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Assessment of Physico-Chemical and Zooplankton Assemblages in Some Ponds within Wilberforce Island, Nigeria

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Abstract

This study investigated the physicochemical and zooplankton assemblages in some selected ponds within Wilberforce Island, Bayelsa state, Nigeria. The study was carried out in August 2015 covering five selected ponds following standard procedure. Results of the physiochemical parameters were in the range of 6.45 – 6.68 (pH), 15.1 – 21.57NTU (turbidity), 9.19 – 10.60mg/l (biological oxygen demand), 0.00 – 0.10mg/l (salinity), 53.33 – 217.00µS/cm (conductivity), 32.67 -114.67mg/l (total dissolved solid), 2.04 – 5.83mg/l (total suspended solid), 6.21 – 6.87mg/l (dissolved oxygen), 85.13 – 143.10mg/l (chloride), 0.02 – 0.02mg/l (manganese) and 0.19 – 0.26mg/l (iron). Analysis of variance showed that there was significance variation ($P<0.05$) among the various locations for most of the physicochemical parameters. A total of 89 zooplankton species were identified and were classified into 13 taxonomic groups namely; Nematoda (17), Protozoa (19), Rotifera (27), Annelida (8), copepoda (1), Chordata (3), Chaetognatha (1), Gastropoda (3), Cladocera (2), Bryozoan (1), Crustaceans (2) and Porifera (3). In the study several zooplankton species that serve as indicator organisms were identified.

Keywords: Species Diversity, Physico-chemical Characteristics**,** Ponds, Wilberforce Island, Zooplankton

1- Introduction

Water is one of the Fundamental resources required by human and other living things for existence and socio economic development [1-7]. Water resources exist as rain water, ground and surface water. Among the surface water resources, estuarine/brackish, fresh and marine water are found predominantly in the Niger Delta region. Irrespective of the water source, they harbor several aquatic biodiversity including plankton (phytoplankton, zooplankton and algae), fishes, aquatic mammals, sea birds etc [4].

Water resources can also be classified based on the size such as creeklets, rivulets, creeks, pond, lakes, stream, and rivers among others. Each of the water bodies is found in Niger Delta Nigeria especially in Bayelsa state. Some of this fresh water bodies within Bayelsa state include Kolo creek [5, 8 – 10], Sagbama creek [11, 12], Epie creek [13, 14], Ikoli creek [6, 15], River Nun [1, 7], Igbedi creek [16, 17], Efi lake [18], Lake Adigbe among others.

Several ponds also exist in Bayelsa state. Majority of them hardly dry up during the dry season. Furthermore, during the wet season (especially during August to October) some of the ponds appear like a creek. During the period (September to October) most of the water bodies i.e. rivers have over flown their banks. Water from rivers such as River Nun at Amassoma axis also flow into farm lands submerging food crops such as sugarcane and cassava, depositing aquatic plants such as water hyacinth at the banks of the water, which get dried up at the onset of dry season (November) at the river banks.

Specifically, Wilberforce Island is located in Southern Ijaw local government area of Bayelsa State, and is one of the gazetted Nun River forest reserves in Niger Delta, Nigeria [19]. The topography of the area is basically flat with several depressions [19]. Some of this depressions are ponds and contain fisheries (especially fin fishes) and other plankton communities. Some of the ponds typically dry up during the dry season.

Basically, plankton play essential role in the biogeochemical cycles of many important elements such as the carbon cycle and as such involved in nitrification, denitrification, remineralization and methanogenesis processes [20]. According to Ogbuagu and Ayoade [20], Abdul et al. [21], the various processes bring about primary production and recycling. The plankton communities are mostly phytoplankton and zooplankton. In addition to cycling, they contribute to the energy flow, food chain and food web [21-25]. Specifically, Zooplankton act as a link between the phytoplankton and whole food chain of the aquatic environment [26]. Zooplankton have been noted to function as intermediaries between fish and lower trophic

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levels [27] such as macro crustaceans, insects, small fish [28]. Zooplankton feed predominantly on algae and bacteria and in turn fall prey to several invertebrates and fish predators [27].

Zooplankton is ecologically an important group of aquatic organisms that occupy a wide range of habitats [22]. Zooplankton which is a vital component of the aquatic environment are used as indicator organisms in aquatic ecosystem against environmental quality especially with regard to pollution, water quality, eutrophication and other environmental problems [21, 22, 28 – 30] and biological production including fish yield [31]. Depending on the characteristics of the aquatic ecosystem the zooplankton assemblages differ.

Zooplankton assemblages have been widely reported in literature in several water body types. Therefore, this present study was designed to investigate the physicochemical parameters and zooplankton assemblages of selected ponds in Wilberforce Island.

2 Materials and Methods

2.1 Study Area

Wilberforce Island is located in Southern Ijaw Local Government Area of Bayelsa state. The area has several communities. The main occupation of the people is fishing and farming and some petty trading like buying and selling. The climatic condition of the area is similar to other water locations in Bayelsa state [5- 10 – 13, 15].

2.2 Sampling Stations and Collection

Five sampling stations were established within Wilberforce Island. The location of the ponds were Wadou-ama (site A), Ebenikiri-Ama (Site B), Adule-ama (Site C), Niger Delta University New site (Site D), 600meter distance away from site D at Niger Delta University New site (Site E). The water samples were collected using 1 liter sampling container. The sampling was carried out in August 2015. The samples collected were carefully labeled and transported to the Laboratory for analysis.

2.3 Zooplankton collection

Zooplankton samples were collected in each sampling site by filtering 50litres of the river water through plankton net. The concentrated Zooplankton samples were put in vials and preserved with 4% formalin before transferring to the laboratory in a cool box [32]. In the laboratory, the concentrated samples were diluted with distilled water until a 50ml concentration was achieved and the samples were homogenized by shaking.

2.4 Water quality analysis

The physicochemical parameters of the water were analyzed using multi-meter (pH, conductivity, salinity, turbidity) and Total suspended solid, total dissolved solid were determined by gravimetric method. Dissolved oxygen and biological oxygen demand were determined by winkler methods. Nutrient compositions including Nitrate, chloride, sulphate, calcium, magnesium, sodium, potassium were determined spectrophotometrically. While the iron and manganese concentration were analyzed using atomic absorption spectrophotometer.

2.5 Analysis and Identification of the zooplankton

In the laboratory, plankton samples were allowed to settle by gravity for 24 hours before decanting carefully the supernatant to achieve 50 ml volume. From the stock sample, 1 ml sub-sample was taken with the help of a Pasteur pipette and transferred into a Sedgwick Rafter counting chamber. Once the slide is filled, it was allowed to settle for approximately 5-10 minutes. This makes counting easier [33]. A DC2 camera was attached to a computer. Maximize the screen and adjust the exposure and the camera is inserted into a light microscope (Lieder Model; MC 332). Identification guides previously described by authors were employed for the identification [34 – 44]. Glycerine (supplied by Sallaymore Nigeria Limited) and a strong sugar solution were used as mount for fast swimming organisms in order to slow down their movement which makes the identification and counting easier. Zooplankton density was estimated using the following formula [45].

$$\text{No/M}^3 = \frac{C \times V'}{V'' \times V'''}$$

Where:
C = Number of organisms counted
V′ = Volume of the concentrated sample, ml.
V″ = volume counted, ml and
V‴ = Volume of the grab sample, m3

Whereas, phytoplankton density was estimated using the following formula [45].

$$\text{No/ml} = \frac{C \times At}{As \times S \times V}$$

Where:
C = Number of organism counted
At = Area of cover slip, mm^2
As = Area of one strip, mm^2
S = Number of strips counted and
V = Volume of sample under the cover slip, ml

2.6 Statistical Analysis

SPSS software version 16 was used to carry out the statistical analysis for the physicochemical parameters. A one-way analysis of variance was carried out at $\alpha = 0.05$, and Duncan’s multiple range test was used for post hoc. Paleontological statistics software package by Hammer *et al*. [46], was used for the zooplankton diversities including Shannon-Weaver (H), Margalef (D) and Equitability (J). Sorenson quantitative index was calculated based on the methodology presented by Ogbeibu [47].

3 Results

Table 1 presents the physicochemical properties of the pond water that the zooplankton species in this study was identified. pH, turbidity, biological oxygen demand ranged from 6.45 – 6.68, 15.12 – 21.57NTU and 9.19 – 10.60 mg/l respectively, being not significantly different (P>0.05) among the various ponds. The salinity, conductivity, total dissolved solid, total suspended solid, dissolved oxygen and chemical oxygen demand ranged from 0.00 – 0.10mg/l, 53.33 – 217.00 μScm^{-1}, 32.67 – 114.67mg/l, 2.04 – 5.83mg/l, 6.21 – 6.87mg/l and 24.32 – 33.63 mg/l respectively. Basically there significance difference (P<0.05) among the various ponds in each of the parameters.

The nutrient compositions of the various pond water that the zooplankton were identified are presented in Table 2. Chloride, potassium, iron and manganese ranged from 85.13 – 143.10 mg/l, 8.70 – 18.12mg/l, 0.19 – 0.26mg/l and 0.02 – 0.02mg/l respectively, being not significantly different (P>0.05) among the various ponds. Nitrate, sulphate, calcium, magnesium and sodium content ranged from 0.11 – 0.27mg/l, 9.92 – 12.32mg/l, 53.32 – 93.53, 14.04 – 25.72mg/l and 25.20 – 44.70 mg/l respectively. There were significance difference (P<0.05) among the various ponds in each of the parameters.

Table 1: Physico-chemical properties of the water samples

Ponds	pH	Salinity, mg/l	Conductivity, μScm^{-1}	Turbidity, NTU	TDS, mg/l	TSS, mg/l	DO, mg/l	COD, mg/l	BOD, mg/l
1	6.46^a	0.10^b	150.33^{bc}	15.12^a	111.50^b	3.73^b	6.75^b	26.10^a	9.19^a
2	6.68^a	0.09^b	232.00^c	20.03^a	114.67^b	4.63^c	6.63^{ab}	33.63^b	10.60^a
3	6.45^a	0.00^a	53.33^a	21.20^a	27.60^a	5.85^d	6.21^a	31.32^{ab}	9.25^a
4	6.52^a	0.09^b	64.33^{ab}	21.57^a	32.67^a	2.04^a	6.87^b	29.39^{ab}	9.48^a
5	6.54^a	0.01^b	217.00^c	17.39^a	108.67^b	2.60^a	6.60^{ab}	24.32^a	9.36^a

Data are expressed as mean (n=3); Different letters along the column is significantly different (P<0.05) according to Duncan statistics

Table 2: Nutrients composition of the pond water

Ponds	Nitrate, mg/l	Chloride, mg/l	Sulphate, mg/l	Calcium, mg/l	Mg, mg/l	Na, mg/l	K, mg/l	Fe, mg/l	Mn, mg/l
1	0.23^b	143.10^a	12.17^b	82.72^{bc}	17.67^{ab}	39.77^b	13.62^a	0.20^a	0.02^a
2	0.27^b	114.10^a	9.92^a	65.66^{ab}	17.29^{ab}	32.29^{ab}	12.33^a	0.19^a	0.02^a
3	0.12^a	85.13^a	11.49^{ab}	53.32^a	14.04^a	25.20^a	8.70^a	0.26^a	0.02^a
4	0.11^a	112.50^a	12.32^b	90.13^{bc}	25.71^{bc}	44.25^b	16.37^a	0.21^a	0.02^a
5	0.20^b	135.27^a	12.13^b	93.53^c	22.56^c	44.70^b	18.12^a	0.19^a	$0.02^{\mathbf{a}}$

Data are expressed as mean (n=3); Different letters along the column is significantly different (P<0.05) according to Duncan statistics

The zooplankton species from the various ponds under study are presented in Table 3. The zooplankton species fall within 14 taxa. The diversity index value of the zooplankton taxa present in the ponds in Wilberforce Island is presented in Table 4 – 8. Based on site A (Table 4), the diversity index shows that rotifer has the highest diversity (D=2.164; H=1.386), and more evenly distributed (J=1.000). Of the 24 taxa 50% (i.e 7) were absent in location A including Chordate, Chaetognatha, Gastropoda, Cladocera, Bryozoans, Crustaceans and Porifera. On the distribution perspectives based on the number of species in a taxa they are in the order of nematode (26%) > protozoans (22%) > annelida (18%), insect = rotifer (15%) > copepod (4%) (Figure 1).

In Table 5 (Site B), the diversity index indicates that protozoans has the highest diversity (D=2.276; H=1.581). While insect, cladocera and gastropoda are more evenly distributed (J=1.000). Of the 14 taxa present in the ponds in this study, four taxa are absent in Location B including Copepoda, Bryozoans, Crustaceans and Porifera On the distribution perspectives based on the number of species in a taxa they are in the order of annelid (23%) >protozoans (21%) = rotifers (21%) > chordate (12%) >insecta (9%) > nematoda (7%), chaetognatha (3%) > cladocera and gastropoda (2% each) (Figure 2).

Table 3: Zooplankton assemblages from selected ponds in Wilberforce Island, Nigeria

Taxa/species	A	B	C	D	E
NEMATODA					
Triplva	1	0	0	3	1
Cylindrolaimus sp.	4	0	0	2	0
Microlaimus	1	0	6	8	3
Helicotylenclus sp.	1	0	1	5	4
Doryllium sp.	0	1	0	0	0
Bunonema sp.	0	2	1	2	6
Wilsonema sp.	0	0	1	0	0
Tetylenchus sp.	0	6	3	1	0
Radiopholus sp.	0	0	1	0	0
Plectus sp.	0	0	2	0	3

Taxa/species	A	B	C	D	E
Tylenchornynchus sp.	0	0	0	2	0
Hemicycliophora sp.	0	0	0	1	1
Dolichodorus sp.	0	0	0	0	1
Tyleptus sp.	0	0	0	0	1
Setnura sp.	0	0	0	0	4
Xiphinema sp.	0	0	0	0	1
Belonolaimus sp.	0	0	0	0	1
TOTAL	7	3	12	23	26
PROTOZOAN					
Euglena sp.	1	0	0	1	0
Pteropoda sp.	4	1	1	0	4
Paramecium sp.	0	1	0	0	1
Amoeba sp.	0	4	3	2	3
Tintinnopsis sinensis	0	1	0	0	0
Gonadium of obella	0	1	0	0	0
Epistyles sp.	0	1	0	0	0
Tintinnidium entizii	0	0	1	0	0
Hemiophyrs pleurosigma	0	0	1	0	0
Arcella vulgaris	0	0	1	0	0
Euglena wangi	0	0	0	1	0
Tintinnids sp.	0	0	0	2	0
Vorticella sp.	0	0	0	1	0
Listostomatea sp.	0	0	0	1	0
Ophrydium sp.	0	0	0	1	0
Dinomonas sp.	0	0	0	0	1
Part of Difflugia oblonga	0	0	0	0	1
Oikomorlas sp.	0	0	0	0	1
Euglena tripteris	0	0	0	0	1
TOTAL	6	9	7	9	12
INSECTA					
Larva of Caddis fly	2	1	2	1	1
Psychoda sp.	1	0	1	0	0
Culex mosquito egg	1	0	0	0	5
Ochratricha sp (larva and case)	0	1	0	0	0
Tabanus sp. (Blowfly)	0	1	0	1	1
Midges larva	0	1	2	0	1
(Cranefly) Tipula larva	0	0	1	0	0
Simulium sp. pupa	0	0	0	1	0
Poissonia sp.	0	0	0	1	0
Mosquito larva	0	0	0	1	0
Larva of Dragonfly	0	0	0	0	1
Eristalis sp. (Rat-tail maggot)	0	0	0	0	1
TOTAL	4	4	6	5	10
ROTIFERA					
Branchionus rubens	1	0	0	0	0
Beauchampin crucigera	1	0	0	0	0
Kellicottia longispina	1	0	0	0	0
Lacane sp.	1	0	1	1	0
Brachionus budapestiensis	0	1	0	0	0
Natholca caudate	0	4	1	0	0
Anuraeopsis sp.	0	1	0	1	0
Notholca squamula	0	2	0	0	0
Microcodides chlaena	0	1	0	0	0
Keratella sp.	0	0	1	0	0
Notholca sp.	0	0	1	1	1
Keratella crassa	0	0	1	0	0
Lophocharis salpina	0	0	1	0	0
Albertia naidi	0	0	1	0	0
Keratella sp.	0	0	0	1	0
Encentrum sp.	0	0	0	1	1

Taxa/species	A	B	C	D	E
Ascomorpha sp.	0	0	0	1	0
Conochiloides dossuarius	0	0	0	1	0
Conochilus hippocrepis	0	0	0	1	0
Colotheca pelagica	0	0	0	0	1
Epiphanies sp.	0	0	0	0	2
Limnais sp.	0	0	0	0	1
Epiphanes pelagica	0	0	0	0	1
Ploesoma truncatum	0	0	0	0	1
Lucane stichae	0	0	0	0	1
Branchionus sp.	0	0	0	0	1
Kellicotia bostoniensis	0	0	0	0	1
TOTAL	4	9	7	8	11
ANNELIDA					
Tubifex sp.	3	6	9	8	12
Limnodrilus sp.	1	3	4	0	0
Nais sp.	1	0	2	1	0
Dero sp.	0	1	2	2	6
Enchytraeus s.p	0	0	3	1	0
Leech sp.	0	0	5	2	1
Polychaete worm larva	0	0	2	0	0
(Earthworm) Lumbricus terrestris	0	0	0	1	3
TOTAL	5	10	27	15	22
COPEPODA					
Copepod sp.	1	0	0	0	0
TOTAL	1	0	0	0	0
CHORDATA					
Fish egg	0	2	1	2	1
Fish larva	0	3	0	0	0
Thaliacea sp.	0	0	0	0	1
TOTAL	0	5	1	2	2
CHAETOGNATHA					
Chaetognath sp.	0	1	0	0	0
TOTAL	0	1	0	0	0
GASTROPODA					
Zebra mussel	0	1	0	0	0
Styliola subula	0	0	1	0	0
Larva of Molllusc	0	0	0	0	1
TOTAL	0	1	1	0	1
CLADOCERA					
Nauplius sp.	0	0	1	0	0
Bosmina sp.	0	1	0	0	0
TOTAL	0	1	1	0	0
BRYOZOAN					
Cyphonaute larva	0	0	1	1	1
TOTAL	0	0	1	1	1
CRUSTACEAN					
Caridina sp.	0	0	0	1	0
Potamonautes sp.	0	0	0	1	0
TOTAL	0	0	0	2	0
PORIFERA					
Sponge sp.	0	0	0	0	5
Ephydatia sp.	0	0	0	0	2
Tubella sp.	0	0	0	0	1
TOTAL	0	0	0	0	8

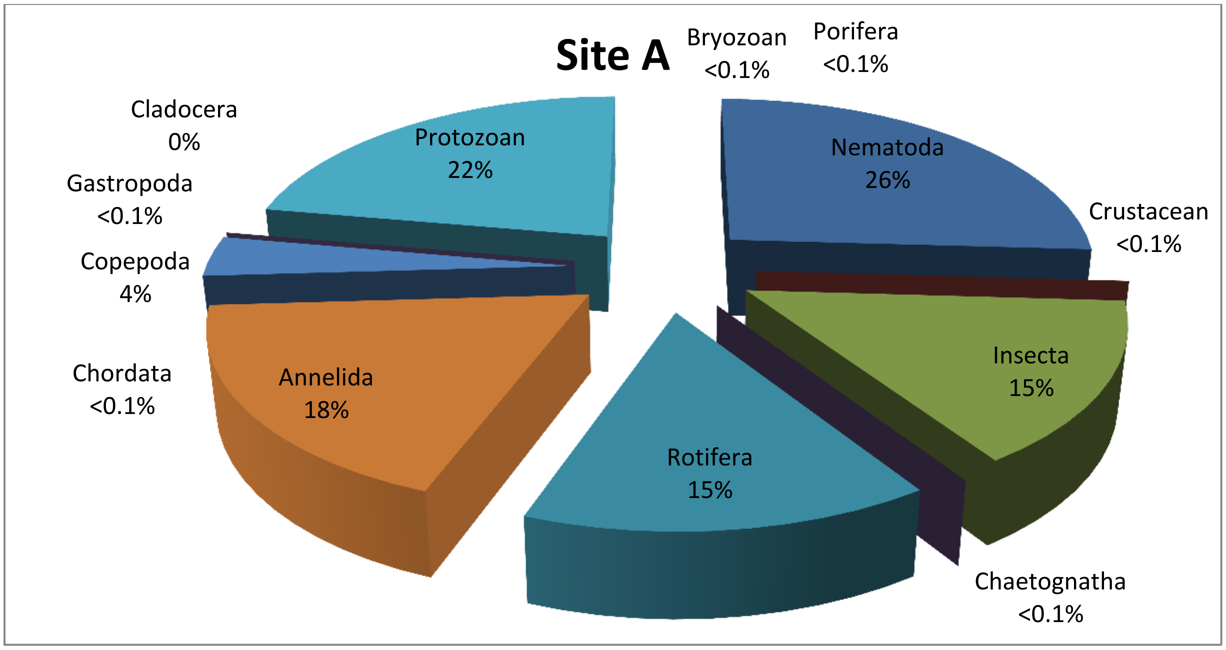

Figure 1: Distribution of taxa on the zooplankton from location A

Table 4: Diversity Index for Site A

Taxa	Shannon_H	Margalef D	Equitability_J
Nematode	1.154	1.542	0.8322
Protozoa	0.5004	0.6213	0.7219
Insecta	1.04	1.443	0.9464
Rotifer	1.386	2.164	1.0000
Anelida	0.9503	1.243	0.865
copepoda	0.000	0.000	0.000
Chordate	-	-	-
Chaetognatha	-	-	-
Gastropoda	-	-	-
Cladocera	-	-	-
Bryozoans	-	-	-
Crustaceans	-	-	-
Porifera	-	-	-

Table 5: Diversity Index for Site B

Taxa	Shannon_H	Margalef D	Equitability_J
Nematode	0.8487	0.9102	0.7725
Protozoa	1.581	2.276	0.8824
Insecta	1.386	2.164	1.000
Rotifer	1.427	1.82	0.8867
Annelida	0.8979	0.8686	0.8173
Copepod	-	-	-
Chordata	0.673	0.6213	0.971
Chaetognatha	0.000	0.000	0.000
Gastropoda	0.6931	1.443	1.000
Cladocera	0.6931	1.443	1.000
Bryozoans	-	-	-
Crustaceans	-	-	-
Porifera	-	-	-

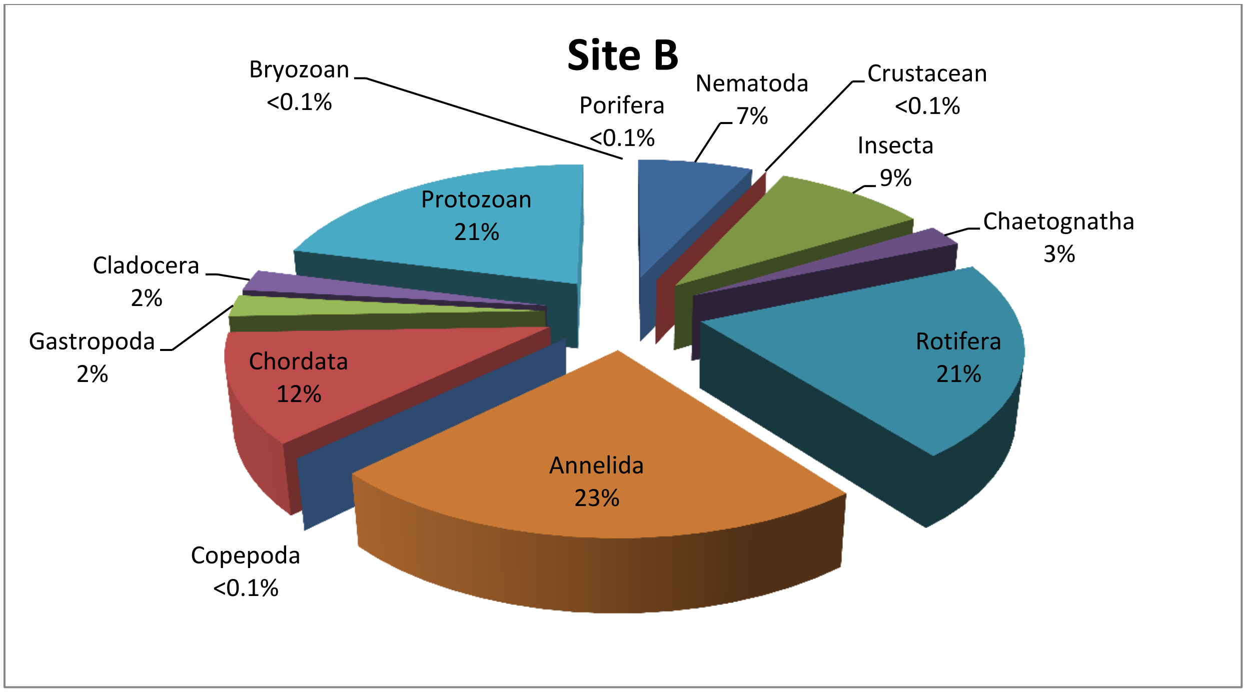

Figure 2: Distribution of taxa on the zooplankton from location B

The diversity index indicates that rotifers has the highest diversity (D=3.083; H=1.946), while rotifers, cladocera and gastropoda are more evenly distributed (J=1.000) (Table 6). Of the 14 taxa present in the ponds in this study, four taxa are absent in Location C including Copepoda, Chaetognatha, Crustaceans and Porifera On the distribution perspectives based on the number of species in a taxa they are in the order of annelida (43%) > nematode (19%), protozoans = rotifers (9%) > gastropoda =cladocera = bryozoans (2% each) > Chordata (1%) (Figure 3).

The diversity index shows that rotifers and insecta has the highest diversity (D=3.366; H=2.079), while rotifers, crustaceans and insecta are more evenly distributed (J=1.000) (Table 7). Of the 14 taxa present in the ponds in this study, five taxa are absent in Location D including Copepoda, Chaetognatha, Gastropoda, Cladocera and Porifera On the distribution perspectives based on the number of species in a taxa they are in the order of nematode (35%) > annelida (23%) > protozoans (14%) > rotifers (12%) > Insecta (8%) > Chordata and Crustaceans (3% each) > Bryozoans (2%) (Figure 4).

Table 6: Diversity Index for Site C

Taxa	Shannon_H	Margalef D	Equitability_J
Nematode	1.679	2.216	0.8629
Protozoa	1.475	2.056	0.9165
Insecta	1.33	1.674	0.9591
Rotifer	1.946	3.083	1.000
Anelida	1.784	1.82	0.9167
Copepod	-	-	-
Chordate	0.000	0.000	0.000
Chaetognatha	-	-	-
Gastropoda	0.6931	1.443	1.000
Cladocera	0.6931	1.443	1.000
Bryozoans	0.000	0.000	0.000
Crustaceans	-	-	-
Porifera	-	-	-

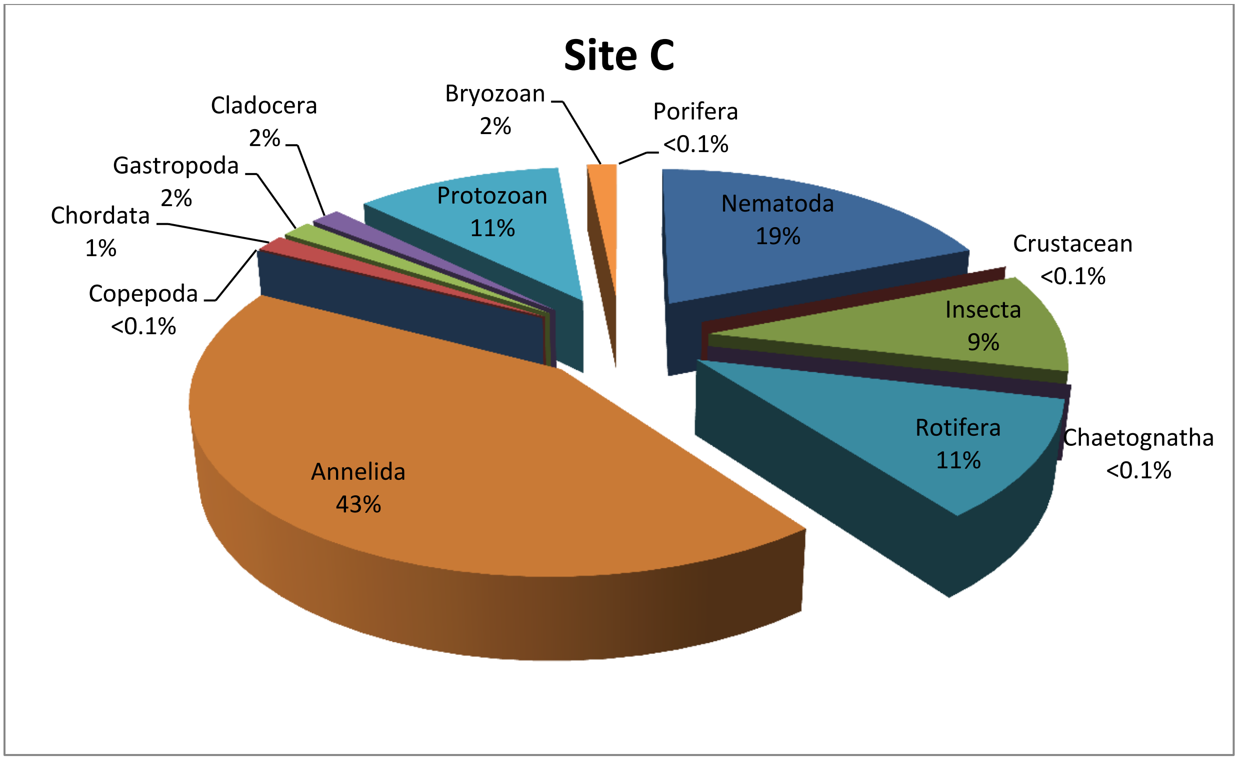

Figure 3: Distribution of taxa on the zooplankton from location C

In Table 8 (Site E), the diversity index shows that rotifers has the greatest diversity (D=3.753; H=2.272) and chordata and gastropoda are more evenly distributed (J=1.000). Of the 14 taxa present in the ponds in this study, four taxa are absent in Location E including Copepoda, Chaetognatha Crustaceans and Cladocera. On the distribution perspectives based on the number of species in a taxa they are in the order of nematoda (28%) > annelid (24%) >protozoans (13%) > rotifers (12%) > insecta (11%) > porifera (8%), chordata (2%) > bryozoan and gastropoda (1% each) (Figure 5).

Table 7: Diversity Index for Site D

Taxa	Shannon_H	Margalef D	Equitability_J
Nematode	1.839	2.203	0.8844
Protozoa	1.889	2.731	0.9708
Insecta	2.079	3.366	1.0000
Rotifer	2.079	3.366	1.0000
Anelida	1.414	1.846	0.7893
Copepod	-	-	-
Chordate	0.000	0.000	0.000
Chaetognatha	-	-	-
Gastropoda	-	-	-
Cladocera	-	-	-
Bryozoans	0.000	0.000	0.000
Crustacean	0.6931	1.443	1.000
Porifera	-	-	-

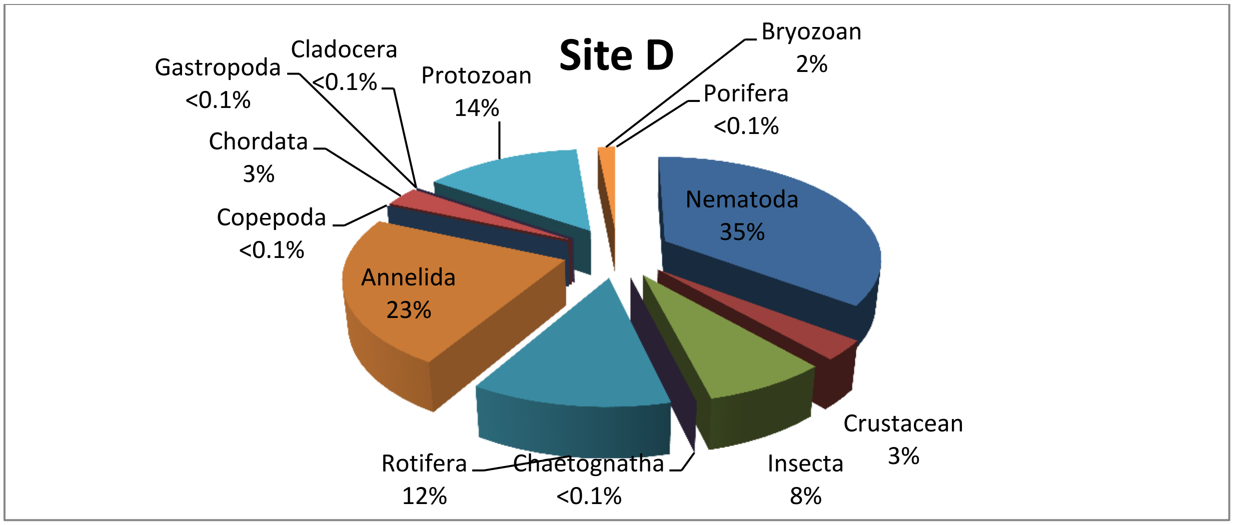

Figure 4: Distribution of taxa on the zooplankton from location D

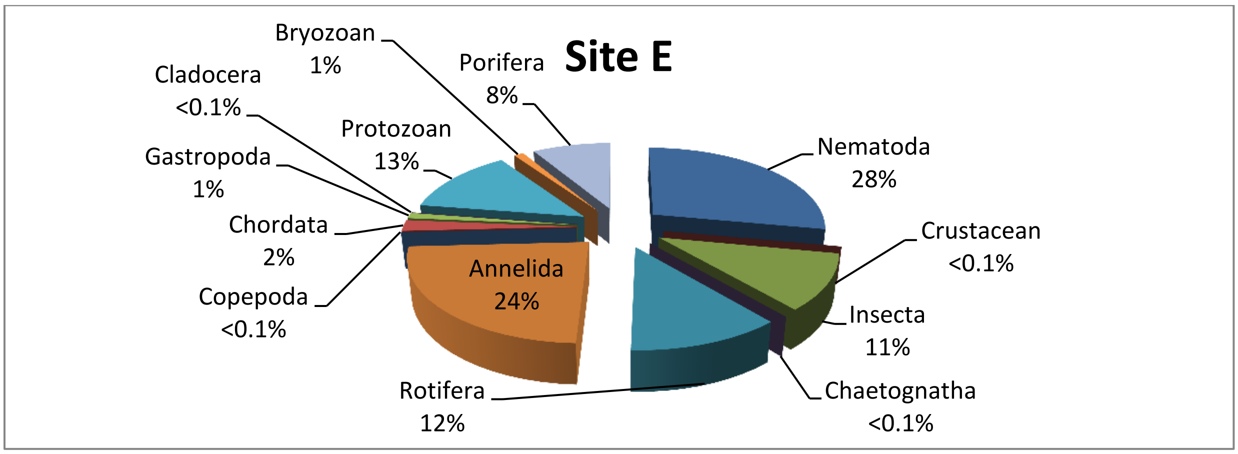

Figure 5: Distribution of taxa on the zooplankton from location E

Table 8: Diversity Index for Site E

Taxa	Shannon_H	Margalef D	Equitability_J
Nematode	2.165	3.069	0.9027
Protozoa	1.594	2.085	0.8897
Insecta	1.946	3.119	0.8856
Rotifer	2.272	3.753	0.9867
Anelida	1.097	0.9705	0.7914
Copepod	-	-	-
Chordata	0.6931	1.443	1.0000
Chaetognatha	-	-	-
Gastropoda	0.6931	1.443	1.0000
Cladocera	-	-	-
Bryozoans	0.000	0.000	0.000
Crustaceans	-	-	-
Porifera	0.9003	0.9618	0.8194

The Sorenson qualitative similarity index for the taxas of zooplankton from the various ponds are presented in Table 9. Beside Ponds A and E, A and E, B and C, B and E, the taxas are similar at Sorenson quantitative index at critical value of 0.5.

Table 9: Sorenson quantitative index interactions

	A	B	C	D	E
A	1.00				
B	0.62	1.00			
C	0.57	0.64	1.00		
D	0.56	0.66	0.75	1.00	
E	0.43*	0.55	0.73	0.79	1.00

* Is not statistically similar according to Sorenson quantitative index at critical value of 0.5

4 Discussion

4.1 Water quality studies pH

pH is the alkalinity and acidity of the water. The pH of water sample is nearly neutral. The pH value is equal to the logarithm of the hydrogen-ion concentration with negative sign. Based on Table 1, the pH of the ponds water has some similarity with those of other surface waters in the Niger Delta especially in Bayelsa state. These include water from Kolo creek [5, 48], Ikoli creek [6], River Nun [1, 7, 49], New Calabar-Bonny River [50], Epie creek [14], Minichnda stream in Rumuokwurushi, Port Harcourt, Rivers state, Nigeria [51].The similarity could be attributed to the geology of the area as well as the fact that they receive effluents and other municipal wastes directly or indirectly.

Salinity: Salinity is a measure of salt concentration of the water. In this study there was nearly low salt concentration in the water body. The findings of this study are comparable to the findings of other studies based on surface water in the Niger Delta Region of Nigeria. Some of these studies include Kolo creek [5], Ikoli creek [6] River Nun [1, 7], Minichnda stream [51]. However, some other authors have reported salinity level not comparable to findings of this study. Some of these studies include the work of Nyananyo *et al*. [49] in Nun River. But the results of this study are slightly lower than values reported by Allison and Otene [51] for Minichnda stream. The decline in the salinity of River Nun at Amassoma axis could be attributed to increased anthropogenic activities in the study area, which could have caused dilution effects [7].

Conductivity: Conductivity is a measure of the ability of the water to convey an electric current. The conductivity level observed in this study is low compared to limits for potable water sources in Nigeria. Also, the conductivity level of the water is merely due to the presence of dissolved mineral matters in the water. A lower conductivity level had been previously reported for River nun by Nyananyo *et al*. [49], Agedah *et al*. [1], Ogamba *et al*. [7], Epie creek in Yenagoa metropolis Izonfuo and Bariweni 14], Ikoli creek[6], Kolo creek [5]. Also the findings of this study is comparable to finding of Allison and Otene [51] that reported conductivity for Minichnda stream, Rivers state. The magnitude of conductivity is a useful indication of the total concentration of the ionic solutes [7].

Turbidity: Turbidity is a measure of the colour of the water as against the normal standard of colorless. Generally, the colour of the water is brown in appearance. Hence the turbidity of the water is high. The turbidity of the water samples is higher that maximum permissible level of 5 NTU for potable water sources recommended by Standard Organization of Nigeria for drinking water. The turbidity level in this study is a reflection of clay nature of the environment and discharge of all forms of anthropogenic materials into the water bodies [5-7]. The turbidity of the water in this study is slightly higher than that of Epie Creek in Yenagoa metropolis [14], Minichnda stream [51]. However, Agedah *et al*. [1] reported a higher turbidity from River Nun. The higher turbidity of the water in this study is a reflection of clay nature of the environment, discharge of all forms of anthropogenic materials into the water bodies [7].

Total dissolved solid: Solids are materials or remains of residue. Total solid dissolved solid are materials that could have dissolved in the pond water sample. The total dissolved solid in this study has some similarity with the findings of authors from surface water in Bayelsa state. Some of these studies include Epie creek in Yenagoa metropolis [14], River nun [7], Ikoli creek [6], Kolo creek [5. 48], New Calabar-Bonny River [50]. This is an indication of high dilution in the surface water and the current intensity of the river; hence all the solid materials deposited into the water body do flow out and dissolve.

Total suspended solid: Total suspended solid are materials that are found in the water and were unable to dissolve, hence they suspend and float in the water. However, most times the materials could be minute and thus cannot be easily detected with mere naked eye. The low total suspended solid in the water at Amassoma Axis could be attributed to the dilution effects [7]. The lower total suspended solid could be attributed to the major low anthropogenic activities that is being carried out in the in the pond and to a lesser extent that ponds receive less wastes when compared to rivers and creeks in the region.

Nitrate: Nitrate is an organic form of nitrogen. Nitrate is found naturally in the environment and is an important plant nutrient. It is present at varying concentrations in all plants and is a part of the nitrogen cycle. The concentration of nitrate in this study is comparable to previous reports of Nyananyo *et al*. [49], Ogamba *et al*. [7] from river Nun, Izonfuo and Bariweni [14] from Epie creek Yenagoa metropolis. The presence of nitrate in surface water is as a result of discharge of organic materials into the water, which is a common practice to the inhabitant of the sample collection areas. Surface water nitrate concentrations can change rapidly owing to surface runoff of organic matter during soil erosion, uptake by phytoplankton and other aquatic herbs and denitrification by bacteria [7].

Chloride: Chloride is produced in large amounts and widely used both industrially and domestically as an important disinfectant and bleach. In water, chlorine reacts to form hypochlorous acid and hypochlorites. The concentration of chloride in this study ranged is far below the level reported from other surface water in the Niger Delta. Some of these study include Epie creek, Yenagoa metropolis [14], Minichinda stream [51], River Nun [7], Ikoli creek [6], Kolo creek [5]. High concentrations of chloride give a salty taste to water. Generally due to the low salinity, it reflects on the chloride concentration of the water. Chloride depends on the associated cation such as sodium, potassium and calcium chloride etc. the low chloride is as a result of the current level of the water and dilution [7].

Sulphate: Sulphate occur naturally in numerous minerals and are used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition. Basically, sulphide oxidized rapidly to sulpahte in well-aerated or chlorinated water, and hydrogen sulphide levels in oxygenated water supplies are normally very low. The concentration of sulphate in this study is far higher than the concentration for other surface water in Bayelsa state including Epie creek in Yenagoa metropolis [14], River Nun [7, 49]. Sulphate occurs naturally in numerous minerals and is used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition. The concentration of sulphate in this study is low to cause laxative effects to biological organisms that reside in the water and its intended users [7].

Cations: Calcium and magnesium are divalent while sodium and potassium are monovalent. The concentration of these nutrient is has some similarity with the values previously reported for Kolo creek [5], Ikoli creek receiving abattoir effluents [6] and River Nun [7], Epie creek [14]. The acidity, nutrient availability and nutrient leachability depend on the relative proportions of the monovalent and divalent cations. Hence, the low exchange cation indicates that the water is classified as soft water no low is some pollution indicators. This is an indication that aquatic plants such as water hyacinth that are capable of remediating toxic pollutant from the water.

Iron : The concentration of iron from the study area across the period is generally low. Similarly concentration have been reported from surface water in Bayelsa state including Kolo creek [5], Ikoli creek receiving abattoir effluents [6] and River Nun [7]. The iron concentration in this study is below the permissible limit that it could cause toxicity to organisms. Basically, iron concentration is a reflection of the acidity of the water (pH). This is in agreement with the pH of the water.

Manganese: The concentration of manganese in this study is low. Basically the manganese level fall within the range reported in different surface water bodies throughout Nigeria especially in Bayelsa state. This include the work of Ogamba *et al*. [5] from Kolo creek, Ogamba *et al*. [6] from Ikoli creek receiving abattoir effluents and Ogamba *et al.* [7] from River Nun. Typically, manganese are need by biological system in trace amount, hence there concentration is below the permissible limit that it could pose danger to biological organisms.

***Oxygen related parameters*:** The dissolved oxygen in this study indicates that the water is suitable for aquatic life. The biological oxygen demand and chemical oxygen demand in the pond water indicate that they are polluted. However, the level of some of the oxygen related parameters in this study has some similarity with previous study by Aghoghovwia and Ohimain [48] for lower Kolo creek in the range of 5.0 – 7.92 mg/l, Izonfuo and Bariweni [14] from Epie creek. The high dissolved oxygen observed from this study could be associated to the time of the sampling (i.e afternoon) [1]. The dissolved oxygen observed from this study suggests that the aquatic organisms are getting the required oxygen need for survival [1].

4.2 Zooplankton studies

The zooplankton studies indicate that the ponds are rich in plankton especially zooplanktons. However, the number and taxa found in each of the ponds differs. These fluctuations could be interpreted as a result of changes in physicochemical parameters of the ponds. This is because there is relationship between the physico-chemical parameters and plankton production of water bodies are of great importance in management strategies of aquatic ecosystem [31]. The main difference characterizing the variation in the zooplankton composition could be due to nutrient variation. Ohimain *et al*. [19] reported that Wilberforce Island which constitutes an integral part of the study area is characterized by depression and often get submerged during the rainy season.

Rotifers, protozoans, insecta and nematodes have the highest number of species while broyozoan, porifera, crustancea, cladocera, gastropoda etc have the least number of species. Again the differences in the number of species in each of the taxa across the ponds could be due to the season of sampling. Some of the species thrive better on the dry season while others on the raining season. The higher number of Rotifer species in the study area could due to their ability to withstand and survive in varying limnological conditions prevailing at the different locations over the seasons[20]. The trend of Rotifer having the highest number of species is comparable to the work of Ogbuagu and Ayoade [20], who reported higher abundance of the rotiferan plankton over some others including fish eggs and larvae, crab larvae, and beetle larvae in Imo River. Furthermore, the higher rotifer species could be associated to their incessant movement and fantastic variety of shapes (varying from worm-like attachment types to rotund forms) and their ability to float in near surface water [27]. Also the findings of this study is far from the work of Ogbuagu and Ayoade [52], who reported cladocera as the predominant zooplankton from fresh water in Etche, Rivers state, Nigeria.

Some of the zooplankton communities identified in the various pond have been reported from water bodies including Minichinda Stream, Niger Delta [53], Amassoma flood plain [54], Imo river [55], Ekpan river, Delta state [28], Orogodo River [56].

The zooplankton diversities (Margalef Index) were within the range reported for zooplankton community of Elechi creek complex receiving human activities in the Niger Delta as reported by Ogamba et al. [26] but lower that the value of 5.00 as reported by Falomo [57].

5 Conclusion and Recommendation

This study assessed the water quality and zooplankton communities of the ponds found in Wilberforce Island, Bayelsa state, Nigeria. The results obtained from this water quality parameter of the measured physical and chemical properties are below the permissible limits by Standard Organization of Nigeria (SON) for water quality except for turbidity. This also suggests that these ponds undergo self purification just like most surface water bodies such as rivers, creeks and creeklets in the Niger Delta. The diversity indices used in this study margalef, Shannon-Weaver and Equitability showed the same trend value in the physiochemical parameters of the water. This indicates that there is relationship between the physicochemical parameters of the ponds water and zooplankton communities. This also indicates that samples taken were true representative of the population. Despite the greatest diversity exhibited by nematodes, rotifers and insect were the most the most diverse. Therefore, ponds are suitable for aquaculture. This is because of the diverse zooplankton communities that they contain which could be a food source to fisheries.

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References

1. Agedah, E.C., Ineyougha, E.R., Izah, S.C.and Orutugu, L.A. (2015). Enumeration of total heterotrophic bacteria and some physico-chemical characteristics of surface water used for drinking sources in Wilberforce Island, Nigeria. *Journal of Environmental Treatment Techniques*, 3(1): 28 – 34.
2. Izah, S.C. and Ineyougha, E.R. (2015). A review of the microbial quality of potable water sources in Nigeria. *J Adv Biol Basic Res* 1(1): 12 - 19.
3. Izah, S.C. and Srivastav, A.L. (2015). Level of arsenic in potable water sources in Nigeria and their potential health impacts: A review. *J Environ Treat Techniq* 3(1): 15 – 24.
4. Izah, S.C., Chakrabarty, N. and Srivastav AL. (2016). A Review on Heavy Metal Concentration in Potable Water Sources in Nigeria: Human Health Effects and Mitigating Measures. *Exposure and Health,* 8:285–304.
5. Ogamba E.N, Seiyaboh EI, Izah SC, Ogbugo I and Demedongha FK (2015). Water quality, phytochemistry and proximate constituents of *Eichhornia crassipes* from Kolo creek, Niger Delta, Nigeria. *International Journal of Applied Research and Technology,* 4(9): 77 – 84.
6. Ogamba, EN, Izah SC and Toikumo, B.P. (2015). Water quality and levels of lead and mercury in *Eichhornia crassipes* from a tidal creek receiving abattoir effluent, in the Niger Delta, Nigeria. *Continental Journal of Environmental Science,* 9(1): 13 – 25.
7. Ogamba, E.N., Izah, S.C. and Oribu, T. (2015). Water quality and proximate analysis of *Eichhornia crassipes* from River Nun, Amassoma Axis, Nigeria. *Research Journal of Phytomedicine, 1*(1): 43 – 48.
8. Ogamba, EN, Ebere N. and Izah SC (2017). Heavy metal concentration in water, sediment and tissues of Eichhornia crassipes from Kolo creek, Niger Delta. Greener Journal of Environmental Management and Public Safety. In press.
9. Ogamba, EN, Ebere N. (2017). Assessment of Physicochemical quality of sediment from Kolo creek, Niger Delta. Greener Journal of Biological Sciences. In press.
10. Seiyaboh, E.I., Izah, S.C. and Okogbue, B.C. (2016). Seasonal Variation in Length-Weight Relationship and Condition Factor of Five Fish Species from Kolo Creek, Niger Delta. Greener Journal of Agricultural Sciences, 6(11): 342 – 348.
11. Seiyaboh, E.I., Izah, S.C. and Oweibi, S. (2017). Assessment of Water quality from Sagbama Creek, Niger Delta, Nigeria. *Biotechnological Research,* 3(1): 3(1):20-24
12. Seiyaboh, E.I., Izah, S.C. and Oweibi, S. (2017). Physico-chemical Characteristics of Sediment from Sagbama Creek, Nigeria. *Biotechnological Research,* 3(1): 25-28.
13. Seiyaboh, E.I., Inyang, I.R. and Izah, S.C. (2016). Spatial Variation in Physico-chemical Characteristics of Sediment from Epie Creek, Bayelsa State, Nigeria. *Greener Journal of Environment Management and Public Safety,* 5(5): 100 – 105.
14. Izonfuo, L.W.A. and Bariweni, A. P. (2001). The effect of urban runoff water and human activities on some physico-chemical parameters of the Epie Creek in the Niger Delta. *Journal of Applied Sciences and Environmental Management,* 5(1):47-55.
15. Seiyaboh, E.I., Inyang, I.R. and Izah, S.C. (2016). Seasonal Variation of Physico-Chemical Quality of Sediment from Ikoli Creek, Niger Delta. *International Journal of Innovative Environmental Studies Research,* 4(4): 29-34.
16. Seiyaboh, E.I., Ogamba, E.N. and Utibe, D.I. (2013). Impact of Dredging on the Sediment Quality of Igbedi Creek, Upper Nun River in Central Niger Delta, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 7(5): 45-50.
17. Seiyaboh, E.I., Ogamba, E.N. and Utibe, D.I. (2013). Impact of Dredging on the Water Quality of Igbedi Creek, Upper Nun River, Niger Delta, Nigeria. *IOSR Journal of Environmental Science, Toxicology* and *Food Technology,* 7(5): 51 – 56.
18. Angaye, T.C.N. and Mieyepa, C.E. (2015). Assessment of Elemental and Microbial Quality of Lake Efi In Bayelsa State, Central Niger Delta, Nigeria. *Journal of Environmental Treatment Techniques,* 3(2): 71 - 75.
19. Ohimain, E.I., Izah, S.C. and Otobotekere, D. (2014). Selective impacts of the 2012 water floods on the vegetation and wildlife of Wilberforce Island, Nigeria. *International Journal of Environmental Monitoring Analysis*, 2: 73 – 85.
20. Ogbuagu, D.H. and Ayoade, A.A. (2012a). Spatial Fluctuations in Zooplankton Biotypes of the Imo River in a Niger Delta Area of Nigeria. International Journal of Ecosystem 2012, 2(4): 54-60
21. Abdul, W.O., Adekoya, E.O., Ademolu, K.O., Omoniyi, I.T., Odulate, D.O., Akindokun, T.E. and Olajide, A.E. (2016). The effects of environmental parameters on zooplankton assemblages in tropical coastal estuary, South-west, Nigeria. *Egyptian Journal of Aquatic Research*, 42, 281–287.
22. N'da, S.A., Etilé, R.N., N'zi, K.G., Berté, S. and N'douba, V. (2015). Composition and Distribution of Zooplankton Relationship to Environmental Factor in a Tropical River: (Bagoe, Côte d'Ivoire). *International Research Journal of Biological Sciences,* 4(11), 1-11.
23. Sinha, B. and Islam, M.R. (2002). Seasonal variation in zooplankton population of two lentic bodies and Assam State Zoo cum Botanical garden, Guwahati, Assam, *Ecol. Environ. Conser.*, 8, 273-278.
24. Aoyagui, A.S.M. and Bonecker, C.C. (2004). Rotifers in different environments of the Upper Paraná River floodplain (Brazil): richness, abundance and relationship with connectivity, *Hydrobiologia*, 522(1-3), 281-290.
25. Park, K.S. and Shin, H.W. (2007). Studies on phyto-and zooplankton composition and its relation to fish productivity

in a west coast fish pond ecosystem, *J. Environ. Biol.*, 28, 415-422.
26. Ogamba, E.N., Ekweozor, I.K.E. and Daka, E.R. (2005). The influence of human activities of the zooplankton of Elechi Creek complex in the Niger Delta. *African Journal of Pollution Health,* 4(2): 31 – 38.
27. Arazu, V.D.N. and Ogbeibu, A.E. (2017). The composition, abundance and distribution of zooplankton Of River Niger at Onitsha stretch, Nigeria. *Animal Research International,* 14(1): 2629 – 2643.
28. Iloba, K.I. and Ruejoma, M.G.O. (2014). Physico-Chemical Characteristics And Zooplankton Of Ekpan River, Delta State, Nigeria. *International Journal of Applied Biological Research*, 6(1): 8 – 30.
29. Webber, M., Edwards Myers E., Campbell C. and Webber D. (2005). Phytoplankton and zooplankton as indicators of water quality in Discovery Bay, Jamaica, *Hydrobiologia*, 545, 177-193.
30. Landa, G.G., Barbosa, F.A.R., Rietzler A.C. and Maia Barbosa, P.M. (2007). *Thermocyclops decipiens* (Kiefer, 1929) (Copepoda, cyclopoida) as indicator of water quality in the State of Minas Gerais, Brazil, *Braz. Arch. Biol. Tech.*, 50(4), 695-705.
31. Edward, J.B. and Ugwumba, A.A.A. (2010). Physico-chemical parameters and plankton community of Egbe Reserviour, Ekiti state, Nigeria. *Research Journal of Biological Sciences*, 5(5), 356 – 367.
32. APHA (American Public Health Association) (1998). *Standard Method for examination of water and waste water*. 20th edition New York: American Public Health Association.
33. Nannette, H. (2012). *Estuaries Phytoplankton Protocol.* pp1-9.
34. Botes, L. (2003), *Phytoplankton Identification Catalogue*. GloBallast Monograph Series No.7, Saldanha Bay, South Africa.
35. Cleveland, P.Hickman Jr., Larry, S.Roberts, Allan, Helen, L. I'anson, and David JE (2006), *Integrated Principle of Zoology*, 13th edition, McGraw-Hill Companies.
36. Dana, W. (2013). *Zooplankton* – A Lake's Best Friend. Indiana Clean Lakes Program. Factsheet 11-01.
37. Edmondson, W.T. (1959). *Freshwater Biology* (Ed.). John Wiley and sons, Inc., USA. 1248pp.
38. Emi, Y. and Caitlin, B. (2007), *Zooplankton Identification Guide*. http://www.marex.uga.edu/aquarium.
39. Goswami, S.C. (2004), *Zooplankton Methodology, Collection and identification-afield manual*.
40. LG 403. (2003). *Standard Operating Procedure for Zooplankton Analysis*. Pp.15.
41. Patterson, D.J. and Hedly, S. (1992), *Free-living Freshwater Protozoan*: A colour Guide. Wolf, England. 223pp.
42. Pennak, R.W. (1978), *Freshwater Invertebrates of the United States* (Ed). John Wiley and Sonii Inc., USA. 803pp.
43. Phyllis, M.M., Miles, H.B. and Graham, V.E. (1970). *Hulton's Biological Field Studies, Tropical Freshwater Ecology.* 1st Edition, Hulton Educational Publications Ltd., pp.130.
44. USEPA(United State Environmental Protection Agency) (2009). *Great Lake Water Life Photo Gallery.* Sea Great Extension Office , Great Lakes Environmental Research Lab, Sea Grant Lake Network.
45. APHA (2005). *American Water Works Association and Water Pollution Control Federation,* Standard Method for Examination of Water and Wastewater, APHA, AWWA and WPCF, New York.
46. Hammer, Ø., Harper, D.A.T., Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm.
47. Ogbeibu, A.E. (2005). *Biostatistics. A practical approach to research and data handling.* Mindex Publishing Company Limited, Benin-City Nigeria
48. Aghoghovwia, O.A. and Ohimain, E.I. (2014). Physicochemical characteristics of lower Kolo creek, Otuogidi, Bayelsa state. *Nigerian Journal of Agriculture, Food and Environment,* 10(1):23 - 26
49. Nyananyo, B.L., Gijo, A.H. and Ogamba, E.N. (2007). The physico-chemistry and distribution of water hyacinth (*Eichhornia crassipes*) on the river Nun in the Niger Delta. *Journal of Applied Sciences and Environmental Management,* 11: 133-137.
50. Agbugui, M.O. and Deekae, S.N. (2013). Assessment of the Physico-chemical Parameters and Quality of Water of the New Calabar-Bonny River, Porthacourt, Nigeria. *Cancer Biology,* 4(1):1 – 9.
51. Allison, M. E. and Otene, B. B. (2012). Phytoplankton Assemblage and Physio-chemical Parameters of Minichinda Stream, Port-Harcourt, Rivers State, Nigeria. *International Journal of Applied Research and Technology,* 1(7):52 – 59.
52. Ogbuagu, D.H. and Ayoade, A.A. (2012). Seasonal Dynamics in Plankton Abundance and Diversity of a Freshwater Body in Etche, Nigeria. Environment and Natural Resources Research, 2(2): 48 – 59.
53. Davies, O. A., Abowei, J.F.N. and Otene, B. B. (2009). Seasonal Abundance and Distribution of Plankton of Minichinda Stream, Niger Delta, Nigeria. *American Journal of Scientific Research*, 2: 20-30.
54. Tawari, C.C., Abowei, J.F.N. and Charles, E. (2014). Effects of Flooding on zooplankton in Amassoma Flood Plain Niger Delta, Nigeria. *Annals of Biological Sciences*, 2 (3):1-7.
55. Sikoki, F. D., Zabbey, N. and Edoghotu, J. (2006). Plankton assemblages and environmental Gradients in the middle reaches of the imo river, Niger Delta, Nigeria. *Caderno de Pesquisa Sér. Bio., Santa Cruz do Sul,* 18(1): 99- 109.
56. Arimoro, F.O. and Oganah, A.O. (2010). Zooplankton Community Responses in a Perturbed Tropical Stream in the Niger Delta, Nigeria. *The Open Environmental & Biological Monitoring Journal*, 2010, 3, 1-11.
57. Falomo, R.O. (1998). The impacts of industrial effluents in the distribution of plankton of the central Bonny Estuary. M.Sc. Thesis, RSUST, Port Harcourt.