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Study of dry season zooplankton of Lower River Benue at Makurdi, Nigeria

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Key words
Abundance, Diversity, freshwater zooplankton, River Benue

SUMMARY

This study was designed to determine how various anthropogenic stressors impact the water body and the effect of stressors on the abundance and diversity of the zooplankton population at the different stations. Abundance and diversity of zooplankton during the dry season in the lower River Benue, Makurdi, Benue State, Nigeria was studied between March and April, 2008. Three sites were chosen and the pour-through method used for zooplankton collection. Fifteen species of zooplankton were identified. Rotifera species was dominant (54.5%); followed by Cladocera (26.82%), Copepoda (7.91%), Ostracoda (6.43%) and Decapoda (4.33%). Through out the study, six species of Rotifera, five species of Cladocera, two species of Copepoda and one species each of Ostracoda and decapoda were identified. Not all of the identified species were found in all three sites, thus indicating different types of pollution across the sites. There was no significant difference in the quantity of zooplankton across the sites; however the quality differs as a result of the various stressors (P>0.05). These findings indicate that the effect of anthropogenic stressors, brewery effluent and refuse impact the water body, albeit minimally.

1 INTRODUCTION

According to Wallace and Snell (1991), the freshwater zooplankton comprises three major groups of invertebrate animals: the rotifers, copepods, and cladocerans. The rotifers constitute a phylum found almost exclusively in freshwater. The copepods and cladocerans are both groups of the large subphylum Crustacea. Copepods constitute a class that is widespread in both freshwater and marine environments. Cladocerans constitute a group of four orders living primarily in freshwater environments. All three of these major groups have species adapted to pelagic (open water), or littoral (vegetated), and benthic (bottom) environments. However, SWCSMH (2007) pointed out that freshwater zooplankton are dominated by four major groups of animals: protozoa, rotifers, and two subclasses of the crustacea, the cladocerans and copepods. The planktonic protozoa have limited locomotion, but the rotifers, cladoceran and copepod microcrustaceans, and certain immature insect larvae often move extensively in quiescent water. Many pelagial protozoa (5-300 µm) are meroplanktonic, in that only a portion, usually in the summer, of their life cycle is planktonic. These forms spend the rest of their life cycle in the sediments, often encysted throughout the winter period.

Zooplankton play an important role in energy transfer from primary producers to secondary consumers higher in the food web.

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Zooplankton productivity is generally tightly coupled with phytoplankton productivity (Mallin & Pearl, 1994) in that phytoplankton serve as food for zooplankton which in turn serve as food for fish. Zooplankton generally provide food for both juvenile and adult stages of pelagic fishes and shrimps. In aquaculture, plankton are sometimes supplied as food and sometimes incorporated into the food as fish feed. According to Suontama (2004), an advantage of zooplankton as fish food is that they contain lower amounts of environmental toxins than organisms higher up the food chain. This is because environmental toxins accumulate as they move up the food chain.

Eutrophic lakes are rich in plant nutrients and thus their productivity is high. They produce high numbers of phytoplankton and zooplankton and minnows and other small fish that feed on the zooplankton. Fishing is often quite good in eutrophic lakes; the high productivity of plankton and benthic (bottom) organisms in the shallows provide for relatively high numbers of fish with relatively good growth rates (Kevern *et al* 1996).

Aquatic environments are dynamic systems with cycles and processes operating at a range of spatial and temporal scales. The dynamic nature of the processes coupled with natural cycles of disturbances, together with anthropogenic stressors, act to distribute the aquatic biotic communities into temporal and spatial mosaics. Factors influencing the distribution of aquatic organisms include wave action, cyclones, runoff, salinity, nutrients, turbidity, light, linkages between other tropic groups and substratum characteristics (Furnas, 1995; Keough & Butler, 1995). The density and distribution of plankton actually vary with varying degrees of these parameters. As a result, there is a dramatic difference between inshore and offshore populations as well as differences in composition as one moves from well-lit surfaces to the dark deeper water (Crane, 1992).

According to Deeley and Paling (1999), casual links between anthropogenic stressors and adverse impacts may be somewhat easier to define where the impact has been severe, or in close proximity to the source of disturbance. It has been much more difficult to ascribe causality where the source is far removed, impacts have been less severe, or where there has been no significant natural disturbance.

This study was therefore designed to determine if various anthropogenic stressors actually impact the water body and if they do, in what way and to determine if there is any significant difference in the abundance and diversity of the zooplankton population at different stations as a result of these stressors.

2 MATERIALS AND METHODS

2.1 Study area: The River Benue is a fresh water body flowing through Nigeria and it is the second longest river in the country. The river originates from the Adamawa mountains of Cameroon some 500km bounding the Nigerian frontier and flows eastward through the Nigerian territory before joining the River Niger at Lokoja, Kogi state, Nigeria (Okayi *et al.*, 2001). Benue State has a tropical climate with two marked seasons, the wet season, characterized with heavy rainfall between April and October and the dry season which is usually marked with high temperature between November and April.

According to Banks *et al.* (1985), the lower Benue has the features of a mature river with extensive alluvial plane stretching for several kilometers. The greater part of this plain is flooded during the rainy season and forms breeding ground for many fish species. When its bank is full, the area of the lower Benue is 129,000 ha, but when flooded, it rises to about 310,000 ha (Welcomme, 1971), and there can be as much as 25m difference between the high and low water levels (Okayi *et al.*, 2001).

Three sample sites were selected along the lower Benue River in Makurdi. The sample sites were designated A, B and C (fig. 3). Sample site A is the outlet of Benue Breweries Limited (BBL) into the river Benue. The water adjacent to the BBL is usually cut off from the river Benue during the dry season, forming an island which however has an outlet downstream into the river Benue, which was selected as the sample site A. Sample site B was downstream of site A. It is under a new bridge located at the North Bank area of Makurdi town.

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On the river bank, there is ongoing irrigation farming, whose run-off flows into the river and has potential impact on the adjacent waters. Sample site C is further downstream at the Wadata market of Makurdi. The water body at this sample site borders the Wadata market refuse dump. The water body is also used as a large reservoir and septic tank where people carry out their domestic and hygiene chores such as washing, bathing, and at times defecating. The abattoir is close to this place and uses water from the river to wash animals being slaughtered and also to wash off the emptied bowels of these animals. At all three sites, human impact is enormous thus justifying their selection.

2.2 Sampling and plankton analysis: Sampling was carried out twice a week for four weeks between 6th March and 4th April 2008, which makes a total of eight samplings. Sampling was done in the mornings before 8.00 am. The abundance and diversity of zooplankton at the three stations were determined by counting and identifying using standard identification keys.

Pour-through method was used to collect the samples. A 10-litre graduated bucket was used to collect water at a depth of about 30cm below the water surface, poured into the plankton net and repeated 10 times to make a total of 100 litres of water filtered. The collected plankton was carefully poured into a plankton bottle, fixed with 5% formalin, corked and labeled and taken to the laboratory for further analysis.

In the laboratory, each preserved plankton sample was poured into a graduated centrifuge tube and centrifuged using a 'Gallen Kamp – Medico' centrifuge. This was allowed to settle and the supernatant decanted. After decanting, the concentrated plankton was then analyzed. A dropping pipette was used to place the concentrated plankton on a glass slide, covered with a cover slip and viewed under a 'Leica' electronic research microscope. The plankton were counted (quantitative analysis) and then identified (qualitative analysis) using standard identification keys and chart (Jeje and Fernando, 1986). This process was repeated four times, the mean was determined and abundance and diversity extrapolated.

2.3 Physico-chemical parameters analysis: The physico-chemical parameters assayed were air and water temperature, turbidity, hydrogen ion concentration (pH), dissolved oxygen (DO), biochemical oxygen demand (B.O.D) and total alkalinity. The dissolved oxygen was determined using the Winkler's method (Winkler, 1888). To determine BOD, three samples were collected from each site in BOD bottles. The oxygen content of one of the samples was determined while the remaining two samples were firmly stoppered and placed in an incubator at 20^{o}C for five days. At the end of the five days, the oxygen content of the incubated samples was determined using the same Winkler's method. BOD = Initial DO - Final DO.

The pH of the water samples was determined using a B. Bran Scientific pH-meter (pHS-25 model). Alkalinity was determined by taking 100ml of the water sample in a conical flask to which 3 drops of methyl orange indicator was added. The solution was titrated against 001M sulphuric acid until the colour changed from orange to pale pink. The volume of standard 001M sulphuric acid used was noted and recorded as the value for total alkalinity in parts per million (ppm).

To determine free CO_2, 100ml of the sample was placed in a conical flask, 8 drops of phenolphthalein indicator was added and titrated against 0.01M NaOH solution until the solution turns a pale pink. The volume of NaOH used was recorded and free CO_2 (mg/L) was calculated using:

$$\frac{\text{volume of titrant} \times N \times 44000}{\text{Sample volume used (ml)}}$$

where N = Normality of NaOH

The biotic community was analyzed using the method adopted from (Jeje, 1989 in Okayi *et. al*, 2001).

2.4 Data analysis: The Instat + v 3.30 Statistical Analysis tool pack was used for all measures of central tendency and dispersion, analysis of variance and graphics.

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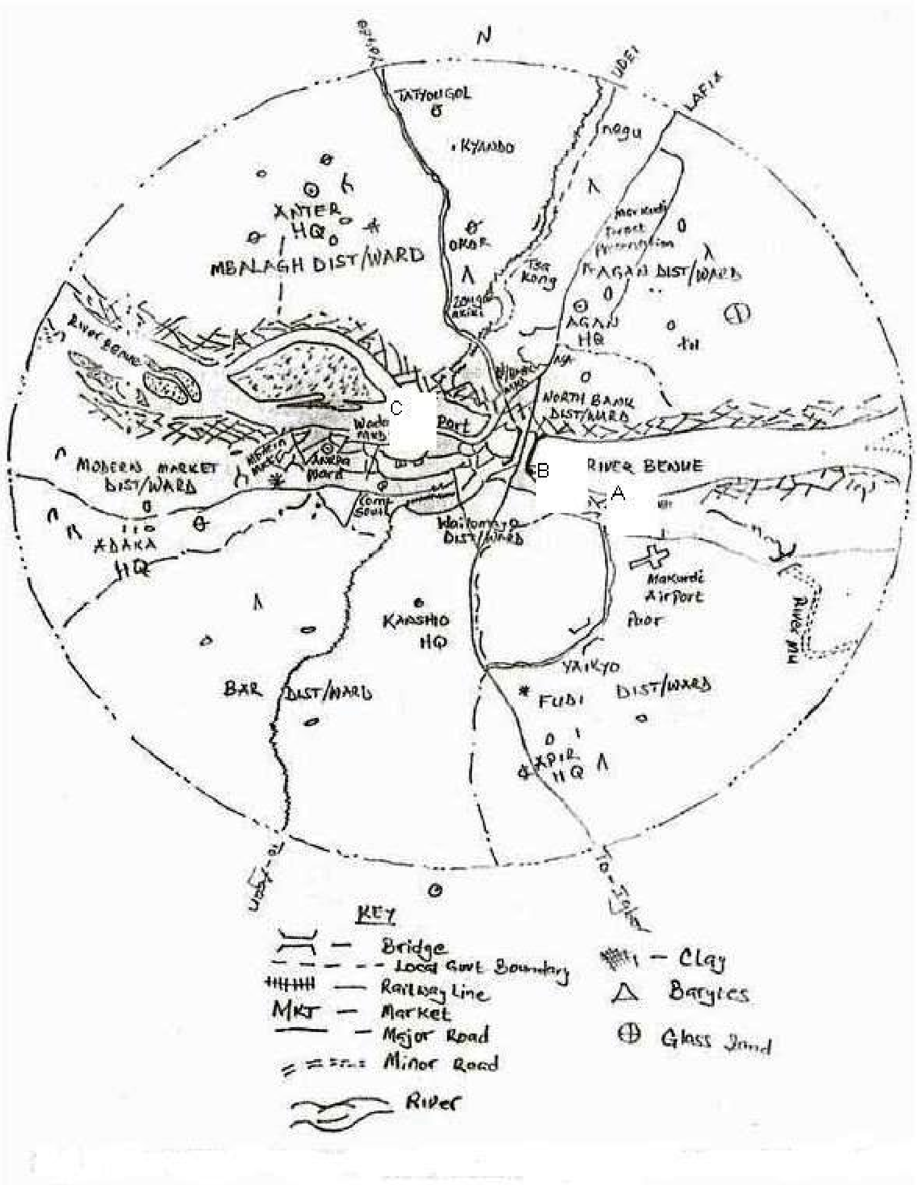

FIG. 1: MAP OF MAKURDI SHOWINGTHE SAMPLING SITES ALONG THE LOWER RIVER BENUE, MAKURDI, NIGERIA

3 RESULTS

In all, 16 species of zooplankton were identified during the period of analysis using an electronic microscope. These include six Rotifera species, five Cladocera species and Nauplius, two Copepoda species and one species each of Ostracoda and Decapoda (Table 1 and Figure 2). The abundance of zooplankton at the three sample sites are summarized in Table 3 and Figure 3.

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TABLE 1: Zooplankton composition and their abundance in River Benue at Markudi, Nigeria.

SPECIES COMPOSITION	ABUNDANCE	% ABUNDANCE
ROTIFERA (6 GENERA)		54.5
Branchionus spp	192	
Nothola spp	73	
Trichocerca spp	68	
Asplanchna spp	44	
Testudinella sp	43	
Rotaria spp	21	
CLADOCERA (5 GENERA)		26.82
Daphnia spp	72	
Nauplius spp	41	
Simocephalus spp	34	
Camptocercus spp	31	
Chydorus spp	21	
Ceriodaphnia spp	18	
COPEPODA (3 GENERA)		7.91
Metacylops spp	39	
Diaptomus spp	25	
OSTRACODA (1 GENERA)		6.43
Cypridopsis spp	52	
DECAPODA (1 GENERA)		4.33
Peneaus spp	35	
TOTAL	809	100

TABLE 2: Occurence and diversity of zooplankton species at three sites in River Benue at Markudi, Nigeria.

SPECIES COMPOSITION	STATION A	STATION B	STATION C
ROTIFERA (6 GENERA)			
Branchionus spp	+++	+++	+++
Notholca spp	++	+++	+++
Trichocerca spp	++	+++	+++
Asplanchna spp	++	+++	+
Testudinella spp	+++	++	-
Rotaria spp	-	+	++
CLADOCERA (5 GENERA)			
Daphnia spp	++	+++	+++
Nauplius spp	+	++	++
Simocephalus spp	+	++	++
Camptocercus spp	++	+	++
Chydorus spp	++	+	-
Ceriodaphnia spp	-	+	+
COPEPODA (3 GENERA)			
Metacylops spp	++	++	++
Diaptomus spp	+	++	+
OSTRACODA (1 GENERA)			
Cypridopsis spp	++	+++	++
DECAPODA (1 GENERA)			
Peneaus spp	+	+	+++

NOTE:
- Absent; += Occurs less often, 1-10; ++= Occurs often, 11-20; +++ = Occurs more often, 21-30.

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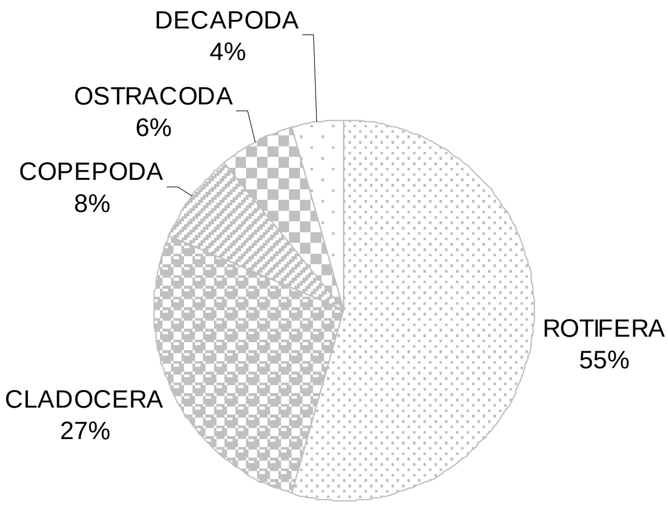

FIGURE 2: Distribution of zooplankton genera in River Benue at Markudi, Nigeria.

TABLE 3: Abundance of zooplankton at three siteS in River Benue at Markudi, Nigeria.

Sample no.	Filtered water (l)	Sample station	No. of organisms in 0.05 ml	No. of organisms in 1 ml	No. of organisms in 100l
1	100·0	A	4·50±0.29	90·00	450·0
		B	6·50±0.65	130·00	650·0
		C	6·00±0.71	120·00	600·00
2	100·0	A	5·00±0.82	100·00	500·00
		B	7·50±1.66	150·00	750·00
		C	6·00±0.41	120·00	600·00
3	100·0	A	6·00±0.41	120·00	600·00
		B	4·00±0.92	80·00	400·00
		C	6·00±0.71	120·00	600·00
4	100·0	A	10·00±1.47	200·00	1000·00
		B	27·00±5.08	540·00	2700·00
		C	4·50±0.65	90·00	450·0
5	100·0	A	12·00±1.47	240·00	1200·00
		B	10·25±0.85	205·00	1025·00
		C	12·00±0.82	240·00	1200·00
6	100·0	A	6·50±1.19	130·00	650·0
		B	6·75±0.85	135·00	675·00
		C	9·00±1.22	180·00	900·00
7	100·0	A	4·00±0.82	80·00	400·00
		B	12·50±1.32	250·00	1250·00
		C	5·50±1.26	110·00	550·00
8	100·0	A	10·00±0.71	200·00	1000·00
		B	10·25±1.97	205·00	1025·00
		C	10·50±1.26	210·00	1050·00

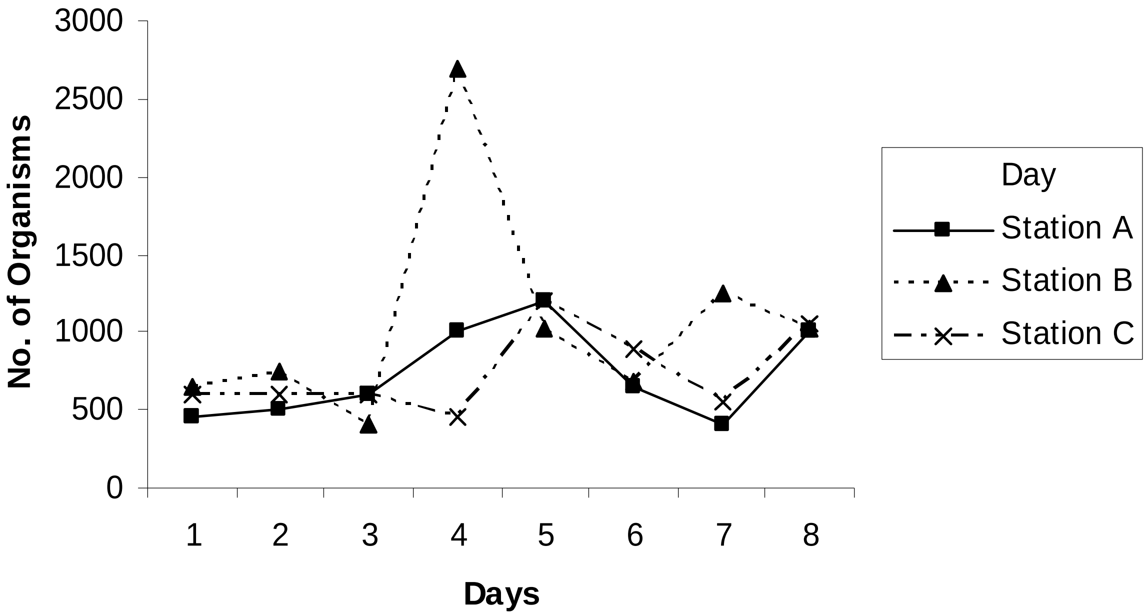

FIGURE 3: Abundance of zooplankton at three stations in River Benue at Markudi, Nigeria.

The highest temperatures recorded were 25·and 29·°C and the lowest temperatures were 23·°C and 26·°C for air and water temperature, respectively. The highest DO value was 6.9 mg/L and the lowest was 5.3 mg/L while the highest BOD value was 3.6 mg/L and the least 0.7 mg/L. The highest free CO_2 was 11.9 mg/L and the least 7.0 mg/L while the pH ranged between 6.65 and 6.22. The highest total alkalinity value was 14.6 ppm and the least was 10.2 ppm. Mean values are given in Table 4.

TABLE 4: Physico-chemical parameters at three sites in River Benue at Markudi, Nigeria (Mean ±SE).

PARAMETERS	STATION A	STATION B	STATION C
AIR TEMP. (°C)	23·1 ±0·1271 [a]	24.1 ±0·1422 [a]	24·3 ±0·1312 [a]
WATER TEMP. (°C)	27·4 ±0·2817 [a]	27·6 ±0·0981 [a]	27.9 ±0·1713 [a]
pH	6·5 ±0·0021 [a]	6·4 ±0·0032 [a]	6·4 ±0·0026 [a]
DO (mg/L)	6·7 ±0·0033 [a]	6·2 ±0·0720 [b]	6·3 ±0·0318 [b]
BOD (mg/L)	2·6 ±0·2519 [a]	1·7 ±0·1215 [b]	1·8 ±0·2280 [b]
FREE CO_2 (mg/L)	9·7 ±3·4118 [a]	8·0 ±2.8107 [b]	8·6 ±0.1111 [ab]
TOTAL ALKALINITY (ppm)	13·6 ±0·1816 [a]	12·3 ±0·5656 [a]	13·0 ±0·1399 [a]

Means followed by the same superscript on the same row means there is no significant difference at $P > 0.05$ (n = 24). BOD = Biochemical Oxygen Demand; DO = Dissolved Oxygen

4 DISCUSSION

The taxonomic composition of zooplankton in the lower Benue is similar to other Nigerian and tropical rivers (Fafioye & Omoyinmi, 2006; Ogbeibu & Edutie, 2002; Onwudinjo & Egborge, 1994; Jeje, 1989; Egborge & Chigbu, 1988; Egborge & Tawari, 1987; Jeje & Fernando, 1986). In this study a total of 16 zooplankton species were identified. This number is low but can be attributed to the fact that the research was carried out during the dry season when the water level is low.

Not all the identified species were present in all three stations. For instance, *Testudinella* sp and *Chydorus* sp were totally absent in site C (Wadata market refuse dump) while *Rotaria* sp and *Ceriodapnia* sp were totally absent in site A (Benue Brewery Limited). *Testudinella* sp was however more abundant in site A (> 70%) than in site B (north bank), which agrees with the findings of Ogbeibu and Edutie (2002) and Abida and Harikrishna (2008). They both associated the presence of *Testudinella* sp with brewery effluent. It can also be concluded that both *Rotaria* sp and *Ceriodapnia* sp have no tolerance for brewery effluents as evidenced by their total absence in site A (Benue Breweries Limited). *Rotaria* sp was most abundant in site C (Wadata market); its presence according to Abida & Harikrishna (2008) can be associated with heavily polluted (eutrophic) waters. It has been observed that sensitive species normally disappear as the water becomes polluted while tolerant ones survive the pollution stress and readily recovers downstream of the point of discharge (Ogbeibu & Edutie, 2002).

At sample site A, the waters adjacent to the Benue Brewery Limited show signs of pollution as a result of brewery effluent, as indicated by its zooplankton composition and water quality parameters, having the highest BOD, free CO_2 and total alkalinity values. This could be as a result of biodegradation of organic materials that exerts oxygen tension in the water and increases the biochemical oxygen demand (BOD) (Hynes, 1960), all of which results in high CO_2.

The sample site B, where irrigation farming is taking place, did not indicate signs of heavy eutrophication as one would expect, which might be due to the fact that the sampling was carried out during the dry season, when the impact of run-off into the water body is minimal. This is however likely to change during the rainy season. The sample site C at the Wadata market refuse dump also showed signs of pollution as indicated by the presence of such zooplankton species as *Rotaria* sp.

The impact of anthropogenic stressors on the zooplankton community cannot be considered exclusively without recourse to the water quality parameters since these singly or synergistically influence cumulative changes in the biotic community. The secchi disc turbidity (SDT) could not be measured due to the depth of the water body; which was so shallow that the river bed could be seen. Again, this is most likely because the sampling was carried out at the peak of the dry season.

The mean temperatures recorded were within the range of 25 - 32°C given by Boyd and Lichtkoppler (1979) for warm water bodies. There was no significant difference in pH values recorded ($P > 0.05$, $n = 24$), and the mean pH values were below the pH range of 6.5- 9.0 given by Boyd and Lichtkoppler (1979).

There was a significant difference in dissolved oxygen (DO) values ($P < 0.05$, $n = 24$) among the sites with station A being relatively high with a mean of 6·7250 ±0·0033, this can be as a result of high aeration due to the paddling activities of fishermen around the area, high photosynthesis, and shallow depth of the water, the later being as a result of the season.

Based on our results, it can be concluded that the River Benue water body around Markudi is fairly rich in terms of zooplankton abundance and diversity. The degree of pollution should however be studied and ascertained. It is clear however that the impact of the various anthropogenic stressors can be felt and thus care should be taken to minimize the effects. Failure to take measures may result in the waters around the sampled areas being unable to support aquatic life in the long run, thereby destroying breeding grounds of fishes, eroding the river bank, reducing the depth and warming up the water body as well as disrupting the particular ecological habitat that may impact the whole ecosystem.

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