097	0.024	-0.124	-0.104	0.389**	0.132	0.107	-0.248*	0.438**	0.184	-0.112	-0.194	-0.249*	0.095	0.000	-0.276*	0.210	0.096	0.120	-0.186	0.219	1							
Y	-0.149	-0.262*	0.178	-0.043	0.284*	0.484**	-0.079	0.282*	0.061	-0.425**	0.089	-0.178	0.309*	-0.031	0.208	0.943**	0.241	-0.057	-0.271*	0.346**	0.505**	-0.119	-0.076	0.110	1						
Z	-0.238	-0.416**	-0.184	-0.343**	0.320*	0.066	0.240	0.026	-0.179	0.232	0.150	-0.515**	0.243	0.281*	0.419**	-0.213	-0.471**	0.860**	0.414**	0.037	-0.800**	-0.457**	0.420**	-0.145	-0.192	1					
a	0.444*	0.285	0.408*	-0.079	0.370*	0.520**	-0.386*	-0.144	-0.229	-0.372*	-0.211	0.071	0.423*	-0.105	0.252	0.286	0.564**	-0.209	-0.468**	-0.048	0.627**	0.009	-0.595**	-0.139	0.418*	-0.430*	1				
b	0.377*	0.011	0.321	-0.150	0.660**	0.673**	-0.384*	-0.059	-0.263	-0.377*	-0.173	-0.203	0.690**	-0.081	0.473**	0.309	0.324	0.134	-0.540**	-0.124	0.310	-0.215	-0.561**	-0.121	0.391*	-0.150	0.747**	1			
c	0.172	0.046	-0.055	-0.122	0.073	0.058	-0.008	-0.056	0.070	0.371*	-0.043	-0.278	0.057	-0.051	0.009	-0.122	0.176	0.072	-0.041	-0.280	-0.236	0.114	-0.036	-0.139	-0.085	0.045	0.017	0.119	1		
d	0.060	-0.193	-0.014	-0.087	0.179	0.099	-0.112	0.144	-0.054	0.216	-0.121	-0.443*	0.149	0.341	0.341	0.025	-0.168	0.396*	0.172	0.042	-0.313	-0.127	0.074	-0.284	0.013	0.453**	-0.186	-0.038	-0.002	1	
e	0.380*	-0.061	0.206	-0.047	0.624**	0.349*	-0.291	-0.216	-0.430*	-0.218	-0.165	-0.245	0.622**	-0.019	0.462**	0.088	-0.045	0.355*	-0.207	-0.216	-0.123	-0.313	-0.400*	-0.057	0.086	0.223	0.235	0.530**	-0.182	0.303	1
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

A- Air Temp., B- Water Temp., C- pH, D- Water Depth, E- Conductivity, F- Transparency, G- Turbidity, H- DO, I- BOD, J- Organic Matter, K- Nitrate, L- Phosphate, M- TDS, N- TSS, O- TS, P- Alkalinity,Q- Acidity, R- Ca^{2+}, S- Mg^{2+}, T- Na^{+}, U- K^{+}, V- Cl^{-}, W- SO_4^{2-}, X- App Colour, Y- Bicarbonate, Z- Hardness, a- Cladocera, b- Copepod, c- Diptera, d- Ostracod, e- Rotifer

Table 4.44: Regression Indices of the relationship between Zooplankton Groups and Different Explanatory variable investigated at Ede-Erinle Reservoir.

Zooplankton Groups	Predictor Parameters	a	b	r
Cladocera	Water Temp.	-1487.980	37.772	0.891
	pH		8.361	
	Transparency		1.327	
	Turbidity		2.381	
	Organic Matter		-9.987	
	TDS		-0.419	
	Acidity		4.882	
	Mg^{2+}		-14.347	
	K^+		36.479	
	Sulphate		-2.933	
	Hardness		5.625	
	Copepod		0.292	
Copepod	Water Temp.	-2697.053	82.731	0.822
	Conductivity		7.858	
	Transparency		-2.005	
	Turbidity		-0.752	
	Organic Matter		-42.775	
	TDS		-10.259	
	TS		0.041	
	Mg^{2+}		-33.060	
	Sulphate		-2.587	
	Bicarbonate		12.251	
	Cladocera		1.68	
	Rotifer		0.277	
Diptera	Organic Matter	0.315	0.039	0.392
Ostracod	Phosphate	13.219	-1.168	0.522
	Ca^{2+}		-0.432	
	Hardness		0.457	
Rotifer	Air Temp.	-1305.196	50.758	0.831
	Conductivity		-6.048	
	Transparency		-18.355	
	BOD		-34.027	
	TDS		22.052	
	TS		0.550	
	Ca^{2+}		-5.345	
	Sulphate		3.680	
	Copepod		0.717	

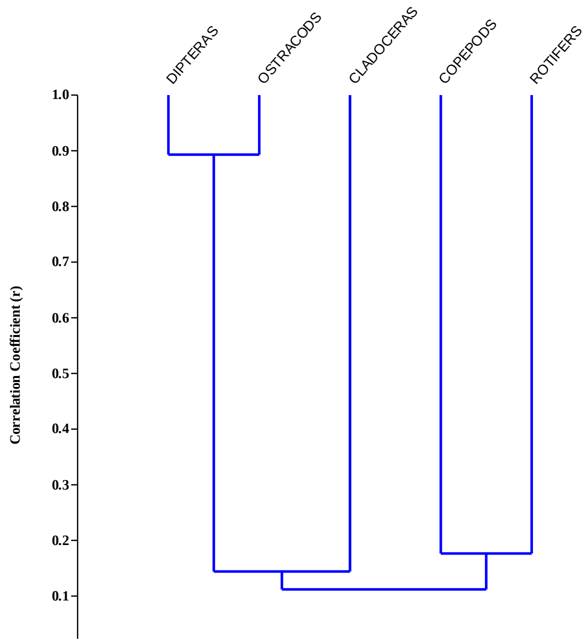

Figure 4.5: Cluster Analysis Showing the Relationship Among the Zooplankton Groups Abundance at Ede-Erinle Reservoir During the Study Period (0.9385).

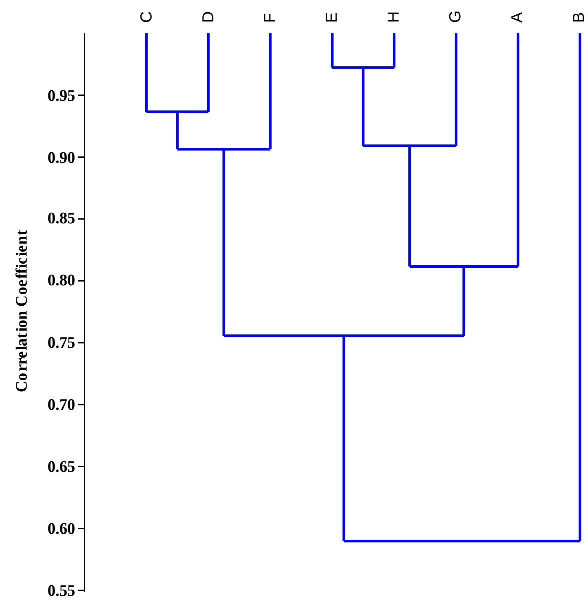

Figure 4.6: Cluster Analysis Showing the Relationship of the Zooplanktons Species Abundance Along the Horizontal Axis of Ede-Erinle Reservoir (R = 0.8537).

IV. DISCUSSION

Influence of Physico-Chemical Characteristics on Zooplankton Diversity and Abundance

Zooplankton assemblages respond rapidly to different water quality conditions, most importantly so to temperature, conductivity, pH, light intensity, and nutrient concentration (Wetzel, 2001). Several authors have noted that it is difficult to designate a single abiotic factor as significantly limiting (Kaartvedt and Svendsen, 1995; Buyukates and Roelke, 2005; Abo-Taleb, 2010). They all, however, concluded that such processes are mainly controlled by a combination of factors acting at different rates throughout the year. Surprisingly, our findings in Ede-Erinle reservoir did not completely agree with this basic assumption. For instance, the current investigation found that most physico-chemical parameters varied both spatially and temporally in tandem with patterns of zooplankton variation. The regression analysis also revealed predictor variables accounting for as much as 65% of the zooplankton's abundance in cladoceras, copepods and rotifers and also that all the predictors significantly affected the abundance of the planktons at ($p < 0.05$).

Rotifers abundance was significantly related to TS, and Ca^{2+}, probably as a result of ionic and nutrient enrichment of the reservoir from the inlet tributaries. TS showing positive relationship could be as a result of rotifers being able to tolerate turbid waters more than other predatory crustaceans that feed on them, thereby leading to increase in rotifer population. BOD_5 showed negative relationship with rotifers and this suggests the amount of organic nutrients dissolved in water. This suggests why some rotifer families have low density or total absence at various times. The dominance of Brachionidae, Lecanidae and Trichocercidae (nutrient loving and unstable environment tolerant rotifer families) in the Ede-Erinle reservoir could also be attributed to this enrichment which could in effect lead to algal bloom. Heiskary and Markus, 2001 established that water bodies with high nutrients exhibited high chlorophyll *a* and high BOD while those with low nutrients exhibited the inverse. These relationships should prove useful for nutrient criteria development, determining the reservoir trophic status and waste load allocations (where excess nutrients and dissolved oxygen are of primary concern). Rotifers are usually considered to be useful indicators of water quality and of trophic status (Whitmana *et al*., 2004; Baiao and Boavida, 2005). According to many studies (Duggan *et al*., 2001; Mageed, 2007; Salvador, 2007) the presence of genus *Brachionus* is indicative of moderate to high organic pollution. Also other genera observed during this study (*Keratella* and *Rotaria*) are cosmopolitan, eurythermic freshwater and indicates eutrophic conditions (Tackx *et al*., 2006; Mageed, 2007). *Trichocerca* are likely to be found in eutrophic environments (Castro *et al*., 2005).

Rotifer, Cladocera and Copepod abundance all had a positive significant relationship with ambient air temperature, conductivity, transparency and TDS. Atmospheric temperature rises with emergence of sunlight and it easily influences temperature of the upper layer of waterbodies and hence will lead to increase in water temperature (Welch, 1952). Temperature is known to have a direct effect on zooplankton populations by influencing reproductive activity, the rate of moulting and the rate of egg development, (Wetzel, 1975; Hutchinson, 1967). These activities all increase as the temperature rises. Water transparency is the limit of visibility in the water. Light intensity has been said to be one of the important factors affecting zooplankton distribution and abundance (Aduwo, 2008). High water transparency increases the euphotic zone in an aquatic ecosystem which in turn favours phytoplankton growth and primary productivity. Any factor that enhances the production of phytoplankton is most likely going to enhance the production of zooplankton also, since the latter are nutritionally dependent on the former. The higher the total dissolved solids (TDS), the higher the conductivity. Zooplankton species diversity is also shown to decrease with conductivity (Tavsanoglu *et al*., 2015).

Copepod and cladocera were still further positively related to pH and bicarbonate. Also, cladocera further showed positive relationship with K^+, hardness. An increase in pH could lead to corresponding increase in zooplankton occurrence as most of the zooplankton species are alkaline water species as suggested by Akinbuwa (1988; 1999). During the study period, the Ede-Erinle reservoir recorded an overall pH mean range of 6.41 - 7.99 (7.20 $\pm$ 0.36) which is slightly alkaline. pH values recommended range for aquatic life as documented by Chapman and Kimstach, 2006 is "6.0 - 9.0" and values outside this range could negatively affect the distribution and abundance of zooplankton in the reservoir.

Copepods and cladoceras are generally considered to have low tolerances to poor water quality (Hoff and Snell 1987). They both relate negatively with turbidity, organic matter, Mg^{2+} and sulphate. The reason for this negative relationship with this mentioned parameters could be due to the fact that they tend to reduce the degree of light penetration which aids primary productivity in the reservoir. Biological productivity in tropical lakes is mainly limited by the introduction of highly turbid waters and wind-induced turbulence during the wet season (Carr and Neary, 2006). This could reduce the phytoplankton food which serves as source of food to zooplanktons. Also, it is suggested that high concentrations of non-nutritional suspended particulate matter may decrease copepod abundances (Bonnet and Frid 2004; Wang *et al*. 2007).

Organic matter favoured the abundance of Diptera. This is evidenced in the diptera species peak abundance coinciding with the peak concentration of organic matter in the early dry season. Organic matter in fresh waters comes from aquatic photosynthetic production and from terrestrial sources such as wash in of dead animals and vegetation, swine and poultry waste (washed into River Erinle and River Awon respectively) from agricultural waste products. These sediment on to the substratum. Diptera larvae make use of the organic matter as food and also for building tubes and hence increase their abundance (Berg, 1995; Chaloner and Wotton, 1996; Pringle, 1985). Similar positive relationship was also documented in the work of Hirabayashi *et al*., 1999.

Ca^{2+} and hardness were found to be significantly positively related with ostracod while phosphate ion showed inverse relationship. There was also strong relationship between the mentioned parameters and ostracods as documented in the work of Iglikowska and Namiotko, 2012 and Gifre *et al*., 2002. The total hardness of water is mainly governed by the content of calcium and magnesium largely combined with carbonates and bicarbonate or with other minerals ions. So the more the presence of calcium in the water, the higher the probability of the water hardness. In freshwater, calcium is often a limiting factor for crustaceans such as ostracods that need it for their carapace formation (Lampert and Sommer, 1997). The importance of calcium availability in controlling and limiting the post-embryonic development of ostracods as individuals, as well as occurrence and diversity of ostracods species and assemblages has been demonstrated in several works (e.g. Mezquita *et al*., 1999a; Holmes and Chivas, 2002 and Viehberg, 2006). The relationship between phosphate and ostracods abundance is a strong indication that the abundance of the ostracods are largely regulated by the resource base and tend to increase with increasing trophic state of freshwaters (Canfield and Jones, 1996).

In addition, the probable reason as documented by Stark *et al*. (2000) for the direct relationships between some zooplankton groups (rotifer, cladocera and copepod) abundance and various ions (Ca^{2+}, K^+ and HCO_3^-) in addition to conductivity and TDS in the reservoir in spite of the inverse relationship between the mentioned zooplankton groups species with sulphate ion could be the fact that dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of aquatic organisms that rely on this ecosystem service. The direct relationships may also be supported by the fact that the mean values for the ions did not exceed their recommended limits for aquatic life (Chapman and Kimstach, 2006). Changes in the ionic composition of water can exclude some species while promoting the population growth of others (Weber-Scannell and Duffy, 2007). Magnesium, sodium, potassium and calcium concentrations tend to be influenced by metabolic activities of aquatic organisms and can exhibit marked seasonal and spatial dynamics as a result of biological activity. Sulphate and bicarbonate ion can be driven by production and respiration cycles of the aquatic biota (Wetzel, 2001). These ions have also been reported as being responsible for salinity in a body of water. The level of salinity in aquatic systems is important to aquatic plants and animals as species can survive only within certain salinity ranges (Friedl *et al*., 2004). The significant positive correlations recorded between zooplankton species abundance with Ca^{2+}, K^+ and HCO_3^- in this study are further justified by the fact that these ions were within their preferred ranges for freshwater life. Zooplankton communities respond to a wide variety of disturbances including nutrient loading (Dodson, 1992), and this was evident in the inverse relationships of organic matter, sulphate (both in rotifer, cladocera and copepod) and phosphate (in ostracods) ion with species abundance. Nutrient compounds are expected to stimulate phytoplankton growth and by extension zooplankton growth, but their positive impacts could have been far outweighed by the high concentrations of hydro-physical parameters which are capable of limiting the euphotic zone, hence the inverse relationships between those nutrient compounds and zooplankton species occurrence (Akindele, 2013).

As observed by Akinbuwa (1999) in his previous rotifer study on the reservoir. It is worth mentioning that dissolved oxygen did not show any significant correlation or regression with zooplankton species. The absence of significant relationship of oxygen with the zooplankton species in Ede-Erinle reservoir may be due to the fairly stable condition of oxygen in the reservoir throughout the study period.

Finally, cladocera and copepod of Ede-Erinle show significant positive relationship between them while rotifer also show similar positive relationship with copepod. Apart from the fact that these zooplankton groups have similar factors (transparency, temperature, pH etc.) affecting their distribution and abundance, another reason for this relationship could be the fact that they all belong to the littoral region of the water, living among the weeds and macrophytes (as a form of shelter from predatory zooplanktivorous fishes) and feeding on phytoplankton algae and similar or rather smaller zooplankton organisms. The cladocera and copepod association could also be primarily due to the frequent upwelling of the reservoir which leads to the mixing of the water and the zooplanktons in it, thereby causing overlap of different zooplankton groups' species (Valentin *et al.*, 1976). This is a more tenable reason as larger zooplankters like the adult cladoceras will normally migrate a bit down the water column in order not to be easily spotted by predatory fishes. More so, sensory acuity of fish decreases with depth as a result of decreased light intensity, producing a refuge for susceptible prey in the deeper layers of lakes (Gliwicz 1986; Lampert 1993). This could be the reason for the overall low cladocera abundance when compared with rotifers and copepods abundance in the Ede-Erinle reservoir. It should also be noted that copepods are more efficient than cladocerans at evading predators due to their ability to perform jumps when attacked (O'Brien 1987). Therefore they may not need to rely so heavily on spatial avoidance.

Rotifers' association with copepods is more likely due to the fact that close to 50% of the copepods observed at Ede-Erinle reservoir are the Nauplius larvae (the copepods developmental stages) which are co herbivores, feeding primarily on phytoplanktons like the rotifers. Generally, the smaller the copepod species and/or the younger its developmental stage, the more important is the algal component in its diet (Adrian and Frost, 1993). However, it is noteworthy that even small species of limnetic copepods (e.g., species of the genera *Tropocyclops* and *Thermocyclops*) prey on rotifers (Brandl, 2005). Practically all of the limnetic rotifer species co-occurring with predatory copepods have been reported as copepod prey. Even predatory rotifers of the genus *Asplanchna* species form prey for some copepod species (Brandl, 2005). Over the years, it has been established that copepods feeding on rotifers positively influences both their survival and reproduction (Adrian (1991); Adrian and Frost (1993); Hansen and Jeppesen (1992); Hansen and Santer (1995) and Brandl, 2005). The ability of copepods to feed on any limnetic rotifers does involve both selection preference for certain prey species: in addition to size limitation and other factors. For example, the vulnerability and consistent selection of soft-bodied rotifers *Synchaeta* and *Polyarthra* species for predation by *Diacyclopsthomasi* was species specific and perhaps related to the slow speed of the escape response (Stemberger and Evans, 1985). This attempts to explain the reason for the low abundances for both rotifer species and high abundance of *Diacyclopsthomasi* (second copepod highest after Nauplius larvae) in the reservoir during the study period. Brandl and Fernando (1981) documented similar inter-relationship of rotifer individuals with *Mesocyclops edax* and *M. leuckarti* (which are also dominant copepod species of Ede-Erinle reservoir). Thus, the coexistence of rotifer and copepod populations in plankton communities can be said to be the result of their interspecific relationships in which copepods act as important predators.

Although rotifers are able to achieve high reproductive rates to maintain their population and generation survival, the impact of copepod predation on rotifer population density can be high (Brandl, 2005; Plassmann *et al.*, 1997; Couch *et al.*, 1999; Yoshida *et al.*, 2000; Die´guez and Gilbert, 2002) and in some cases responsible for the decline of a rotifer population and seasonal extermination of a species from a community. Predation by copepods may have a significant impact on rotifers often causing seasonal decline of the rotifer populations and replacement of species that are more susceptible to predation by the less susceptible ones (Brandl, 2005).

V. CONCLUSION

The physico-chemical characters and zooplankton fauna shares a lot in common with other Nigerian and tropical waters. The reservoir water can be considered fairly clean and not under serious pollution threat. The reservoir water can be said to be potable and suitable for pisciculture, irrigation and agricultural uses.

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REFERENCES

[1] Abo-Taleb, H.A., 2010. Dynamics of Zooplankton Community in the Connection Between the Mediterranean Sea and the River Nile at Rosetta Branch, Egypt (M.Sc. thesis). Al-Azhar University, Faculty of Science, p. 183.

[2] Aduwo, A. I. (2008). The Study of the Zooplankton Fauna and Physico-Chemical Water Properties of Obafemi Awolowo University teaching and Research farm lake. *Unpublished M.Sc Thesis,* Obafemi Awolowo University, 287pp.

[3] Akinbuwa, O. (1988). The Study of the Physico-Chemical Factors and Rotifer Fauna of Opa Reservoir, Ile-Ife, Nigeria. *Unpublished M.Sc. Thesis*. Zoology Department, University of Ile-Ife, Nigeria. 261 pp.

[4] Akinbuwa, O. ´The Rotifer Fauna and Physico-Chemical Conditions of Erinle Lake and its Major Inflows at Ede, Osun State, Nigeria." *Ph.D. Thesis.* Obafemi Awolowo University, Ile – Ife, 1999

[5] Alekseev V. R. "Copepoda". In: Fernando, C. H. (2002). Guide to tropical freshwater zooplankton: identification, ecology and impact on fisheries. In *Guide to tropical freshwater zooplankton: identification, ecology and impact on fisheries*. Backhuys, 2002, pp 123-187.

[6] Baião, C., and Boavida, M. J. (2005). Rotifers of Portuguese Reservoirs in River Tejo Catchment: Relations with Trophic State. *Limnetica*, *24*(1), 103-113.

[7] Bonnet D, Frid C. S. (2004). Copepod Species Considered as Indicators of Water Mass Influence and Changes: Results from a Northumberland Coastal Station. J. Mar. Sci. 61: 485-491.

[8] Boulton, A. "Connectivity in a Dryland River: Short-Term Aquatic Microinvertebrate Recruitment Following Floodplain Inundation." *Ecology*, 2003, pp *84*(10), 2708-2723.

[9] Brooks J. L. "Cladocera." In: Edmondson WT (ed.), *Freshwater biology* (2nd edn). New York: John Wiley and Sons, 1959, pp 587–656.

[10] Buyukates, Y., Roelke, D.L., (2005). Influence of Pulsed Inflows and Nutrient Loading on Zooplankton and Phytoplankton Community Structure and Biomass in Microcosm Experiments Using Estuarine Assemblages. *Hydrobiologia* 548, 233–249.

[11] Cander-Lund, H., and Lund, J. W. G., "Freshwater Algae. Their Microscopic World Explored." Biopress Ltd., England, UK, 1995, pp 360.

[12] Cander-Lund, H., and Lund, J. W. G., "Freshwater Algae. Their Microscopic World Explored." Biopress Ltd., England, UK, 1995, pp 360.

[13] Cander-Lund, H., and Lund, J. W. G., "Freshwater Algae. Their Microscopic World Explored." Biopress Ltd., England, UK, 1995, pp 360.

[14] Carr, G. M. and Neary, J. P. (2006). Water Quality for Ecosystem and Human Health. United Nations Environment Programme Global Environment Monitoring System (Gems)/Water Programme. 132pp.

[15] Castro, B.B., Antunes, S.C., Pereira, R., Amadeu, M.V. M., Soares, F., Goncalves, F., 2005. Rotifer Community Structure in Three Shallow Lakes: Seasonal Fluctuations and Explanatory Factors. *Hydrobiologia* 543, 221–232.

[16] Chapman, D. and Kimstach, V. (1992). Selection of Water Quality Variables. In: Chapman, D. (Ed.). Water Quality Assessment. Chapman and Hall, London for UNESCO/WHO and UNEP. pp 59-126.

[17] Couch, K. M., Burns, C. W. and Gilbert, J. J. (1999). Contribution of rotifers to the diet and fitness of Boeckella (Copepoda: Calanoida) Freshwater Biology 107–118.

[18] Deborah Steinberg K. and Robert Condon H. "Zooplankton of the York River." *Journal of Costal Research*, Sl, 2009, pp 57: 66-79.

[19] Die´guez, M. C. and Gilbert,J. J. (2002). Suppression of the Rotifer *Polyarthra remata* by the Omnivorous Copepod *Tropocyclops extensus*: Predation or Competition. *Journal of Plankton Research* 24: 359–369.

[20] Duggan, I. C., Green, J. D., & Shiel, R. J. (2001). Distribution of Rotifers in North Island, New Zealand, and Their Potential use as Bioindicators of Lake Trophic State. In *Rotifera IX* (pp. 155-164). *Springer* Netherlands.

[21] Durand, J. R. et Leveque, C. "Flora et Faune Aquatiques de L˙Afrique." Sahelo-Soudanienne Tomme 1 Paris, 1980, pp 189.

[22] Edmondson, W. T., *Freshwater Biology.* (Second Edition).John Wiley and Sons.Inc. London, 1959, pp 421 – 450.

[23] Egborge, A. B. M. "Water Pollution in Nigeria." Vol. I. Biodiversity and Chemistry of Warri River. Benin City, Nigeria: Ben Miller Books, 1994

[24] Egborge, A. B. M. "Water Pollution in Nigeria." Vol. I. Biodiversity and Chemistry of Warri River. Benin City, Nigeria: Ben Miller Books, 1994

[25] Egborge, A. B. M. "Water Pollution in Nigeria." Vol. I. Biodiversity and Chemistry of Warri River. Benin City, Nigeria: Ben Miller Books, 1994

[26] Goldman, C. R. and Horne, A. J. "Limnology". McGraw Hill Book Co. New York, 1983, pp 464

[27] Heiskary, S., and Markus, H. (2001). Establishing Relationships among Nutrient Concentrations, Phytoplankton Abundance, and Biochemical Oxygen Demand in Minnesota, USA, rivers. *Lake and Reservoir Management*, 17(4), 251-262.

[28] Hoff F. H. and T. W. Snell. (1987). Plankton Culture Manual (3rd Ed.). Dade City, FL: Florida Aqua Farms, 155 pp

[29] Hoxmeier, R. J. H and Wahl, D. H. "Growth and Survival of Larval Walleyes in Response to Prey Availability." Transactions of the American Fisheries Society, 2004, pp 133:45–54.

[30] Hutchinson, G. E. (1957). A Treatise on Limnology, *Geography, Physics and Chemistry*. John Wiley and Sons, New York. 1: pp1015.

[31] Jeje, C. Y. and C. H. Fernando, "An illustrated guide to identification of Nigerian freshwater rotifers." *Nigerian Journal of Science*, 1991, 25: 77-95.

[32] Jeje, C. Y. and C. H. Fernando, "An illustrated guide to identification of Nigerian freshwater rotifers." *Nigerian Journal of Science*, 1991, 25: 77-95.

[33] Jeje, C. Y., & Fernando, C. H. "A practical guide to the Identification of Nigerian Zooplankton (Cladocera, Copepoda and Rotifera)." *Kainji Lake Research. Institute*, 1986, pp *142*.

[34] Jeje, C. Y., & Fernando, C. H. "A practical guide to the Identification of Nigerian Zooplankton (Cladocera, Copepoda and Rotifera)." *Kainji Lake Research. Institute*, 1986, pp *142*.

[35] Jeje, C. Y., &Fernando, C. H. "A practical guide to the Identification of Nigerian Zooplankton." *Kainji Lake Research Institute Nigeria*. ISBN 978–177-025, 1982, pp 2.

[36] Jeje, C. Y., &Fernando, C. H. "A practical guide to the Identification of Nigerian Zooplankton." *Kainji Lake Research Institute Nigeria*. ISBN 978–177-025, 1982, pp 2.

[37] Jenkins, K., and Arumugam, P. T. and Furtado, J. I. "Physico-Chemistry, Destratification and Nutrient Budget of a Lowland Eutrophicated Malaysian Reservoir and its Limnological Implications." *Hydrobiologia*, 1980, *70* pp (1-2), 11-24.

[38] Kaartvedt, S. and Svendsen, H., (1995). Effect of Freshwater Discharge, Intrusions of Coastal Water, and Bathymetry on Zooplankton Distribution in a Norwegian fjord system. *Journal of Plankton Research*. 17 (3), 493–511.

[39] Korinek, V. "Cladocera." In A guide to Tropical Freshwater Zooplankton: Identification, Ecology and Impact Fisheries (C. H. Fernando, ed.). Backhuys Publishers, Leiden, 2002 pp 69-122.

[40] Korinek, V. "Cladocera." In A guide to Tropical Freshwater Zooplankton: Identification, Ecology and Impact Fisheries (C. H. Fernando, ed.). Backhuys Publishers, Leiden, 2002 pp 69-122.

[41] Kubar Kaidi, Agasild Helen, Virro Taavi and Ott Ingmar (2005). Vertical Distribution of Zooplankton in a Strongly Stratified Hypertrophic Lake. *Hydrobiologia*. 547:151–162

[42] Kutikova L. A. "Rotifera." In: Fernando C. H. (ed.), A Guide to Tropical Freshwater Zooplankton; Identification, Ecology and Impact on Fisheries. *Leiden*: *Backhuys*, 2002, pp 23–68.

[43] Kutikova L. A. "Rotifera." In: Fernando C. H. (ed.), A Guide to Tropical Freshwater Zooplankton; Identification, Ecology and Impact on Fisheries. *Leiden*: *Backhuys*, 2002, pp 23–68.

[44] Mageed, A.A., (2007). Distribution and long-Term Historical Changes of Zooplankton Assemblages in Lake Manzala (South Mediterranean Sea, Egypt). *Egyptian Journal of Aquatic Research* 33, 183–192

[45] Margaleff, R. "Limnologia". Omega, Barcelona, 1983, pp 1010

[46] Marneffe, Y., Comblin, S. and Thomé J. "Ecological Water Quality Assessment of the Bûtgenbach lake (Belgium) and its Impact on the River Warche Using Rotifers as Bioindicators." *Hydrobiologia*, 1998, pp 387-388, 459-467

[47] Masundire, H.M., (1994). Seasonal Trends in Zooplankton Densities in Sanyati Basin, Lake Kariba: Multivariate Analysis. *Hydrobiologia* 272: 211-230.

[48] Ovie, S. I. "A Synopsis of the Zooplankton Fauna of Lakes Kainji and Jebba." *In*: Forty Years on Lake Kainji Fisheries Research. Eds: Raji, A. Okaeme, A. N. and Ibeun, M. O. NIFFR, New-Bussa, Nigeria, 2011, 1 pp 133-143.

[49] Plassmann, T., G. Maier and H. B. Stich, (1997). Predation Impact of *Cyclops vicinus* on the Rotifer Community in Lake Constance in Spring. *Journal of Plankton Research* 19: 1069–1079.

[50] Pradhan. A., Bhaumik,P., Das,S., Mishra, M., Khanam,S., Hoque,B. A., Mukherjee, I., Thakur, A. R. and Chauthuri, S. R. Phytoplankton Diversity as Indicator of Water Quality for Fish Cultivation. *American Journal of Environmental Sciences*, 2008 4 pp 406-411.

[51] Purushothama, R., Sayeswara, H. A., Goudar, M. A., Harishkumar, K. "Physicochemical Profile and Zooplankton Community Composition in Brahmana Kalasi Tank", Sagar, Karnataka, India. *Ecoscan.*, 2011, 5(3) pp 99-103.

[52] Rajagopal, T., Thangamani, A., Sevarkodiyone, S. P., Sekar, M., & Archunan, G. "Zooplankton Diversity and Physico-Chemical Conditions in Three Perennial Ponds of Virudhunagar District, Tamilnadu". *Journal of Environmental Biology*, 2010, *31*(3) pp 265-272.

[53] Salvador, A.B., (2007). Limnological Characteristics and Zooplankton Community Structure of Mediterranean Coastal Lagoons Undergoing Restoration, 245pp.

[54] Seminara, M., Vagaggini, D., and Margaritora, F. G. "Differential Responses of Zooplankton Assemblages to Environmental Variation in Temporary and Permanent Ponds". *Aquatic Ecology*, 2008, *42*(1) pp 129-140.

[55] Sousa W., Attayde J. L., Rocha E. D. S., and EskinaziSant'Anna E. M. (2008). "The Response of Zooplankton Assemblages to Variations in the Water Quality of Four Man-Made Lakes in Semi-Arid Northeastern Brazil,"*Journal of Plankton Research*, 30 (6), 699–708.

[56] Sthapit, E., Ochs, C. and Zimba, P. "Spatial and Temporal Variation in Phytoplankton Community Structure in a South-Eastern U.S. Reservoir determined by HPLC and light Microscopy". *Hydrobiologia*, 2008, 600 pp 215-228.

[57] Suresh, S., Thirumala, S. and Ravind, H. "Zooplankton Diversity and its Relationship with Physico-Chemical Parameters in Kundavada Lake, of Davangere District, Karnataka, India". *Pro Environment*, 2011, 4:56 – 59.

[58] Tackx, M.L.M.,Pauw,N.D.,Mieghem,R.V.,Aze´mar, F., Hanonouti, A., Damme, S.V., Fiers, F., Daro, N., Meire, P., (2006). Zooplankton in the Schelde estuary, Belgium and The Netherlands. Spatial and Temporal Patterns. *Journal of Plankton Research*. 26, 133–141.

[59] Tavernini, S. "Seasonal and Inter-Annual Zooplankton Dynamics in Temporary Pools with Different Hydroperiods". *Limnologica-Ecology and Management of Inland Waters*, 2008, *38*(1) pp 63-75.

[60] Tideman, E. M. "Watershed Management: Guidelines for India conditions, Omega Scientific Publishers New Delhi". 2000.

[61] Turner, P. N., & Da Silva, C. (1992). Littoral Rotifers from the State of Mato Grosso, Brazil. *Studies on neotropical fauna and environment*, *27*(4), 227-241.

[62] Tyor, A. K., Chopra, G., & Kumari, S. "Zooplankton Diversity in Shallow Lake of Sultanpur National Park, Gurgaon (Haryana)".*Int. J. Appl. Biol.Pharm. Technol.*, 2014, 5(1) pp 35-40.

[63] Uttah, C., E.C. Uttah, C. Okonofua, E. Ogban, L. Usip, and J. Ogbeche. "Pollution Biotic Index and the Biota Indicative Signatures of Transects in Calabar River Around A Busy Jetty Facility in Calabar, Nigeria". Trans. J. Sc. Technol., 2013, 3(4).55-67.

[64] Victor, R. (2002). Ostracoda. A Guide to Tropical Freshwater Zooplankton. Backhuys, Leiden, The Netherlands, 189-233.

[65] Vieira A. C. B., L. L. Ribeiro, D. P. N. Santos and Crispim, M. C. (2009). "Correlation between the Zooplanktonic Community and Environmental Variables in a Reservoir from the Northeastern Semiarid,"*Acta Limnologica Brasiliensia*, 21 (3), 349–358.

[66] Wang, C. F., M. H. Hsu, W. C. Liu, J. S. Hwang, J. T. Wu, A. Y. Kuo. 2007. Simulation of Water Quality and Plankton Dynamics in the Danshuei River Estuary, Taiwan. *Journal of Environmental Science.* Health Part A 42:933-953.

[67] Welch, P.S. (1952). *Limnology*. 2nd edition. McGraw-Hill book company, Inc. London, pp.538.

[68] Wetzel, R. G. Land-Water Interfaces Metabolic and Limnological Regulators. *Verhandlungen der Intertionalen Vereinigang fur theoretische und angewandte Limnolgie*, 1990, 24 pp 6-24.

[69] Wetzel, R.G., "Limnology: Lakes and River Ecosystems". 3rd Edition. Academic press. 2001

[70] Whitmana, R.L., Nevers, M.B., Goodricha, M.L., Murphy, P.C., Davis, B.M., (2004). Characterization of Lake Michigan Coastal Lakes Using Zooplankton Assemblages. Ecol. Indicators 4, 277–286.

[71] Wilson, M. S. and Yeatman, H. C. (1959). "Free-Living Copepoda". *Freshwater Biology*, 2001, 2 pp735-815.

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