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Comparative Study on Water Variables and plankton diversity of earthen Fish Ponds along River Ethiope

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Abstract: *This study investigated water quality and plankton as natural food supply indicators in three earthen fish ponds at Obiaruku, Delta State, Nigeria. The investigated water variables include Water temperature and depth, transparency, pH, conductivity, alkalinity, dissolved oxygen, BOD, phosphate-phosphorus and nitrate-nitrogen. The water variables differed significantly within and among the ponds (p<0.005) and were within the recommended limits for fish culture. The Ponds featured phytoplankton and zooplankton constituting of six and three taxa respectively. Thirty phytoplankton species listed in this study varied differently in the ponds. Their order of significance in the various ponds is in the pattern reported viz: Pond I had Chlorophyceae > Bacillariophyceae > Cyanophyceae > Xanthophyceae> Dinophyceae > Euglenophyceae. In pond 2, it was Chlorophyceae > Bacillariophyceae > Euglenophyceae > Cyanophyceae while in Pond III; the order was Chlorophyceae > Cyanophyceae > Bacillariophyceae> Euglenophyceae. Diversity indices indicated moderate stability of ponds with none similar. While the fourteen (14) species of zooplankton identified to belong to Rotifera (71.4%), Cladocera and Copepods 14.35% respectively. Their abundances in the various ponds varied significantly in this order: Pond I > Pond 3 >Pond 2. We, therefore, conclude that the plankton resources of these ponds are adequate for fish production if proper Management is put in place to underplay the blue-greens.*

Key Words*:Water variables, Phytoplankton, Zooplankton,Diversity indices, Fish culture, River Etiope*

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I. Introduction

Earthen fish pondsalong riversfor the rearing of fishes for both domestic and commercial use has been highly invoked during this period of economic recession to increase food production. Even due to red flags posedto its manageability and pollution abatement(Thompson et al.,2002; Iliyasu et al., 2016). Despite these red flags, earthen pond method of fish farming still has a good number of benefits which lure farmers into practising it. For a start, the construction of these ponds on natural water bodies eliminates the challenge of low availability ofwater which is usually faced in numerous areas. Also, the cost used in the construction of other facilities (like a concrete wall in the case of concrete ponds) and water maintenance equally reduced. Finally, it creates an environment for the generation of higher profitability (lower capital/overhead cost). It thus achieves the primary purpose of fish farming, creating job opportunities and providing a means of livelihood for the jobless populace(Primavera, 1993; Asamare et al., 2016;Iliyasu et al., 2016).

In fish farming, success is highly dependent on water quality and the quality and quantity of food(Davies and Otene,2009; Bhatnagar and Devi, 2013). The food-quality underpinned by the abundance of plankton (phytoplankton and zooplankton) in the water body(Iloba, 2012; Gupta and Gupta, 2014). Plankton richness, therefore, is an indicator of the food-grade in any aquatic ecosystem. Plankton as foodin addition to ideal water quality will support profitable fish production(Davies and Otene,2009; Ikpi et al., 2013).Thus these pivotable civic productions of plankton in water bodies have encouraged the setting of extensive fish ponds along the course of rivers (Adeosun et al., 2014; Oketoki,2015).

*Clarias*sp and *Heterobranchus*farming by artisanal fish farmers has increased during the past few years at the Obiaruku; a community in Ukwani Local Government Area (LGA) of Delta State, Nigeria along the course of River Ethiope.Extensive type of fish farming practised by the artisans exclusively feedson natural feeds, thereby circumventing the cost of feeding. Plankton are food producers occupying pivotal places in the food production chainin aquatic ecosystems.In other words, Fish ponds rich in plankton with ideal water status will support high variable organisms which swivel to high production. Thus, this study was hitherto designed to investigate the sustainability of the waters and plankton components for fish farminginRiver Ethiope atObiaruku.

II. Materials and Method

Description of Study Area

Three isolated earthen fish pondsfed by River Ethiope at Obiaruku, Ukwani local Government Area Delta State, Nigeria, latitude6.00°- 6.11°E and longitude 5.40° -5.51°N of the equator (Fig. 1) were randomly selected to be study areas. Oil palmplants (*Elaeisguineensis*) were the dominant plants in the area. Outflow pipes connected to the River, regularly supplied water to the ponds to cub evaporation and seepage

The Pond I has a dimension of (13.1× 6.1 × 1.4). Tree canopies partially shade this station; there are few aquatic plants and surrounded by grasses. The substratum is a deep layer of clay and silt flocs mixed with organic matter derived from the surrounding decaying vegetation, and the water is brownish.

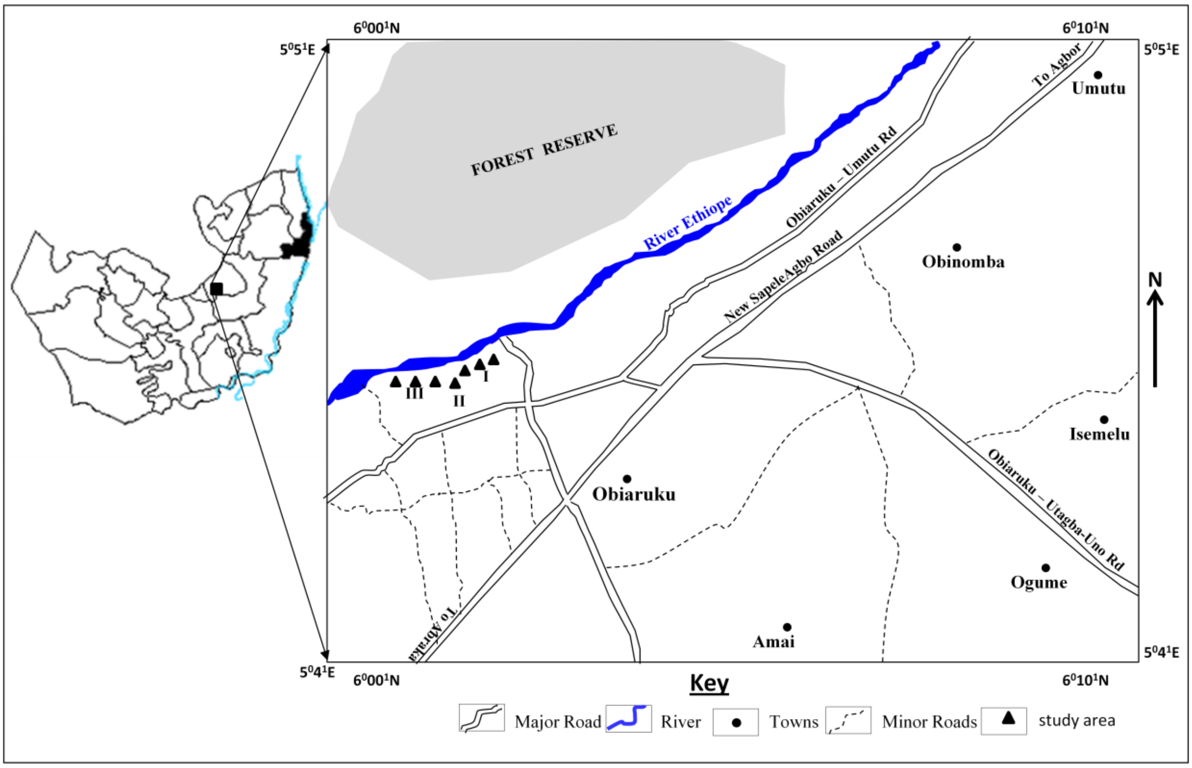

Figure no 1: Map showing the location of study sites at Obiaruku and environ (index Map of Delta State)

Pond 2 has a dimension 12 × 7.1× 1.9 m. It is exposed to direct sunlight, and the substratum is a mixture of chalky clay and decaying vegetation fragments while pond 3 is the longest of all the three ponds with 14.5 × 6.9 × 1.7 m. The trees do not form any canopy, and it has floating, submerged and rooted aquatic macrophytes. The water was greenish. The substratum is rich in sticky organic mud overlaid with an entangled mesh of roots and stems of macrophytes.

Sampling

Water and plankton samples were collected between the hours of 7 am to 11 am from each Pond for six months (January to June) by the adoption of standard methods (APHA, 1990). The abiotic components investigated include water depth (m), transparency (m), temperature (°C), conductivity, hydrogen ion concentration (pH) (pH meter model 5793/2), alkalinity (mgCaCO3/L), Dissolved oxygen, biochemical oxygen demand, phosphate -phosphorus and nitrate – nitrogen.

Plankton

The biotic (plankton) samples collected monthly from the ponds using plankton net of 25µm mesh size were preserved in 4% formalin, and water samples then examined and observed plankton was identified to the lowest possible taxonomic level and estimated by counting the number of phytoplankton per ml of sample, and the number of organisms was expressed as the number of organism per m3 using the formula;

$$x = \frac{N \times 1000}{\text{Initial Volume of water filtered}}$$

Where N = number of phytoplankton per ml of sample

Statistical Analysis

Species richness, Shannon-Wiener genera diversity (H) and Evenness (E) indices were used to evaluate the plankton community structure. The one - ANOVA was used to evaluate the differences between the three ponds. Turkey's pairwise was used to detect where the significant differences lie. All statistical analysis was done with the use of PAST statistical software.

III. Results

The ranges, means, standard errors, coefficient of variation, the test of significant values evaluated at 0.05 level of significance of all investigated water quality variables are in Table 1. Comparatively, apparent significant abiotic variations ($p< 0.05$) occurred within the individual ponds than among them except for a few parameters. Within Pond I, the only variations in transparency, nitrate-nitrogen were not significant as well as phosphate phosphorus and nitrate- nitrogen in ponds II and III. The percentages of variations were revealed by the coefficient of variation (C.V %). Some parameters such as phosphate phosphorus and nitrate- nitrogen in Ponds II and III varied widely (CV >40%) in all Ponds. alkalinity, conductivity in ponds I and II and only depth and transparency varied significantly in Pond I. When the three earthen fish ponds were investigated comparatively using one-way ANOVA, all variables except alkalinity was found highly significantly different ($p = 0.0007$). However, weak significance was established with depth ($p= 0.0534$). Turkey's pairwise comparison test identified Pond III as significantly different from Pond I and III, as shown in Table 2. There is a significant difference between the ponds and between the months ($P = 0.3921$). These variations observed were, however, still within the boundaries of internationally recommended standards for fish culture (Table1).

Plankton

Naturally, the plankton samples had both algae and zooplankton components, as shown in Tables 2 and 3 with the former (phytoplankton) constituting 73.6% of the total plankton species. In comparison, the zooplanktonic species contributed to the rest (26.4%).

Six phytoplankton taxa were encountered; Chlorophyceae had the highest species composition (46.2%). The next is Bacillariophyceae with 28.2%, followed by Cyanophyceae species constituting 12.8%, Dinophyceae and Xanthophyceae (5.1%) each and Euglenophyceae (2.6%). The most abundant were the Chlorophyceae (green algae) dominated by *Ceolestrum cambrium, Scenedesmus quafricauda, Pediastrium duplex, Ulothrix* sp (Table 2).

Table no 1: Ranges, means ± standard error, coefficient of variation (CV %) p values of the abiotic components investigated compared with desirable standards for fish ponds

	Water temp (0C)	Air temp (0C)	Depth (m)	Transparency (m)	Conductivity (µS/cm)	pH	Alkalinity mg CaCO3/L	Do (mg/L)	BOD5 (mg/L)	PO4 - p (mg/L)	NO3 – N (mg/L)
POND 1											
Range	26 - 31.2	22.1 - 31.1	0.05- 1.08	0.21- 0.5	6.5 -60.0	5.7- 7.7	4.0 - 16.5	6.7- 8.2	5.8 -8.0	0.015- 0.7	0.01- 0.22
x ± S.E	28.2 ± 0.76	27.2±1.26	0.79±0.04	0.33±0.04	45.9 ±8.05	7.1 ±0.33	0.93±1.97	7.5±0.23	6.99±0.37	0.37±0.12	0.06±0.04
p	0.0000*	0.0000*	0.0036*	0.1962	0.0023*	0.0000*	0.0169*	0.0000*	0.0000*	0.0226*	0.181
CV (%)	6.5	11.4	47.4*	164.3*	43.0*	11.3	69.5*	7.5	13.0	75.3*	157.7*
POND 2											
Range	23.2-30.0	22.1-30.0	1.01-1.2	0.38 – 1.0	5.0 – 47.2	5.36-7.4	1.0 - 10.1	5.1-9.0	5.35-8.3	0.001- 0.53	0.001-0.18
x ± S.E	26.4±0.92	26.8±1.29	1.10±0.03	0.68 ±0.10	36.37±6.50	6.67±0.35	4.8 1 ±1.21	7.2±0.64	6.39±0.45	0.22±0.1	0.08±0.04
p	0.0000*	0.0000*	0.0000*	0.008*	0.0025*	0.0000*	0.0156*	0.0000*	0.0000*	0.0751	0.0777
CV (%)	8.6	11.8	6.7	34.5	43.8*	12.7	61.6*	21.6	17.2	109.3*	110.1*
POND 3											
Range	24.3-31.2	22-30.0	0.99-1.21	0.27-0.79	26.98-126.5	6.26- 9.9	12.0 -15.17	6.0 -9.5	4.2 - 8.9	0.004-0.59	0.001-0.251
x ± S.E	27.7 ± 1.1	26.8±1.13	1.07±0.03	0.52±0.08	56.1±15.5	7.35±0.40	13.9±0.60	7.4±0.51	5.90 ±0.78	0.28±0.11	0.102±0.05
p	0.0000*	0.0000*	0.0000*	0.0014*	0.0153*	0.0000*	0.0000*	0.0000*	0.006*	0.0595	0.0833
CV (%)	9.6	10.4	7.6	38.5	67.8*	13.3	10.5	17.0	32.5	100.9*	113.5*
F- value	0.9973	0.0449	3.585	0.3342	0.97	0.8526	12.04	0.0743	0.9281	0.5588	0.2535
P - value	0.3921	0.9562	0.0534	0.7211	0.62	0.4460	0.0007*	0.9288	0.4460	0.5835	0.7793
Standard	15 -35	24 - 38		25 - 27	10 – 1000	6.5 – 9.0	50 - 200	3 - 5	- 2	0.01 – 3.0	4.5

Table no 2: Turkey comparison test of the Water quality variables investigated at the different ponds

	Pond I	Pond II	Pond III
Pond I		0.534	0.0071*
Pond II	1.543		0.0009*
Pond III	5.088	6.631	

Table no 3: Abundances and Composition, Diversity Indices of Phytoplankton in the three earthen fish ponds

Taxonomic group	Pond 1	Pond II	Pond III
Chlorophyceae			
Desmidium sp	49	0	0
Staurastrum gracile	28	33	0
Staurastrumtetracerum	0	14	47
Euastrumsp	0	50	0
Ankistrodesmusfalcatus	136	0	0
Ceolastrumcambricum	520	236	142
Ulothrixsp	395	0	0
Actinastrumsp	17	0	0
Closteriumdianae	14	15	10
Cosmariumrectangulare	22	0	0
Cosmariumdecoratum	70	0	0
Golenkiniaradiata	66	0	59
Docidium	0	55	3.2
Pleurotaeniumsp	0	78	17
Pediastrum duplex	154	221	123
Eudorinasp	0	35	56
Scenedesmusquadricauda	55	236	174
Scenedesmusperforatus	0	0	173
Bacillariophyceae			
Nitzschia sigmoidea	12	22	
Nitzschiaamphioxys	0	29	0
Naviculasp	66	30	104
Tabellaria	13	55	18
Cymbellasp	0	47	28
Bacillariapaxillefer	29	0	0
Pleurosigmaangulatum	15	0	0
Pinnullarianobilis	45	17	
P.cardinaliculus	27	70	35
P. elongatum	0	12	0
P. angulatum	35	16	
Cyanophyceae			
Oscillatoria sp	117	15	117
Anabaena sp	12	0	50
Merismopediasp	0	29	12
Arthrospira	0	25	15
Lyngbyasp	14	14	
Dinophyceae			
Rhodomonas sp	30		
Ceratiumtripos	12	0	0
Xanthophyceae			
Vaucheria sp	0	0	14
Ophiocytiumcapitatum	92	0	66
Euglenophyceae			
Phacus sp	15	92	88
Diversity Indices			
Taxa_S	27	24	21
Individuals	2060	1446	1351.2
Shannon_H	2.599	2.708	2.702
Margalef	3.407	3.161	2.774
Equitability_J	0.7887	0.8522	0.8873
Fisher_alpha	4.388	4.088	3.529
Berger-Parker	0.2524	0.1632	0.1288

Comparatively, Figure 2 revealed the phytoplankton abundance in the different ponds. The Pond I presented all phytoplankton taxa recorded in this study in the following order of abundance; Chlorophyceae > Bacillariophyceae > Cyanophyceae > Xanthophyceae> Dinophyceae > Euglenophyceae. In pond 2, Chlorophyceae remained the most abundant then Bacillariophyceae > Euglenophyceae > Cyanophyceae while in Pond III, Chlorophyceae > Cyanophyceae > Bacillariophyceae> Euglenophyceae. The class Dinophyceae was recorded only in Pond I during the present investigation. The chlorophytes were the most abundant in all the ponds and *Ceolastrumcambricum, Scenedesmus,Ankistrodesmus, Ulothrix* were the most occurring genera all in the ponds. The class Bacillariophyceae abundance was subdominant to the greens with three genera *Pinnullaria,* *Navicula*, *Tabellaria*, *Nitzschia* contributing significantly to the class abundance. The Cyanophyceae though minor but contributed significantly to phytoplankton abundance, particularly the genera *Oscillatoria*.

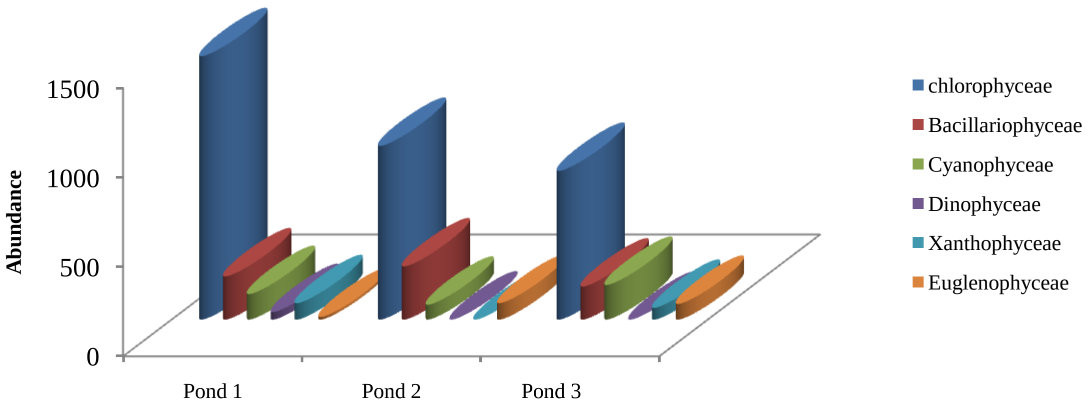

Figure no 2: Abundances of the different phytoplankton taxa in the three earthen fish ponds during the study

The Shannon diversity comparison t-test for the phytoplankton revealed the phytoplankton abundances between Pond I and Pond II (P = 0.00245), Pond I and Pond III (0.0015) were significantly different (P< 0.05) while Ponds II and III (P = 0.8291) phytoplankton abundance were not abundantly significant (P>0.05)

Fourteen (14) species of zooplankton belonging to three groups, namely rotifer, cladocera and copepods, were identified. Rotifers contributed the highest number of species (71.4%), Cladocera and copepods 14.35, respectively (Table 4). The contribution of the two Cladoceran genera in number; Daphnia and Bosmina was more significant than the rotifers and followed by the copepods in Pond I (Fig. 3). In pond 2, rotifer's abundance was more significant than that Cladocera and no records of copepods in this Pond. In Pond III, Rotifera had the highest individuals, followed by the Cladocerans and then copepods. The copepods did not contribute significantly to the zooplankton populations in these ponds. Summarily, zooplankton population in this study varied thus Pond I > Pond III >Pond III. Shannon diversity t-test revealed that the ponds were significantly different from one another. The Pond I different from Pond II, P = 0.0001; Pond II from Pond III, P = 0.0101 and Pond III from Pond I, P = 0.0000). The diversity indices presented in Table 4, revealed low zooplankton stability in the earthen ponds even though the equitability is relatively high.

Table no 4: Checklist, Abundances and Diversity Indices of Zooplankton in the three earthen fish

Taxonomic group	Pond 1	Pond II	Pond III
CLADOCERA			
Daphnia sp	198	77	0
Bosmina sp	166	17	80
ROTIFERA			
Brachionus variabilis	121	38	0
B.calyciflorus	79	0	188
B. kostei	13	30	16
B. bidentatus	0	73	0
B. quadridentatus	0	0	20
Keratella javena	0	11	31
Keratella sp	84	23	0
Trichocerca sp	0	0	19
T. elongata	27	0	23
Collotheca edentata	14	0	0
COPEPODA	0	0	
Cyclops sp	24	0	
Calanoid sp	13	0	13
Diversity indices			
Taxa_S	10	7	8
Individuals	739	269	390
Shannon_H	1.92	1.749	1.589
Margalef	1.363	1.072	1.173
Equitability_J	0.834	0.8986	0.7641
Fisher_alpha	1.635	1.314	1.425
Berger-Parker	0.2679	0.2862	0.4821

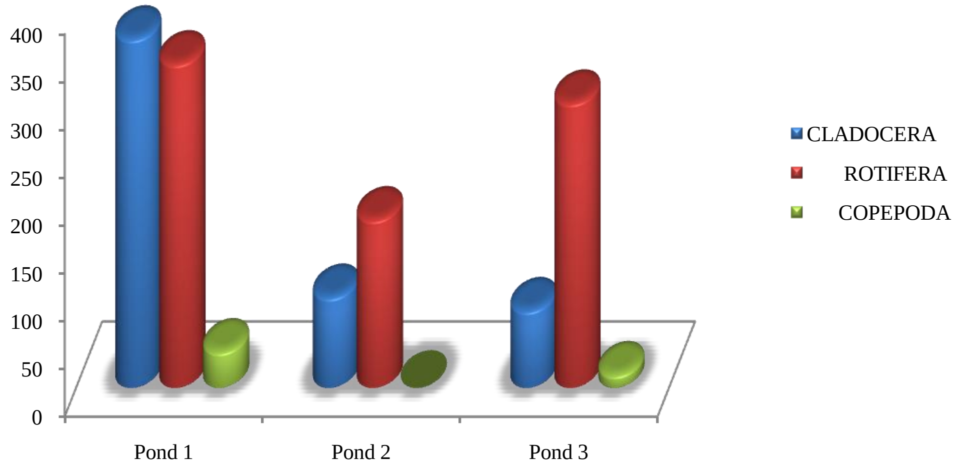

Figure no 3: Abundances of the different zooplanktontaxa in the three earthen fish ponds during the study

IV. Discussion

This study revealed that the water quality parameters in each Pond varied significantly despite the common source of water used. The impoundment or excavation of land along the River to create basins for fish culture produces environmental heterogeneity in aquatic ecosystems (ecotone) experiencing similar climatic or geographical influence (Naik et al., 2015). The modification of the river bank could have informed the differences noted in the different ponds (Rostamian et al., 2015). The record of high values of most physicochemical parameters during the rains and vice versa is attributed to the influence of rains increasing or diluting the concentration of these parameters in the ponds (Ikpi et al., 2013; Adeosun et al., 2014). These variations could be considered a natural phenomenon(interactions) as the parameters still fluctuated within the desirable or recommended limits for fish ponds (Nabila et al., 2014) except for some low alkalinity values below the lower recommended limit. The apparent glaring disparity in alkalinities is of no aquacultural challenge. It could be fixed by the application of agricultural lime to improve the buffering capacities of the ponds (Solanki et al., 2015). The low alkalinities could be attributed to low buffering of earthen ponds and also to the oligoionic nature of RiverEthiope (Iloba, 2012) and the non-accumulation of bicarbonates due to its high removal rate from the ponds by the diverse group of algae recorded in the ponds and also by the aquatic plants (Talling, 2010; Thilza and Muhammad, 2010; Iloba, 2012).

The nature of Pond III could be another probable reason for the difference with the two other ponds. The high BOD contents of the ponds are an indication of high stabilisation of organic matter in the ponds. The high stabilisation was through its degradation by microorganisms, whose effects were nullified by the adequate supply of well-oxygenated water from the River (Iloba, 2012; Diatin et al., 2015). The stabilisation of these ponds further confirmed by the low values of coefficient of variations of most water variables and existing within desirable limits is an indication water qualities in these ponds is good and will support good fish production (Magurran, 1988).

This study revealed diverse plankton composition with adequate biomass (> 2000) as a desirable range of plankton (2000 – 6000) as natural food for fish culture (Bhatnagar and Devi, 2013). The high occurrence of Chlorophyceae species in all the ponds means that the fingerlings, adult catfishes and the *Heterobranchus sp* will flourish in these ponds. Desmids are reportedly high valuable fish-food diet in fish production(Goes et al., 2016).

The different diversity indices employed in the present study were all less than 3.00 except Magalef's indices suggesting the need to improve on the maintenance of the ponds and with adequate supply and flushing of the ponds. These diversity indices (less than 3.0 bits / Cel) suggest relatively low pond stability and impaired ponds (Shannon and Weaver, 1949; Magurran, 1988). The Shannon diversity t-test values revealed differences between the phytoplankton and zooplankton of these ponds, thereby suggesting biological heterogeneity of the ponds (Magurran, 1988). Biological heterogeneity is expected as the biological component of an aquatic ecosystem is a reflection of its water quality as noted by Sarker et al., (2016).

The diatoms were the second group of phytoplankton in this present study. The most occurring species (*Navicula and Tabellaria, Pinnullaria*) have also been documented as the best choice for freshwater fishes in River Ethiope (Ikomi and Jessa, 2003). These species have been identified as oligoionic species which is the nature (low conductivities) of River Ethoipe the source of water supply to the ponds (Iloba, 2012).

The significant outing made by the blue-greens as third dominant species is worrisome due to their toxin-producing capacity. These toxins could have deleterious effects on fishes or cause off-flavour if not carefully monitored to prevent their upsurge (Mohamed, 2016). This deleterious effects could be achieved by regular exchange of water to improve on water quality which must be monitored routinelyon a daily bases.

The three groups ofzooplankton listed form an important dietary food component of plankton used in fish farming(Davies and Otene, 2009) The species compositional structure ofzooplankton in this present study is typical oftropical freshwater dominated by the family Brachionidae (Iloba, 2002). Zooplankton dominating biomass differed in the ponds; Cladocera (Daphnia and Bosmina) in Pond 1 and rotifers (Brachionus, Trichocerca and Keratella) in Ponds II and III as well as the insignificant contribution by the Copepods. The outburst of Cladocera in Pond 1 suggested the creation of suitable ecological (slow-moving) or biological environment required multiplication (Burke and Bayne, 1987). The outburst of *Daphnia* is uncharacteristic of tropical waters (Egborge, 1981). This difference could be attributed to habitat heterogeneity as no two ponds were identified similar by the Shannon diversity t-test in the present study (Magurran, 1988). The zooplankton abundance in this study indicates the good qualitative and quantitative supply of food source for fish production in these ponds (Davies and Otene, 2009). The plankton resources of these ponds are adequate for fish production if proper Pond management is put in place. To prevent their disastrous consequences on the quality and quantity of fish yield.

V. Conclusion

The study compared the water quality variables and plankton in three isolated earthen fish ponds fed by River Ethiope. The study revealed differences in water variables and plankton. The study noted that the water quality variables and plankton biomass were within recommended limits to realise optimum fish production. The study, therefore, commends the establishment of more ponds to create jobs and alleviate poverty.

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