PLANKTON AND BENTHOS DISTRIBUTION OF RIVER DONGA, TARABA STATE, NORTH EAST, NIGERIA

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Abstract

A twelve (12) week investigation was carried out in River Donga, to determine the plankton and benthos distribution and abundance. Three sections of the River were sampled and human activities were considered in the choice of sampling stations. A total of thirty three (33) individual species of plankton and benthos were identified; sixteen (16) individual species belonging to phytoplanktons were harvested, eleven (11) individual species belonging to zooplanktons were harvested, while six (6) individual species belonging to benthos were also harvested in stations A, B and C respectively. They comprised of 31 families and 26 orders; the highest harvested individual species was C. radiates (100 species), while the least harvested individual species was A. lumbricoide (1 species). A total of 881 species of plankton and benthos were harvested 524 species (59.48%) belonging to phytoplanktons; 299 species (33.94%) belonging to zooplanktons were recorded, while 58 species (6.58%) belonging to benthos were also recorded. Analysis of variance (ANOVA P<0.05), Fisher' s Least Significant Difference (FLSD) and Pearson' s Correlation P<0.01 were used to test significant levels. The highest temperature value was (29.0±1.36ºC) in Station A; the least was (27.9±0.6 ºC) in station B. The highest Dissolved Oxygen was (8.08±0.22mg/L) in station B; the least was (7.32±0.5mg/L) in station A. The mean pH values were slightly acidic; the highest value was (6.71±0.62) in station A; the least value was (6.27±0.27) in station C. Electrical conductivity, though, the highest value was (16.07±0.25µs/cm) in Station C; the least was (15.58±0.52µs/cm) in station A. The highest turbidity value was (33.25±6.15cm) in station A; the least value was (32.08±4.54cm) in station B. The highest total dissolved solid value was (0.36±0.38ppm) in Station C; the least was (0.24±0.32ppm) in station A. The river was highly productive in terms of its plankton and benthos richness; it was recommended that the physico-chemical characteristics of the researched ecosystem will aid the culture of edible frogs and fish. Nevertheless, monitoring of human activities and the conservation of its natural resources is key to a sustainable biodiversity for food sovereignty and security to better lives as climate change bites.

Keywords: *River, Anthropogenic, Productivity, Physicochemical, Biodiversity, and Aquatic Ecosystem*

1. INTRODUCTION

Rivers are important systems of biodiversity and are among the most productive ecological systems on the earth because of the favourable conditions that support number of flora and fauna. They play a vital role in productivity as they are home to a variety of flora and fauna including planktons (Komala *et al*., 2013). The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers of the aquatic environment (Azrina *et al*., 2005). Planktons are very sensitive to the environment they live in, any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat (Mathivanan and Jayakumar, 2007). Plankton organisms occur in open waters and move primarily with general water motions (Ovie *et al.,* 2009). The plankton and benthos species composition could be used to evaluate the ecological status of aquatic habitats because of their quick response to environmental changes (Onyema *et al.,* 2007). These organisms are very good indicators of water qualities due to possessing a narrow range of tolerance to environmental perturbations. Plankton are any drifting or wandering organisms (plants and animals) that spend either part or all of their life in a drifting state and have little or no ability to swim. They are usually found in the surface and upper layers of water where sunlight and nutrients are readily available (Peg *et al*., 2012).

Antai and Joseph (2015), researched on the planktonic abundance and diversity in Great Kwa River, Cross River State, Nigeria. They reported 918 individual plankton, phytoplanktons record were 574 individual (62.53%) and zooplanktonsrecorded were 344 individual (37.47%). They also recorded nine (9) taxa which phytoplankton recorded four (4) taxa which were *Bacillariophyceae* 49.83%, *Chlorophyceae* 21.25%, *Chrysophyceae* 16.55 and *Cyanophyceae* 12.37. while five (5) taxa of zooplankton were *Rotifera* 28.49%, *Arthropoda* 24.71%, *Palaemonidae* 16.86%, *Ciliophora* 15.12% and *Annelida* 14.82%. They concluded that the diversity in plankton distribution in the Great Kwa River showed possible impacts on the local fisheries.

Ugwumba *et al*. (2020), they researched on the anthropogenic impact on plankton and benthos assemblage in the Lagos Lagoon, Nigeria. They reported 91 species of plankton and benthos, phytoplankton were 56 species with the highest abundance to be *Bacilliarophyceae* (72%) and the least was *Euglenophyceae* (3%); zooplankton were 26 species with the highest abundance to be *crustacea* (82%) and the least was *Arachnida* (7%) and benthos were 9 species with the highest abundance to be *Mollusca* (90%) and the least was *Annilida* (1%). They reported that the results also indicated that the main drivers affecting the abundance and distribution of planktonic and benthic invertebrates were water temperature, pH, TDS and EC.

Adesalu *et al*. (2015), studied on the plankton and microbenthos communities of freshwater habitats in Kogi state, North-Central Nigeria. They recorded 377 individual species of plankton, phytoplanktons were 277 individual species (73.47%) and zooplanktons were 100 individual species (26.53%), they also identified various divisions of phytoplanktons such as *Bacillariophyta, Chlorophyta* and *Cyanophyta* as recorded with pennate *diatoms* dominating the phytoplankton spectrum; zooplankton with *Cladophora, Copepoda* and *Rotifera* being the frequently encountered group; macrobenthos with *Mollusca, Insecta, Hirudinea, Crustacea* and *Oligochaeta*. They stated that high species in terms of number were identified in the wet (raining) season; because of the environmental conditions such as rainfall and nutrients as major factors controlling the plankton abundance.

Agouru and Audu (2012), researched on the range of plankton in River Benue, North Central, Nigeria, and Western Africa. They reported that two major types of plankton were identified. They recorded thirty five (35) species of plankton, Phytoplanktons were nineteen (19) species (54.29%) and zooplanktons were sixteen (16) species (45.71%), they also stated a total of twelve (12) taxa of which phytoplankton recorded seven (7) which were *Chlorophyta* 49.32%, *Bacilliarophyta* 2.783%, *Cyanophyta* 0.18%, *Dinophyta* 62%, *Euglenophyta* 1.8%, *Chrysophyta* 0.185% and *Rodophyta*0.09%, while zooplankton in an increasing dominante were five (5) *Rotifera* 52.75%, *Cladocera* 31.41%, *Copeda* 6.84%, *Ostracoda* 5.40% and *Decapoda* 3.6%. They stated that the abundance and diversity of plankton in river Benue is affected by human activities along the shores and offshore of the river.

Barau *et al*. (2020), researched on the plankton diversity in the upper river of Taraba state, Nigeria. They reported 5,321 individual plankton, phytoplanktons were 3,551 individuals (66.74%) and zooplanktons were 1,770 individuals (33.26%). They also stated a total of twenty four (24) plankton genera belonging to nine (9) taxa, of which phytoplanktons recorded fourteen (14) genera (58.33%), while zooplanktons recorded ten (10) genera (41.67%). They stressed that *Chlorophyceae* was the highest species among the seven (7) phytoplankton species as the least was *Viridiplantae* species, while that of zooplankton, the highest was *Arthropoda* amongst eight (8) species, and the least was *Rotifera* with only one (1) species. Therefore, they observed that the Upper River Benue, Mayo-Renewo axis was productive.

Nwagba *et al*. (2022), worked on seasonal variation and plankton physico-chemical characteristics of Omeremaduche River, Abia state, Niger delta, Nigeria. They reported sixteen (16) species of plankton; ten (10) species belonging to phytoplankton were recorded and six (6) species belonging to zooplankton were recorded. They also stated that four (4) phyla namely, Bacillariophyceae; Chlorophyceae; Euglenophyceae and Chrysophyceae were recorded, while Bacillariophyceae recorded the highest number of individual species across the stations; two (2) phyla Cladocera and Rhizopoda belongs to Zooplanktons were recorded. They concluded that the seasonal variation may be attributed to

varied rainfall pattern,while the partial variation may be due to the influence of various anthropogenic activities taking place around the river.

Usman *et al.* (2019), researched on the survey of zooplankton diversity and abundance and its relationship with physicochemical parameters in river Kashimbila Takum, Taraba state, Nigeria. They identified *a* total of twenty one (21) species of zooplanktons, which was dominated by *Ciliophora* (34.61%), followed by *Rotifera* (32.92%) and the least being *Cnidaria* (0.02%). They concluded that based on the zooplankton diversity and abundance, the rivers holds high possible impact on fish production.

Andrew *et al.* (2017), researched on the seasonal analysis of water quality in two settlements of Wukari local government area, Taraba state, Nigeria. They investigated on temperature, turbidity, suspended solids, total dissolved solids (TDS), conductivity, pH, phosphate, chloride, alkalinity, hardness, chemical oxygen demand (COD), dissolved oxygen (DO) and biological oxygen demand (BOD). Nwagba *et al.* (2022), worked on the seasonal variation and plankton physico-chemical characteristics of Omeremaduche River, Abia state, Niger delta, Nigeria. They reported that the mean values for pH, water-temperature, DO, BOD, phosphate and nitrate during the wet season were 6.91, 27.3, 5.86mg/l, 7.24mg/l, 0.38 and 4.18 respectively, while mean values of the physico-chemical characteristics during the dry season were 6.68, 26.8, 7.22mg/l, 5.44mg/l, 0.25mg/l and 3.09mg/l respectively. They also stated that, there was a significant difference in seasonal variation in DO, BOD, Nitrate and Phosphate, while no significant difference in pH and Water-temperature.

1.1 Objectives of this study are to:
i. Identify the plankton distribution in river Donga,
ii. Identify the benthos distribution in river Donga;
iii. Examine the physico-chemical characteristics of river Donga.

2.1 Materials and Methods
The study was carried out at Donga River in Donga, it is bounded with Kurmi Local Government Area by the east, Wukari Local Government Area by the south, Gassol Local Government Area to the north, Bali Local Government Area by the northeast and Takum Local Government Area by the west. It is located at longitude 7°43′00″N and latitude 10°03′00″E. The Donga River is a river that runs from Nigeria into Cameroon country as tributary into the atlantic ocean (Inger *et al.*, 2005) (Fig. 1).

2.1.1 Sample Location
The study area is design to have three (3) sampling stations along the river. The selected stations are numbered, thus: Station A-Shisha, Station B-Nyakwala and Station C-Nikanaki. The river was sampled twice per month for three (3) months, from December to February; sampling was done by interval of two (2) weeks, that is, 1st and 3rd weeks of each month to consider disturbances.

2.1.2 Plankton Sample Collection
Plankton samples were collected from undisturbed water areas of the River. The sampling were carried out two (2) times per month for 3 months, that is first and third weeks of each month, making it two (2) weeks interval. Plankton samples were collected from undisturbed water areas of the River; the sampling was carried out using the quantitative method. A composite sample of 100 litres of water was filtered through 55 um plankton net (with the aid of a 10 litres of bucket drawn 10 times at each station). The net content was washed out into plankton bottles of 250 ml size and preserved in 4% formalin solution after a proper labeling (Anene, 2003). In the laboratory, 1 ml of the preserved sample was taken as a sub sample using a pipette. The collected sample was put on the Sedgwick-rafter counting chamber and viewed under a light binocular microscope (Nikon 400 binocular microscope) using a low magnification of x10 and x40. Planktons were sorted into different groups and the cells per milimeter were counted. Species identification was done using key literatures (Vuuren *et al*., 2006).

2.1.3 Benthos Sample Collection
Sediment samples were collected two (2) times per month for 12 weeks (3months), that is, the first and the third weeks of each month, were sampled making it two (2) weeks interval. At each station, soil samples were scooped using van veen grab from the bottom directly at the sampling points due to shallowness of the sites. Each sediment sample was diluted with water and sieved throughout 0.5 mm mesh size, then put inside a plastic container and labeled. Species identification was made using appropriate keys (Atobatele *et al*., 2005; APHA. 2005).

2.1.4 Determination Of Plankton And Benthos Abundance
Plankton and benthos abundance can be determine using a formula as follows;
Abundance: $d = (S - 1)/\ln N$
Where;
d = Margalef richness index or species abundance index,
S = Number of species in the population,
N = Total number of individuals in species,

In = Logarithm (Antai and Joseph 2015).

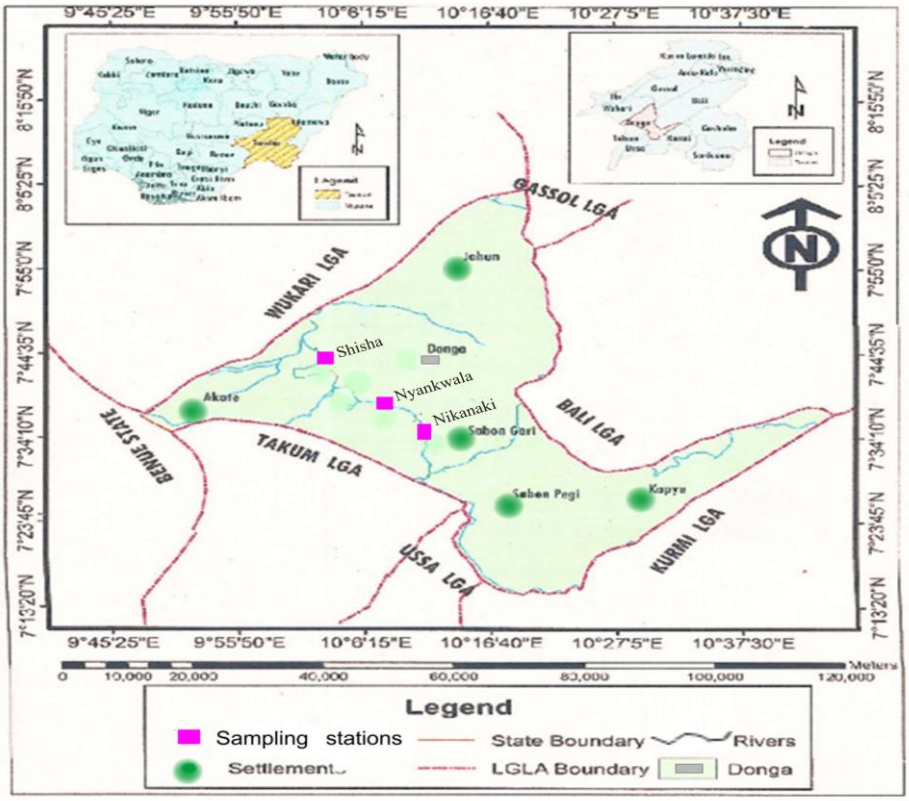

Figure 1: Map showing sampling stations.

2.1.5 Determination Of Physico-Chemical Characteristics

1.1.5.1 Water Temperature

Temperature was determined in-situ using mercury in glass thermometer. This was done by lowering the thermometer bulb into the water below for about 2 to 5 minutes and taking its stable reading (APHA. 2005).

1.1.5.2 Dissolved Oxygen

Dissolved oxygen (DO) was determined in-situ using DO meter (Lutron DO-5509 Model). This was done by lowering the DO meter into the water below for about 2 to 5 minutes and taking
its stable reading (APHA. 2005).

1.1.5.3 pH (power of Hydrogen)

pH (power of Hydrogen) was measured in-situ with a pH meter (HANNA 3100 Model). This involved probing the electrode of the pH into the water for about 3 to 5 minutes and taking its stable reading (APHA. 2005).

1.1.5.4 Electrical Conductivity

Conductivity of water was measure in-situ with EC Meter (DDS-307 Model). This was done by lowering the EC Meter into the water below for about 2 to 5 minutes and taking its stable reading (APHA. 2005).

1.1.5.5 Turbidity

Turbidity was measure in-situ with Secchi disc this was done by lowered slowly the Secchi disc down into the water and when the disc in no longer visible the length of the line lowered was measure and recorded (APHA. 2005).

1.1.5.6 Total Dissolved Solid

Total dissolved solid was measure in-situ with TDS/Meter (HANNA 3100 Model). This was done by lowering the TDS/Meter into the water below for about 3 to 5 minutes and taking
its stable reading (APHA. 2005).

1.1.5.7 Statistical Analysis

Analysis of variance (ANOVA) was used to test for significant difference occurring in various physico-chemical characteristics between stations. Fisher' s Least Significant Difference (FLSD) was used to separate the mean difference. Pearson' s Correlation was used to test the relationship between physico-chemical characteristics and plankton composition of the river at $P<0.01$ significant level.

2. Results

2.1 Identification of Plankton and Benthos Species

A total number of thirty three (33) individual species of plankton and benthos were identified; sixteen (16) species belonging to phytoplanktons were recorded; eleven (11) species belonging to zooplanktons were recorded; while six (6) species belonging to benthos were recorded; respectively (table 2.1). The species identified were a total number of thirty three (33) individual species. They comprised of thirty one (31) families and twenty six (26) orders; the highest harvested individual species was *C. radiates* recorded (100 species) and the lowest was *A. lumbricoide* recorded one (1 species).

Table 2.1 Plankton And Benthos Species Identified In River Donga

S/N	SPECIES	FAMILIES	ORDERS	NUMBER OF SPECIES CROPPED
1.	*Nitzschia gracilis*	Bacillariaceae	Bacillariales	20
2.	*Coscinodiscus radiates*	Coscinodiscaceae	Coscinodiscales	100
3.	*Microcystis flos-aquae*	Microcystaceae	Chroococcales	36
4.	*Chlamydomonas reinhardtii*	Chlamydomonadaceae	Chlamydomonadales	26
5.	*Volvox carti*	Volvocaceae	//	28
6.	*Closterium gracile*	Closteriaceae	Desmidiales	28
7.	*Euglena gracilis*	Euglenaceae	Euglenida	37
8.	*Fragilaria pectinalis*	Fragilariodaceae	Fragilariales	29
9.	*Melosira varians*	Melosiraceae	Melosirales	35
10.	*Navicula cuspidate*	Naviculaceae	Naviculales	53
11.	*Pleurosigma cuspidatum*	Pleurosigmataceae	//	40
12.	*Oscillatoria princeps*	Oscillatoriaceae	Oscillatoriales	2
13.	*Pediastrium duplex*	Hydrodictyaceae	Sphacropleales	12
14.	*Scenedesmus obliquus*	Scenedesmaceae	//	3
15.	*Cosmarium botrytis*	Desmidiaceae	Zygnematales	18
16.	*Spirogyra sp.*	Zynemataceae	//	57
17	*Daphnia pulex*	Daphniidae	Anomopoda	31
18	*Ascaris lumbricoide*	Ascarididae	Ascaridida	1
19	*Cyclopoid copepod*	Cyclopoidae	Cyclopoid	35
20	*Nauplius larvae*	Crustacea	Copepod	9
21	*Tintinnid*	Codonellidae	Choreotrichida	3
22	*Calanoid copepod*	Calanoidae	Calanoida	36
23	*Moina belli*	Moinadae	Anomopoda	4
24	Fish eggs(Tilapia)	Cichlidae	Cichliformes	31
25	Fish larvae(Tilapia)	//	//	76
26	*Brachionus calyciflorus*	Brachionidae	Ploima	50
27	*Keratella valga*	//	//	23
28	*Gammarus roeseli*	Gammaridae	Amphipoda	13
29	*Moina belli*	Moinadae	//	7
30	*Eisenia foetida*	Oligochaeta	Opisthopora	13
31	*Lumbricus terrestis*	Lumbriculidae	Haplotaxida	5
32	*Dugesia sp.*	Dugesiidae	Tricladida	12
33	*Hydachnidnia*	Hydachnidae	Trombidiformes	8
	Total Individual Species Cropped			**881**

2.2 Identification of Plankton and Benthos Species

2.2.1 Phytoplankton Species:

Plate 1: Scientific Name: *Nitzschia gracilis* (Hassall, 1845)

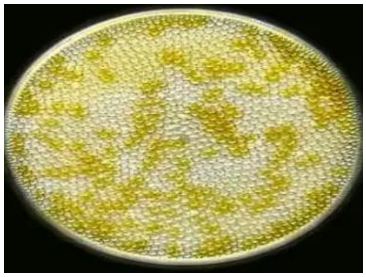

Plate 2: Scientific Name: *coscinodiscus radiates* (Ehrenberg, 1839)

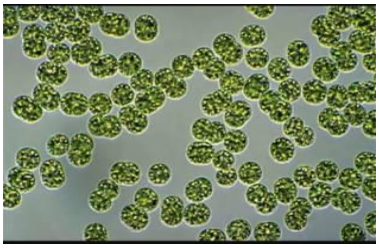

Plate 3: Scientific Name: *Microcystis flos-aquae* (Lemmemann, 1907)

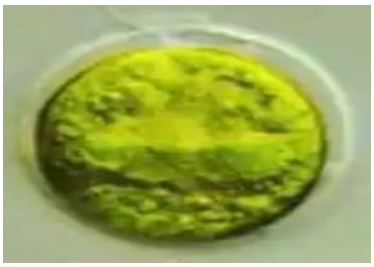

Plate 4: Scientific Name*: Chlamydomonas reinhardtii* (Dang, 1862)

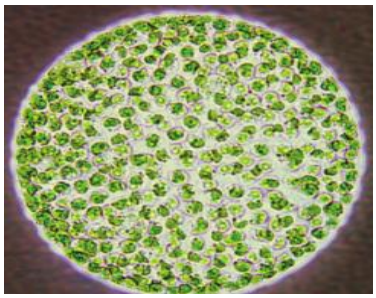

Plate 5: Scientific Name: *Volvox carteri* (Stein, 1878)

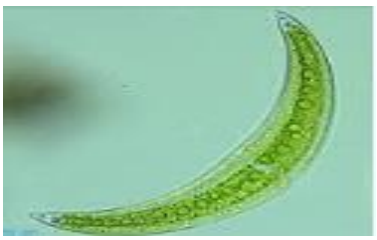

Plate 6: Scientific Name: *Closterium gracile* (Ehrenberg, 1848)

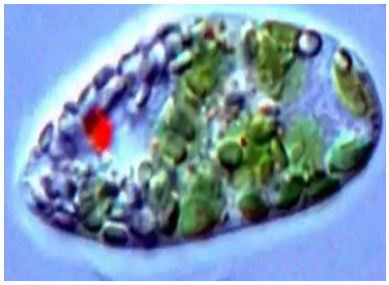

Plate 7: Scientific Name: *Euglena gracilis* (Ehrenberg, 1830)

Plate 8: Scientific Name: *Fragilaria pectinalis* (Lyngbye, 1819)

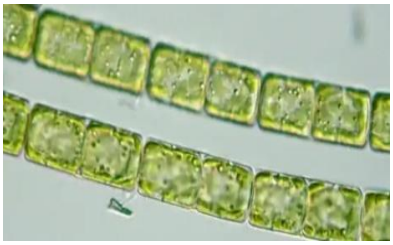

Plate 9: Scientific Name: *Melosira varians* (Agardh, 1824)

Plate 10: Scientific Name: *Navicula cuspidate* (Bory, 1822)

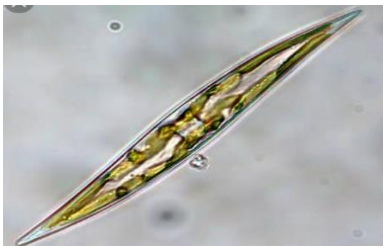

Plate 11: Scientific Name: *Pleurosigma cuspidatum* (Peragallo, 1891)

Plate 12: Scientific Name: *Oscillatoria princeps* (Vaucler, 1822)

Plate 13: Scientific Name: *Pediastrium duplex* (Meyen, 1829)

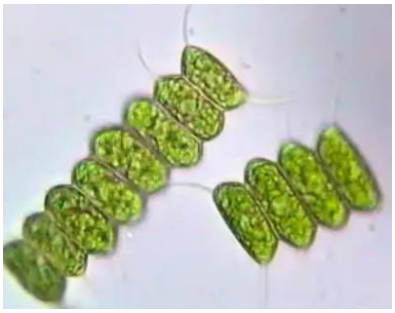

Plate 14: Scientific Name: *Scenedesmus obliquus* (Turpin, 1833)

Plate 15: Scientific Name: *Cosmarium botrytis* (Archer, 1861)

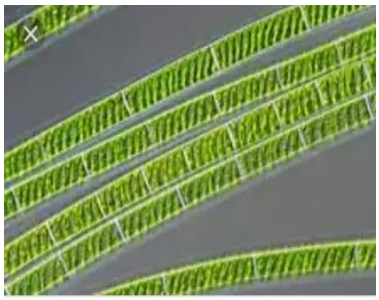

Plate 16: Scientific Name: *Spirogyra Maxima* (Nees, 1820)

2.2.2 Zooplankton Species:

Plate 17: Scientific Name: *Daphnia pulex* (Muller, 1785)

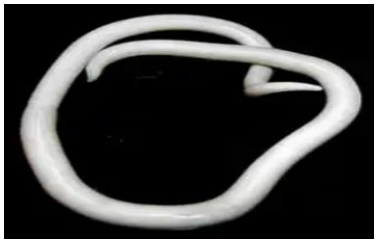

Plate 18: Scientific Name: *Ascaris lumbricoide* (Goeze, 1782)

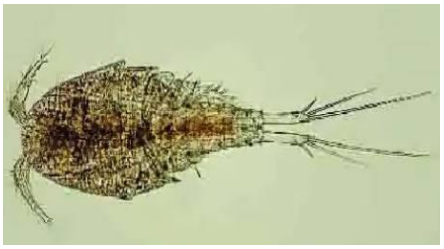

Plate 19: Scientific Name: *Cycloid copepod* (Burmeister, 1834)

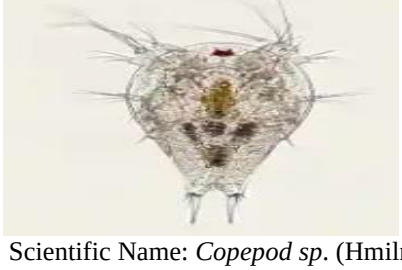

Plate 20: Scientific Name: *Copepod sp*. (Hmilne, 1840)

Plate 21: Scientific Name: *Tintinnid sp*. (Kofoid, 1929)

Plate 22: Scientific Name: *Calanoid copepod* (Sars, 1903)

Plate 23: Scientific Name: *Moina belli* (Gurney, 1904)

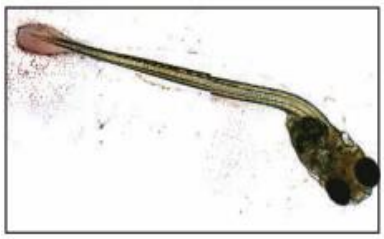

Plate 24: Scientific Name: *Oreochromis niloticus* larvae (Linnaeus, 1904)

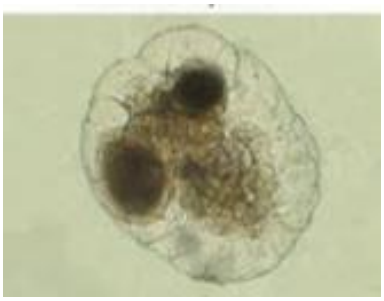

Plate 25: Scientific Name: *Brachionus calyciflorus* (Pallas, 1766)

Plate 26: Scientific Name*: Keratella valga* (Vincent, 1822)

2.2.3 Benthos Species

Plate 27: Scientific Name: *Gammarus roeseli* (Sars, 1863)

Plate 28: Scientific Name: *Moina belli* (Gurney, 1904)

Plate 29: Scientific Name: *Eisenia foetida* (Linnaeus, 1758)

Plate 30: Scientific Name: *Hydrachnidia sp.* (Muller, 1776)

Plate 31: Scientific Name: *Lumricus terrestris* (Micheal, 1930)

Plate 32: Scientific Name: *Dugesia* (Ehrenberg, 1831)

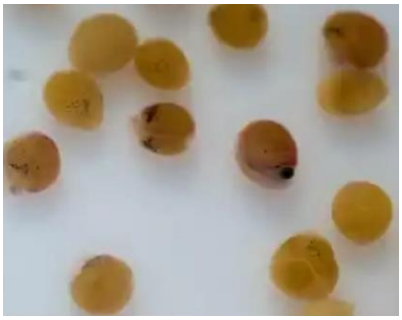

Plate 33: Scientific Name: Tilapia zillii ova (Gervais,1848)

2.3 Abundance And Distribution Of Plankton And Benthos

A total of 881 individual species of plankton and benthos were harvested/cropped along River Donga. A total number of 524 individual species (59.48%) belonging to phytoplankton; 299 individuals species (33.94%) belonging to zooplankton and 58 individual species (6.58%) belonging to benthos were recorded in (table 1). The Margalef species richness index (species abundance index (d)) were recorded: phytoplanktons recorded on sampled stations A, B and C were (2.70, 2.84 and 2.50) respectively (table 2); station B has the highest score (2.84) and the least was recorded in station C (2.50); the most abundance species of phytoplanktons identified was *C. radiates*; the least was *O. princeps*. In zooplankton, it recorded the highest abundance in station A (2.10) and the least was in station C (1.00), while the most abundance score of zooplankton was O. niloticus larvae and the lowest was *A. lumbricoide* (table 3); while in benthos, it recorded the highest abundance score in station A and B (1.70); the lowest was in station C (1.40) and the most abundance score was recorded with *G. roeseli* and *E. foetid;* the lowest was recorded with *L. terrestis* (table 4)**.**

Table 2: Distribution and Abundance of Phytoplankton

S/N	Species	Families	Orders	Sites			Total
				A	B	C	Species
1.	*Nitzschia gracilis*	Bacillariaceae	Bacillariales	5	9	6	20
2.	*Coscinodiscus radiates*	Coscinodiscaceae	Coscinodiscales	32	41	27	100
3.	*Microcystis flos-aquae*	Microcystaceae	Chroococcales	11	16	9	36
4.	*Chlamydomonas reinhardtii*	Chlamydomonadaceae	Chlamydomonadales	9	16	1	26
5.	*Volvox carti*	Volvocaceae	Chlamydomonadales	14	8	6	28
6.	*Closterium gracile*	Closteriaceae	Desmidiales	8	12	8	28
7.	*Euglena gracilis*	Euglenaceae	Euglenida	11	10	16	37
8.	*Fragilaria pectinalis*	Fragilariodaceae	Fragilariales	10	11	8	29
9.	*Melosira varians*	Melosiraceae	Melosirales	18	11	6	35
10.	*Navicula cuspidate*	Naviculaceae	Naviculales	30	16	7	53
11.	*Pleurosigma cuspidatum*	Pleurosigmataceae	Naviculales	16	12	-	40
12.	*Oscillatoria princeps*	Oscillatoriaceae	Oscillatoriales	1	1	-	2
13.	*Pediastrium duplex*	Hydrodictyaceae	Sphacropleales	6	4	2	12
14.	*Scenedesmus obliquus*	Scenedesmaceae	Sphacropleales	2	1	-	3
15.	*Cosmarium botrytis*	Desmidiaceae	Zygnematales	-	11	7	18
16.	*Spirogyra sp.*	Zynemataceae	Zygnematales	25	17	15	57
Total Abundance				198	196	130	524
Total number of species				15	16	13	
Total number of individual Species				198	196	130	
Margalef Species richness index				**2.70**	**2.84**	**2.50**	

Table 3: Abundance And Distribution Of Zooplanktons In River Donga

S/N	Species	Families	Orders	Sites			Total
				A	B	C	Species
1.	*Daphnia pulex*	Daphniidae	Anomopoda	11	12	8	31
2.	*Ascaris lumbricoide*	Ascarididae	Ascaridida	1	-	-	1
3.	*Cyclopoid copepod*	Cyclopoidae	Cyclopoid	12	12	11	35
4.	*Nauplius larvae*	Crustacea	Copepod	5	4	-	9
5.	*Tintinnopsis beroidae*	Codonellidae	Choreotrichida	2	1	-	3
6.	*Calanoid copepod*	Calanoidae	Calanoida	13	9	14	36
7.	*Moina belli*	Moinadae	Anomopoda	3	1	-	4
8.	Tilapia ova	Cichlidae	Cichliformes	22	9	-	31
9.	Tilaapia larva	Cichlidae	Cichliformes	33	23	20	76
10.	*Brachionus calyciflorus*	Brachionidae	Ploima	17	12	21	50
11.	*Keratella valga*	Brachionidae	Ploima	10	6	7	23
Total Abundance				129	89	81	299
Total number of Species				11	10	7	
Total number of individual Species				129	89	81	
Margalef Species richness index				**2.10**	**2.00**	**1.00**	

Table 4: Abundance And Distribution Of Benthos In River Donga

S/N	Species	Families	Orders	Sites			Total
				A	B	C	Species
1.	*Gammarus roeseli*	Gammaridae	Amphipoda	5	7	1	13
2.	*Moina belli*	Moinadae	Anomopoda	2	1	4	7
3.	*Eisenia foetida*	Oligochaeta	Opisthopora	5	2	6	13
4.	*Lumbricus terrestis*	Lumbriculidae	Haplotaxida	2	3	-	5
5.	*Dugesia*	Dugesiidae	Tricladida	4	4	4	12
6.	*Hydachnidnia*	Hydachnidae	Trombidiformes	2	3	3	8
Total Abundance				20	20	18	58
Total number of Species				6	6	5	
Total number of individual Species				20	20	18	
Margalef Species richness index				1.70	1.70	1.40	

2.4 Percentage Distribution Of Plankton And Benthos

The pie chart showed the distribution of the 881 harvested species comprising of phytoplanktons, zooplanktons and benthos; thus 524(59.48%), 299(33.94%) and 58(6.58%) belonging to phytoplankton, zooplankton and benthos species respectively (Fig. 4.1).

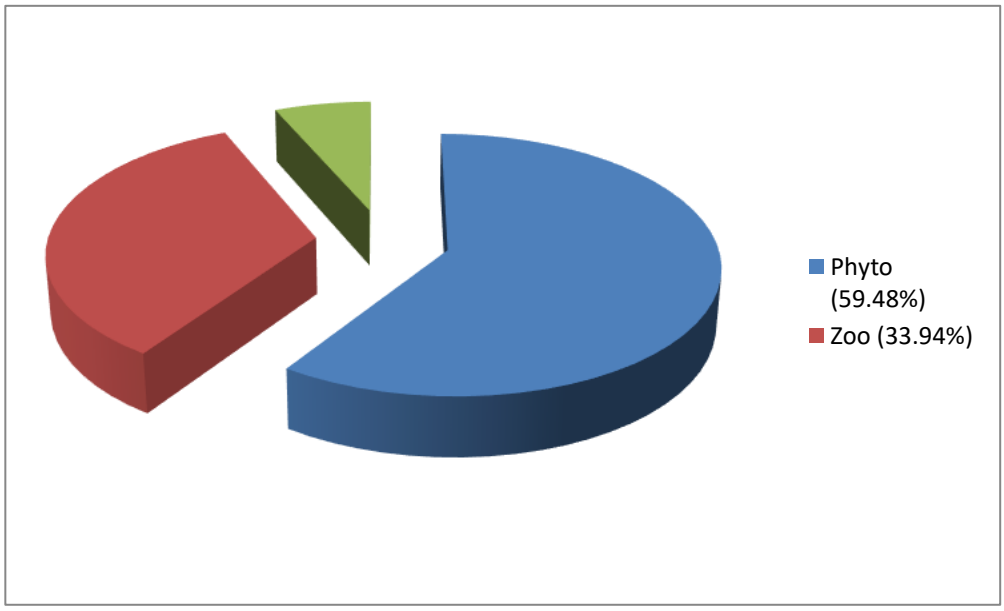

Fig 2: Pie chart showing percentage distribution of plankton and benthos

2.5 Mean Value Of Physico-Chemical Characteristics Among Stations

Mean values of physicochemical characteristics were presented in (Table 5), Mean water temperatures were between (27.9±0.6^{bo}C) and (29.0±1.36^{ao}C). The temperature values were within the acceptable limits (29ºC-30ºC) set by World

Bank Range for freshwater aquaculture (Ronald *et al*., 1999), the highest temperature was (29.0±1.36^{a}°C) were recorded in station A, and the least (27.9±0.6^{bo}C) was recorded in station B. The mean values of dissolved oxygen ranged between (7.32±0.5^{a}mg/L) and (8.08±0.22^{a}mg/L), station B recorded the highest (8.08±0.22^{a}mg/L), while station A was recorded the lowest (7.32±0.5^{a}mg/L); all the DO values were above the acceptable limits (>5.0-6.0 Mg/l) set by World Bank Range for Freshwater aquaculture (Ronald *et al*.,1999). The pH mean values were slightly acidic, ranging from (6.27±0.27^{c}) to (6.71±0.62^{a}); the highest values (6.71±0.62^{a}), while the lowest values (6.27±0.27^{c}) was recorded station C. Electrical conductivity mean value were from (15.58±0.52^{a}µs/cm) to (16.07±0.25^{a}µs/cm). the highest value (16.07±0.25^{a}µs/cm) was recorded in Station C and the least values (15.58±0.52^{a}µs/cm) was recorded in station A. The turbidity mean values range from (32.08±4.54^{b}cm) to (33.25±6.15^{a}cm); the highest values (33.25±6.15^{a}cm) were recorded in station A and lowest value (32.08±4.54^{b}cm) were recorded in station B. The TDS mean values range from (0.24±0.32^{a}ppm) to (0.36±0.38^{a}ppm); the highest values (0.36±0.38^{a}ppm) was recorded in station C and the lowest values (0.24±0.32^{a}ppm) was recorded in station A.

Table 5: Mean Value Within Station Of Physico-Chemical Characteristics At (P<0.01)

	Physico-chemical Characteristics					
Stations	Temperature(°C)	DO (Mg/l)	pH	EC(µs/cm)	Turbidity (cm)	TDS(ppm)
A	29.00±1.36^{a}	7.32±0.58^{a}	6.71±0.62^{a}	15.58±0.52^{a}	33.25±6.15^{a}	0.24±0.32^{a}
B	27.98±0.66^{b}	8.08±0.22^{a}	6.31±0.23^{bc}	15.73±0.54^{a}	32.08±4.54^{b}	0.24±0.33^{a}
C	28.13±1.23^{ab}	7.90±0.18^{a}	6.27±0.27^{c}	16.07±0.25^{a}	32.83±4.82^{ab}	0.36±0.38^{a}

^{abc} Mean having the same superscript are not significantly different at (P<0.01).

2.6 Pearson Correlation Of Physico-Chemical Characteristics With Plankton And Benthos

There was a negative correlation with all the physico-chemical characteristics except dissolved oxygen which showed positive correlation with phytoplankton (table 6). In zooplanktons, it showed negative correlation to water temperature, dissolved oxygen, power of Hydrogen, electrical conductivity, turbidity and total dissolved solid and positive correlation in station B wih electrical conductivity and station A also showed positive correlation with total dissolved solid (Table 7). Benthos showed negative correlation with all the physico-chemical characteristics, while water temperature showed positive correlation in staion A and B; turbidity also showed positive correlation in station A (table 8).

Table 6: Pearson Correlation Of Phytoplankton With Physico-Chemical Characteristics With Stations

	Stations	Phyto A	Phyto B	Phyto C	Temp A	Temp B	Temp C	DO A	DO B	DO C	pH A	pH B	pH C
Phytoplanktons	**A**	1	0.808**	O.609*	-0.607*	-0.656	-0.600	0.565	0.454	0.606	-0.511	-0.604	-0.666
Phytoplanktons	**B**	0.808**	1	0.791**	-0.512	-0.571	-0.551	0.357	0.323	0.388	-0.433	-0.500	-0.611
Phytoplanktons	**C**	O.609*	0.791**	1	-0.346	-0.340	-0.331	0.315	0.254	0.424	-0.204	-0.258	-0.426
	Stations	**Phyto A**	**Phyto B**	**Phyto C**	**EC A**	**EC B**	**EC C**	**Turbid A**	**Turbid B**	**Turbid C**	**TDS A**	**TDS B**	**TDS C**
Phytoplanktons	**A**	1	0.808**	O.609*	0.949*	-0.242	-0.277	-0.421	-0.316	0.178	-0.173	0.387	-0.120
Phytoplanktons	**B**	0.808**	1	0.791**	0.961**	-0.22	-0.565	-0.207	-0.547	0.134	-0.078	0.516	-0.331
Phytoplanktons	**C**	O.609*	0.791**	1	0.952	0.194	-0.388	-0.512	-0.571	-0.159	-0.399	0.440	-0.175

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

Table 7: Pearson Correlation Of Zooplankton With Physico-Chemical Characteristics With Station

	Stations	ZOO A	ZOO B	ZOO C	Temp A	Temp B	Temp C	DO A	DO B	DO C	pH A	pH B	pH C
Zooplanktons	**A**	1	0.903**	0.747	0.372	0.394	0.356	-0.498	-0.276	-0.588	0.247	0.339	0.355
Zooplanktons	**B**	0.903**	1	0.636	0.289	0.243	0.104	0.273	0.498	0.160	0.250	0.322	0.223
Zooplanktons	**C**	0.747	0.636	1	-0.516	-0.397	-0.111	0.866	0.835	0.990	-0.614	-0.652	-0.562
	Stations	**ZOO A**	**ZOO B**	**ZOO C**	**EC A**	**EC B**	**EC C**	**Turbid A**	**Turbid B**	**Turbid C**	**TDS A**	**TDS B**	**TDS C**
Zooplanktons	**A**	1	0.903**	0.747	-0.583	0.632	-0.303	0.291	0.000	-0.241	0.747	-0.293	-0.095
Zooplanktons	**B**	0.903**	1	0.174	0.267	0.603	-0.544	0.636	-0.713	-0.038	0.065	0.295	-0.266
Zooplanktons	**C**	0.747	0.636	1	0.866	0.693	-0.982	-0.569	0.866	-0.629	0.033	-0.866	0.000

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

Table 8: Pearson Correlation Of Benthos With Physico-Chemical Characteristics With Stations

	Stations	Benthos A	Benthos B	Benthos C	Temp A	Temp B	Temp C	DO A	DO B	DO C	pH A	pH B	pH C
Benthos	**A**	1	0.978**	0.917*	0.299	0.923*	-0.949	-0.466	-0.441	-0.664	0.396	0.481	0.390
Benthos	**B**	0.978**	1	0.965**	0.307	0.896*	-0.928	-0.820*	-0.881*	-0.616	0.911*	0.928**	0.963**
Benthos	**C**	0.917*	0.965**	1	0.091	0.785	-0.900	0.748	0.836	0.323	-0.946*	-0.911*	-0.904*
	Stations	**Benthos A**	**Benthos B**	**Benthos C**	**EC A**	**EC B**	**EC C**	**Turbid A**	**Turbid B**	**Turbid C**	**TDS A**	**TDS B**	**TDS C**
Benthos	**A**	1	0.536	0.018	-0.434	0.278	0.535	0.274	0.000	0.270	0.078	-0.090	0.584
Benthos	**B**	0.536	1	-0.789	-0.553	-0.325	0.557	0.070	-0.158	-0.121	-0.317	0.230	-0.098
Benthos	**C**	0.018	-0.789	1	0.123	0.609	-0.557	0.276	0.492	0.465	0.746	-0.553	0667

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

3. Discussion

A total of 881 individual species of plankton and benthos were harvested along River Donga during the period of this research. The distribution and abundance of plankton and benthos were reported in (table 1). This showed that the plankton and benthos distribution were high, although some species were more abundant than others. There is no existing research work carried out along this river on the plankton and benthos distribution for direct comparison. The result showed highest individual species of phytoplankton recorded was C. *radiates* (*Bacillariophyceae*) and the least was O. *princeps* (*Cyanophyceae*); the highest individual species of zooplankton recorded was fish larvae and the least was *Ascaris lumbricorde* while the highest individual species of benthos recorded were *G. roeseli; E. foetida* and the least was *L. terrestis.* Base on these research phytoplankton is more abundance than zooplankton and benthos; benthos record the least in abundance due to the effect of human activities along the river (Elijah and John, 2019; Antai and Joseph, 2015; Agouru and Audu, 2012). The analysis of variances (ANOVA, $P<0.01$) for phytoplankton; zooplankton and benthos distribution showed that there was no significant difference. The species abundance between stations for phytoplankton; zooplankton and benthos also showed that there is no significant difference while station abundance between species for phytoplankton; zooplankton and benthos showed significant difference at probability <0.01. The Physico-chemical characteristics showed that water temperature; dissolved oxygen; power of hydrogen; electrical conductivity; turbidity and total dissolved solid mean value were(27.98±0.66°C to 29.00±1.36°C), (7.32±0.58mg/l to 8.08±0.22mg/l), (6.27±0.27 to 6.71±0.62), (15.58±0.52 µs/cm to 16.07±0.25 µs/cm), (32.08±4.54cm to 33.25±6.15cm) and (0.24±0.32ppm to 0.36±0.38) respectively (Nwagba *et al.*, 2022).

4. Conclusion

The said River Donga could be described to be rich in aquatic flora and fauna as there were a lot of species represented in this aquatic ecosystem, considering the short period of sampling; in spite of its anthropogenic activities going on in this river. The research revealed that plankton and benthos communities were present; plankton was more diverse and abundant compared to its benthos species population; showing that species composition and abundance were less in benthos. There are some pollution tolerant species, such as *E. gracilis, O. princeps, S. obliquus, C.* species; this showed that, there is a point source of pollution with regard to human activities. The results of the present investigation compared with literature values of other rivers in Nigeria, revealed that there is fluctuation in the physico-chemical characteristics of the ecosystem and the activities around the river, has significant effects on the water quality as indicated by the variations in physico-chemical characteristics; species distribution and abundance.

5. Recommendations

The results on phytoplanktons, zooplanktons and benthos could be used by zoology, microbiology, biochemistry, agriculture, aquaculture, water science, hydrobiology, fisheries students and graduates. The results on physico-chemical characteristics could be used as a base line for aquatic threshold and fresh water culture indicator. The plankton and benthos species identified could serve as identification key to zoology, biology, water science, hydrobiology, microbiology, agriculture, biochemistry, aquaculture, fisheries students and graduates.

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