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Physico-Chemical Characteristics and Zooplankton Distribution and Abundance in Upper Luubara Creek, Niger Delta, Nigeria

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Abstract

A study on the effect of some physico-chemical parameters on distribution and abundance of zooplankton in the Upper Luubara Creek was studied. Samples were collected biweekly during the day in four stations of the creek. The physico-chemical parameters studied and their mean values are : temperature (27.79), pH (6.65), alkalinity (8.54 mg/liter), conductivity (20.04 μs/cm), turbidity (3.42 NTU), DO (5.44 mg/liter), BOD (2.81 mg/liter), phosphate (0.08 mg/liter) and nitrate (1.15 mg/liter). ANOVA showed that temperature, pH, were significant across the seasons but not significant across the stations. BOD was significant across the seasons and stations respectively. Alkalinity, turbidity, DO, phosphate and nitrate were not significant across the seasons and stations. A total of 13 zooplankton species made up of 3 Cladocera, 2 Copepoda, 6 Rotifera and 2 other zooplankter were identified. Cyclops sp. was the dominant form among all the identified zooplankton species followed by calanoid sp. There was significant variations in zooplankton abundance across the stations and seasons. There was also strong positive correlation between zooplankton and DO, BOD, nitrate, and species diversity and a weak negative correlation with pH and temperature.
Key words : Physico-chemical, Distribution, Abundance, Zooplankton, Upper Luubara Creek.

Freshwater zooplankton serve as an important food source for many species of fish acting as primary and secondary links in the food chain and also as important components of most inland waters. In Nigeria, limnological researches on zooplankton have been conducted by various workers in different aquatic ecosystems and include Oshun River (1). Lake Asijire (2), Asa Lake, (3), Jos Plateau reservoir (4), Take Channel of Lake Chad (5), River Sokoto (6), all in Nigeria. However, nothing is known about the zooplankton of Luubara Creek which underscores this study aimed at determining the composition, distribution and abundance of the zooplankton community of the creek and the effect of some physico-chemical characteristics.

Methods

Study Area

Luubara Creek, is a tributary of the Imo River, found in Khana Local Government Area of Rivers State, Eastern Niger Delta. It lies between Longitude 7°15′ E and 7° 32′ E and Latitude 4° 32′ N and 4° 37′ N (Fig. 1). Human settlements are found along the creek. Residents use the water for washing, bathing, and fishing. The water body is usually contaminated through discharge of domestic wastes, and run-offs from the catchment area. There is plenty of agricultural land in the catchment area. The normal freshwater vegetation includes *Crinum natans, Pistia* sp. and *Nymphea* sp. The climate of the area is characterized by dry season (November—April) and wet season (May—October). It is described as humid/semi hot equatorial type (7).

Sample Collection and Analyses

Samples were collected at the upper limit of the creek at four stations : Station I (Bori), II (Kor), III (Wiiyakara) and IV (Beeri) (Fig. 1). Water samples

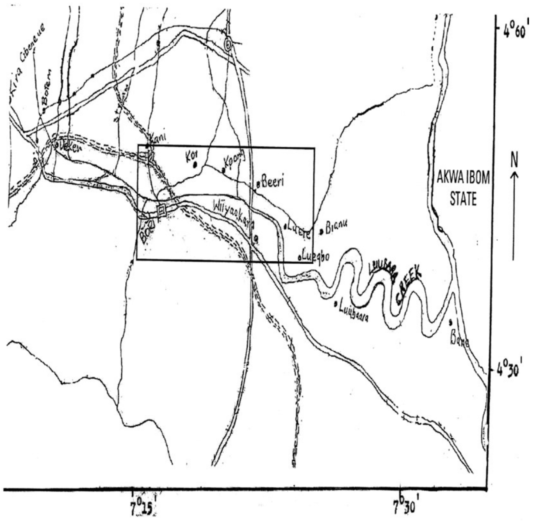

Figure 1. Map of the study area and sampling stations. Source : Rivers State Government (RSG) 1980.

for physical, chemical and biological analyses were collected fortnightly in the daytime between 0900 and 1700 hours for a period of 6 months representing the wet and dry seasons from June—August, November and December, 2005 and January 2006. Samples were collected from the main flow near the center of the creek against the creek flow direction at the sub-surface at about 0.5 m depth. Surface water temperature was measured with a mercury-in-bulb thermometer to the nearest 0.1 C *in-situ* at each station. Dissolved oxygen (DO) and biological oxygen demand (BOD) were determined by Winkler Method (8). The pH was estimated using a pH meter (Hanna instrument 8614 model). Conductivity and turbidity values were measured using the TDS/conductivity meter (Lovibond US meter, type CM-21). Alkalinity, phosphate-phosphorus and nitrate-nitrogen were estimated in the laboratory using the standard methods (9). Zooplankton samples were collected at each of the stations by tows of approximately 5-minute duration with standard plankton net of mesh size 25 μm by dragging the net in water from a hand-paddled boat at low speed against the water flow. Collected samples were immediately transferred into a plastic sample bottle and preserved in 4% formalin solution (10).

In the laboratory, the samples were allowed to stand for about 48 hours before the supernatant were pipetted off until a 50 ml volume concentration was obtained. One ml sub-sample was collected into a Sedgewick-rafter counting chamber with a dropping pipette and examined using Lettz-Wetzlar binocular microscope. Zooplanktons were identified and total number of species recorded using identification keys and checklist (11—14). Species diversity of zooplankton was determined using Shannon-Weaver function H^1 given by the equation :

$$H^1 = \sum ni/N \mathrm{Log}_2 [\, ni/N \,] \quad (15).$$

Where ni is the number of species in group (i), N is total number of individuals in (i) group.

Evenness index (J^1) was calculated thus : $J^1 = \frac{H}{H_{max}}$

Where H is the Shannon index and

$H_{max} = \mathrm{Log}_2 S$ (S is the number of species in the sample)

Species richness was calculated using Margalef's index :

$$\text{Richness} = \frac{S-1}{\mathrm{Log}N} \quad (16)$$

Where S = number of species
N = number of individuals

The coefficient of correlation between zooplankton and physico-chemical parameters of the creek was computed at $P = 0.05$ levels of significance. Two-way analysis of variance (ANOVA) was used to determine the variations in both zooplankton biomass and physico-chemical parameters in the different stations and seasons. Duncan's multiple range test (DMRT) was performed to compare the means of the stations and seasons.

Results and Discussion

Physico-Chemical Characteristics

The mean monthly variations in the physico-chemical characteristics studied are presented in Table 1. Mean temperature ranged between 26.2 and 30.2 C with an overall mean of 27.79 ± 0.29 C. This is similar to that of the Nun River of 26 to 31^{0}C (17). This is considered normal in the Niger Delta with its characteristic humid/semi hot equatorial climate (7). Gener-

Table 1. Mean monthly variation of physico-chemical parameters in Upper Luubara Creek, Rivers State, Niger Delta.

Period		Station	Temp (C)	pH	Alkalinity (mg/l)	Cond (µS/cm))	Turbidity (NTU)	DO (mg/l)	BOD (mg/l)	PO_4—P (mg/l)	NO_3—N (mg/l)
2005	I.	BORI	26.2	7.00	5	14	3	6.48	2.43	0.05	0.05
Jun	II.	KOR	26.4	7.00	5	49	3	6.48	3.24	0.08	0.05
	III.	WIIYAKARA	26.2	7.21	5	13	8	6.90	1.68	0.07	0.05
	IV.	BEERI	26.6	7.25	5	10	10	6.48	2.43	0.07	0.05
Jul	I.	BORI	26.6	7.10	5	14	4	4.87	2.43	0.05	0.05
	II.	KOR	26.4	7.12	19	50	3	4.87	2.43	0.24	0.05
	III.	WIIYAKARA	26.4	7.20	6	10	7	4.87	1.68	0.05	0.05
	IV.	BEERI	26.6	7.22	6	10	11	4.06	2.43	0.05	0.52
Aug	I.	BORI	26.7	7.02	15	14	1	4.06	2.43	0.05	6.05
	II.	KOR	26.8	7.81	14	80	0	4.06	2.43	0.05	5.15
	III.	WIIYAKARA	26.8	6.63	6	12	1	4.87	2.43	0.05	5.40
	IV.	BEERI	26.8	6.39	6	11	2	4.87	3.24	0.05	5.72
Nov	I.	BORI	27.8	6.21	8	31	1	5.68	3.24	0.07	1.20
	II.	KOR	27.8	6.10	10	15	2	5.68	3.24	0.10	2.05
	III.	WIIYAKARA	28.0	6.06	9	13	0	4.06	2.43	0.08	0.80
	IV.	BEERI	27.9	6.00	8	12	1	4.06	2.43	0.10	0.40
Dec	I.	BORI	29.0	6.05	8	24	5	7.30	4.06	0.15	0.05
	II.	KOR	29.2	6.07	8	17	7	7.30	4.06	0.14	0.05
	III.	WIIYAKARA	29.2	6.22	8	15	2	4.87	3.24	0.12	0.97
	IV.	BEERI	29.0	6.25	9	15	3	4.87	3.24	0.10	0.33
2006	I.	BORI	30.2	6.10	10	22	3	7.30	3.24	0.05	1.71
Jan	II.	KOR	30.2	6.17	10	10	2	7.30	3.24	0.03	1.63
	III.	WIIYAKARA	30.0	6.81	10	10	2	5.27	2.43	0.05	1.0
	IV.	BEERI	30.0	6.50	10	10	2	4.06	3.24	0.05	0.16

ally, significantly higher temperatures (P<0.001) were recorded in the dry season than the wet season which could be attributed to increased solar radiation during this period (18). Similar observation was made in Woji Creek (19). There was however no significant difference among the stations.

The pH values ranged between 6.00 and 7.81 with a mean of 6.65 ± 0.11 which is within the range of 6.5—8.5 considered for inland waters (20). The range indicates an acidic to neutral water condition in Luubara Creek. This may be attributed to the discharge of domestic wastes and run-offs from the catchment areas. According to Mizuno and Mori (21), changes in pH in flood plains could be due to factors such as animal droppings and soil type. Significantly higher pH (P < 0.001) in the wet season than dry season was observed in all the stations. Chindah (22) had a similar result in the Lower Bonny River. The pH did not vary significantly (P > 0.05) among the stations. Total alkalinity concentrations ranged from 5.0 to 19.0 mg/liter with a mean of 8.54 ± 0.71 mg/liter during the study period. Alkalinity was relatively higher in the dry season than the wet season but were not statistically significant (P>0.05). Total alkalinity showed that Luubara Creek is hard with considerable buffering capacity characteristic of water bodies in the Niger Delta (23, 24).

Conductivity ranged from 10.0 to 80.0 µS/cm with a mean of 20.04 ± 3.45µS/cm and were significantly higher in Stations 1, 111 and IV in the dry season than the wet season which is in agreement with earlier reports (17, 19, 25). This might be attributed to high concentration of dissolved solids due to high evaporation rates caused by high temperature (18). Conductivity was however higher in station II in the wet season than dry season. This may be attributed to the effect of mixing of fresh-water and organic and inorganic materials that are emptied into the Creek from the catchment area. Similar conductivity trends have been reported for similar water bodies in the Niger Delta (22, 23, 26).

Turbidity values ranged from 1.0—11.0 NTU with a mean value of 3.42 ± 0.62 NTU which were not significantly different (P>0.05) across the stations and

Table 2. Seasonal variation in composition and abundance of zooplankton (nos. / liter) at the various sampling stations.

	Station I						Station II					
	Wet			Dry			Wet			Dry		
Species	Jun	Jul	Aug	Nov	Dec	Jan	Jun	Jul	Aug	Nov	Dec	Jan
Cladocera												
Daphnia sp.	1	1	1	2	2	1	1	1	1	2	2	2
Moina sp.	1	1	1	2	2	2	1	1	1	1	2	2
Diaphanosoma sp.	1	1	1	1	1	2	1	1	1	2	1	2
Total	3	3	3	5	5	5	3	3	3	5	5	6
Copepoda												
Cyclops sp.	1	1	2	2	2	2	1	1	1	2	2	1
Calanoids sp.	1	2	2	2	2	2	1	1	1	1	1	2
Total	2	3	4	4	4	4	2	2	2	3	3	3
Rotifera												
Branchionus sp.	1	1	1	1	1	1	1	–	–	1	1	1
Asplanchna sp.	–	1	–	1	1	1	–	–	1	1	1	1
Polyarthra sp.	1	–	1	1	1	1	–	–	–	–	1	1
Colurella sp.	1	–	–	1	–	1	1	1	–	–	1	1
Keratella quadrata	1	1	1	–	1	1	1	–	–	1	–	1
Filinia sp.	1	1	–	1	1	1	–	–	–	1	–	1
Total	5	4	3	5	5	6	3	1	1	4	4	6
Others												
Shrimp (*Mysis*)	1	1	1	–	–	1	1	1	–	–	–	1
Fish larvae	1	–	1	–	–	1	–	–	–	–	–	–
Total	2	1	2	0	0	2	1	1	0	0	0	1
Grand total	12	11	12	14	14	17	9	7	6	12	12	16

Table 2. Continued.

	Station III						Station IV					
	Wet			Dry			Wet			Dry		
Species	Jun	Jul	Aug	Nov	Dec	Jan	Jun	Jul	Aug	Nov	Dec	Jan
Cladocera												
Daphnia sp.	–	1	1	1	1	1	–	1	–	1	1	1
Moina sp.	1	–	1	1	1	1	–	1	1	–	1	1
Diaphanosoma sp.	–	1	–	1	1	1	–	–	1	1	–	1
Total	1	2	2	3	3	3	0	2	2	2	2	3
Copepoda												
Cyclops sp.	1	1	–	1	2	2	1	1	1	2	2	2
Calanoids sp.	–	–	1	2	1	2	–	1	1	1	2	1
Total	1	1	1	3	3	4	1	2	2	3	4	3
Rotifera												
Branchionus sp.	–	–	–	1	1	1	1	–	–	1	–	1
Asplanchna sp.	–	1	–	1	–	1	–	–	1	–	1	1
Polyarthra sp.	–	1	–	–	1	1	–	–	1	–	1	1
Colurella sp.	–	–	–	–	–	–	–	–	–	–	–	–
Keratella quadrata	–	–	–	1	–	1	–	1	–	1	1	1
Filinia sp.	–	–	–	–	–	–	–	–	–	–	1	1
Total	0	2	0	3	2	4	1	1	2	2	4	5
Others												
Shrimp (*Mysis*)	1	–	–	1	–	–	–	1	–	–	1	1
Fish larvae	–	–	–	–	–	1	–	–	–	–	–	–
Total	1	0	0	1	0	1	0	1	0	0	1	1
Grand total	3	5	3	10	8	12	2	6	6	7	11	12

seasons. The slightly high turbidity recorded during the dry season in stations I and II might be as a result

Table 3. Seasonal abundance of zooplankton taxa at the sampling stations.

Plankton taxa	Wet season (percent of total) S. I.	S. II.	S. III.	S. IV.	Percent of total	Dry season (percent of total) S. I.	S. II.	S. III.	S. IV.	Percent of total
Cladocera	9 (25.7)	9 (40.9)	5 (45.5)	4 (28.6)	27 (32.9)	15 (33.3)	16 (40.0)	9 (30.0)	7 (23.3)	47 (32.4)
Copepoda	9 (25.7)	6 (27.3)	3 (27.3)	5 (35.7)	23 (28.0)	12 (26.7)	9 (22.5)	10 (33.3)	10 (33.3)	41 (28.3)
Rotifera	12 (34.3)	5 (22.7)	2 (18.2)	4 (28.6)	23 (28.0)	16 (35.6)	14 (35.0)	9 (30.0)	11 (36.7)	50 (34.5)
Other zooplankton	5 (14.3)	2 (9.1)	1 (9.1)	1 (7.1)	9 (11.0)	2 (4.4)	1 (2.5)	2 (6.7)	2 (6.7)	7 (4.8)
Total	35	22	11	14	82 (36.1)	45	40	30	30	145 (63.9)

of increased silt particles and sedimentation caused by the serious sand-mining operations and human activities including cattle grazing within and around the stations.

Dissolved oxygen (DO) values were generally moderate ranging from 4.06—7.30 mg/liter with a mean value of 5.44 ± 0.24 mg/liter. The difference in DO concentration between seasons and stations were not statistically significant. BOD ranged from 1.68—4.06 mg/liter with a mean of 2.81 ± 0.13 mg/liter. Significantly higher BOD values ($P < 0.001$) were recorded in the dry season than the wet season. BOD did not significantly ($P>0.05$) vary among stations I, II and IV, except in station III ($P<0.05$). The non-significance in DO concentrations between the seasons and the higher BOD in the dry season in this study, differs from earlier reports (19, 25). They observed higher DO and BOD values in the rainy season than the dry season which was considered normal since there is an inverse relationship between temperature and DO in water.Solubility of oxygen decreases with high temperature. The difference may be as a result of the more acidic condition of the Luubara Creek.

Phosphate values ranged from 0.03—0.24 mg/liter with a mean of 0.08±0.01 mg/liter without significant difference ($P >0.05$) in seasons and stations. The range is within the range of 0.05 to 0.2 mg/liter considered favorable for aquatic productivity (27). Nitrate concentrations ranged from 0.05 to 6.05 mg/liter with a mean of 1.5±0.36 mg/liter throughout and did not show any significant ($P>0.05$) seasonal variations. The non-seasonality in nitrate and phosphate concentrations are in agreement with earlier reports (25). However relatively higher values of nitrate-nitrogen in the wet than dry season was observed. This could result from run-off from agricultural lands, livestock and human wastes (18) ; while low values during the dry season could possibly be due to utilization by biota which is in agreement with this study.

Significant ($P<0.05$) seasonal variation was observed in temperature, pH, conductivity and BOD of the creek water, while alkalinity, turbidity, DO, phosphate and nitrate were non-significant ($P>0.05$). Also, temperature, pH, alkalinity, turbidity, DO, phosphate and nitrate were not significantly ($P>0.05$) different in all the stations, which suggest that the station did not significantly affect their concentrations.

Zooplankton Composition and Abundance

The zooplankton composition and abundance are as shown in Table 2. Quantitatively, total zooplankton counts per liter varied between 26 and 57 and it ranged from 11—17, 6—16, 3—12 and 2—12 in stations I—IV, respectively. Generally, abundance was higher in the dry season than in the wet season and was statistically significant ($P<0.001$) between the seasons and among the stations. Qualitatively, 12 species were observed consisting of 3 Cladocera, 2 Copepoda, and 5 Rotifera. Others include shrimp (mysis) and fish larvae. The Copepoda were dominated by *Calanoids* sp. followed by *Cyclops* sp. ; the Rotifera were dominated by *Branchionus* sp. followed by *Polyarthra* sp., *Keratella quadrata, fili-*

nia sp. *Asplanchna* sp. and *Colurella* sp. ; Cladocera were dominated by *Moina* sp. followed by *Daphnia* sp. and *Diaphanosoma* sp. (Table 2). The community composition by taxa showed that Cladocera was dominant during the wet season (32.9%) followed by Copepoda and Rotifera of 28.0% each. The dry season was dominated by rotifers constituting 34.5% followed by Cladocera (32.4%) and Copepoda (28.3%). Others recorded 11.0% in the wet season and 4.8% in the dry season (Table 3).

During the rainy months, Cladocera was more dominant by percentage composition in station III (45.5%) Copepoda in station IV (35.7%) and Rotifera in station I constituting 34.3%. In the dry season months, Cladocera was more abundant in station II with 40.0%, Copepoda in stations III and IV (33.3%) each while Rotifera abundance was highest in station IV (36.7%) (Table 3).

There was no definite pattern in species diversity among stations with season but zooplankton diversity was slightly higher in the dry season, in all the stations except in station I. The mean maximum diversity came from rotifera in both dry and wet seasons. Maximum and minimum species evenness was indicated in rotifera and other zooplanktons respectively. Species richness distribution did not vary much between stations but showed both temporal and seasonal variations. Temporally, there was a declining trend from stations I to IV during the dry season and a rising trend from stations I to III during the wet season with a slight drop in station IV. Seasonally, species richness was slightly higher in the wet season than the dry season.

Relationship Between Zooplankton and Some Physico-chemical and Biological Attributes

In the wet season, zooplankton had a strong positive correlation with diversity, and evenness (r = 0.96 and 0.85) and a weak positive correlation with alkalinity (r = 0.48) and BOD (r = 0.36). A strong negative correlation with richness (r = – 0.93) and turbidity (r = – 0.69) was also observed. In the dry season a strong positive correlation was observed between zooplankton and conductivity, turbidity, DO, BOD, phosphate, richness and diversity (r = 0.79, 0.88, 0.91, 0.97, 0.84 and 0.65) respectively. A weak positive correlation with nitrate (r = 0.49) was also observed.

Correlation matrix for the combined seasons showed that zooplankton had a strong positive correlation with DO, BOD, nitrate and diversity (r = 0.82, 0.77, 0.71 and 0.96) respectively but a strong negative correlation with richness (r = – 0.87). A positive correlation of alkalinity, conductivity and evenness with zooplankton density (r = 0.52, 0.518 and 0.54) were also observed.

Effect of Season on Zooplankton Abundance

Significantly (P<0.05) higher abundance of zooplankton occurred in the dry than wet season as also reported earlier (10, 28) who reported that zooplankton growth was less during lower temperature periods.

Effect of Station on Zooplankton Abundance

Zooplankton biomass in station I did not differ significantly (P > 0.05) from station II but differed significantly from stations III and IV. The high zooplankton density recorded in station I may possibly be due to accumulated cow dung manure at the station which is in close proximity to the spot were cattle usually drink water daily before and after grazing. Manure as an important local raw material supports production of bacteria and protozoan which are good food source for zooplankton (5).

Results also indicated that the zooplankton community of the creek is typical of a eutrophic environment. This is so because many species cited by Gannon and Stemberger (29) as indicators of eutrophy were identified ; some of these species are Branchionus sp., *Keratella* sp., *Filinia* sp., and *Polyarthra* sp.

The low density of the zooplankton observed in the Upper Luubara Creek may not be due to food limitation. The explanation for these low densities possibly lie in ecological relationship like competition, predation and, or as a result of migratory behavior of the zooplankter, such that at the time of sampling during the day, zooplankter could be concentrated in the deeper layers of the Creek searching for shelter ; this could possibly lead to underestimated densities and species richness and composition.

Also the low zooplankton density is in agreement with Nilssen (30) who reported that zooplankton communities could be simplified in the tropics, and low densities are not infrequent in tropical waters. Mean values of the diversity and evenness indices and species richness calculated in this study were rather low and typical of eutrophic waters (31).

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