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Zooplankton Species Compositions, Abundance and Diversity of Gbalegbe River, Delta State, Nigeria.

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ABSTRACTS

Gbalegbe River (12.5 Km), Delta State is very significant to its surrounding inhabitants. The river in recent time has been experiencing high rate of effluent discharge due to increased anthropogenic activities. Studies on Gbalegbe River's flora and fauna abundance are limited. Hence, this study was under taken to evaluates its zooplankton species compositions, abundance and diversity. The river was spatially stratified into eight stations (S1, S2, S3, S4, S5, S6, S7, and S8) based on closeness to major anthropogenic activities. In each station, three sampling points were randomly selected. Temporal stratification covered wet (March - October) and dry (November – February) seasons. Water and zooplankton samples were collected from each station forth – nightly for 24 months following standard methods. Water samples were analysed for Temperature (°C) and Dissolved Oxygen (DO, mg/L), while Zooplankton were identified to species level by using standard keys. Abundance (%) was calculated according to standard method. Data were analysed by using descriptive statistics and ANOVA at α0.05. Spatially, significantly highest (28.45±2.06) and least (24.28±5.84) Temperatures were recorded in S2 and S3, while 4.00±0.66 and 3.79±0.71 were recorded as highest and least for DO in Raining and Dry seasons, respectively. A total number of 1070 zooplankton species belonging to 6 orders and 9 families were recorded. The most (14.6 %) and least (2.2 %) abundance zooplankton species recorded were Diaptomus augustaensis and Moinodaphnia acleaya, respectively. Spatially, S 1 recorded the highest (27.0 %), while S 2 recorded the least (2.2 %) abundance of zooplankton. Raining season recorded Calanoid copepod (6.1 %) and Daphnia magna (1.5 %) as highest and least, while Calanoid copepod (8.4 %) and Brachionus caudatus (1.9 %) were recorded as highest and least in the dry season, respectively. Physicochemical parameter (DO = 3.79±0.71) and zooplankton abundance (S 2 = 2.2 %) of Gbalegbe River are gradually declining.

Keywords: Zooplankton abundance, Gbalegbe River, Anthropogenic activities, Physicochemical parameters

Keywords: Eradication, Violence, Terrorism, Universities, Islamic and International Law Perspectives

Aims Research Journal Reference Format:
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1. INTRODUCTION

Zooplankton are diverse floating and drifting organisms with limited power of locomotion (Ogbuagu, 2013). It is one of the most commonly studied biological organisms in rivers (Ogamba et al., 2010). Majority of them are microscopic, unicellular or multicellular in forms with size ranging from a few microns to a millimeter or more (Kigbu et al., 2015). In addition to size variations, plankton differ in morphological features and taxonomic compositions (Ewutanure and Olaifa, 2018). Zooplanktons play important roles in the study of aquatic fauna diversity and have members in nearly every taxon of the animal kingdom (Ukaonu et al., 2015). They are found in pelagic ecosystem as holoplankton or meroplankton (Kwen et al., 2012). Due to their abundance and presence at varying depths, the zooplanktons are utilized to assess energy transfer at secondary trophic level (Grace, 2013). Their food are mainly phytoplankton and speed up the conversion of plant resources into animal tissue (Ezekiel et al., 2011). They constitute the basic food for higher animals and fish fry (Adeleke and Babalola, 2014; Ekwu and Sikoki, 2006).

The occurrence and distribution of zooplankton influence pelagic fishery potentials (Ajuonu et al., 2011). Fishes breed in water bodies where zooplankton are abundance so as ensure adequate nutrients supply, growth and survival their young ones (Ekwu and Sikoki, 2005). In comparison with phytoplankton, zooplanktons are more varied, while their variability in the aquatic ecosystems is influenced mainly by diurnal vertical migration, seasons and patchiness (Adeogun et al., 2005). One of the major reasons for studying zooplankton is that they could be used as indicator aquatic pollution (Ewutanure and Olaifa, 2018).

Data on the various types of zooplankton species found in the aquatic environment and the abundance of some species relative to each other could serves as a measure of biological condition (Adeogun et al., 2005). Zooplankton are essential indicators of fluctuation in nutrient concentration and pollution because they respond speedily to variation in nutrient inflow to water bodies (Dejen et al., 2004). Zooplankton abundance is a veritable component of the aquatic food chain, serving as an intermediary species in the transfer of energy from planktonic algae to the larger predators such as fish that eventually feed on them (Kwen et al 2019). Zooplankton are very sensitive to changes in aquatic ecosystems (Ekwu and Udo, 2013). The effects of environmental alteration can be detected through changes in species composition, abundance and body size distribution (Ajuonu et al., 2011).

2. MATERIALS AND METHODS

2.1 Description of the study area

According to Ewutanure and Olaifa, (2018), Gbalegbe River (Figure 1) is located between latitudes 5°10'N and 5°17'N of the Equator and Longitudes 5°56'E and 5°13'E of the Greenwich meridian. It is a branch of the Asaba - Ase River, the western branch of River Niger in the Delta Area of Southern Nigeria. Gbalegbe River has a length of 12.45 km, maximum depth of 10.45m and a mean depth of 4.31m (Ewutanure and Olaifa, 2018). The study area lies between 0 – 100 meters above sea level (Ewutanure and Olaifa, 2017). It is the major River flowing through Ughelli Town. Originally, the Town was an agricultural settlement but rapid industrialization has taken place with major oil and

construction companies such as SHELL, NNPC, SETRACO, Rubber Factory, Beta glass, sand miners and natural gas (Aweto, 2002).

2.2 Climate and vegetation of the study area

The study area has two major seasons which include wet (March to October) season and a dry (November to February) season. The climate of the study area is determined the South – West monsoon wind from the Atlantic Ocean and the North – East trade wind from the Sahara Desert. About 2700 mm annual rainfall is recorded in the study area (Ewutanure and Olaifa, 2018). The rainfall regime is double – peak (June/July and September) which are separated by a relatively dry period in August. The lowest amount of rainfall (27 mm) is recorded in December, while the mean annual temperature is about 27 °C. The original vegetation of the study area is rain forest with low – lying valley which are seasonally or permanently submerged.

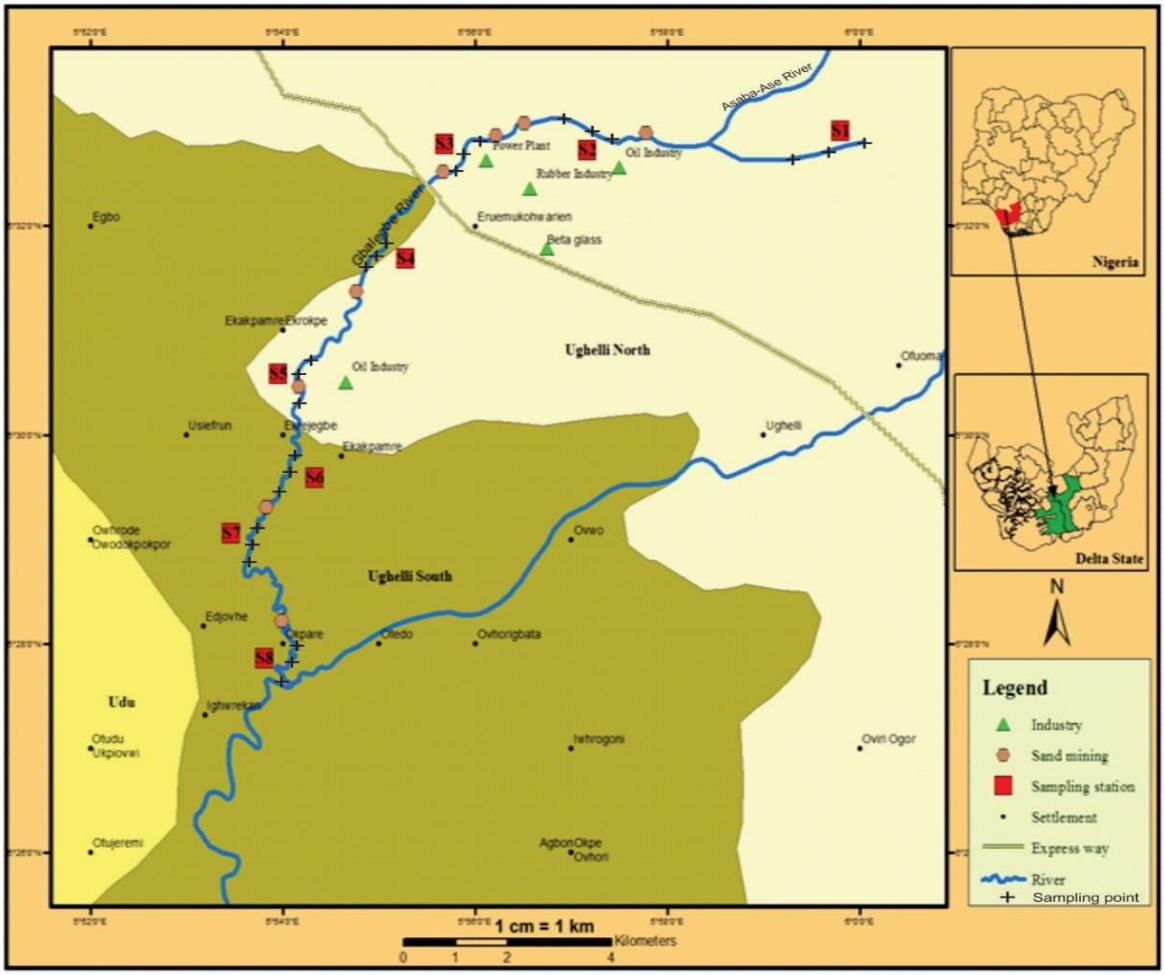

Figure 1. Map of Gbalegbe River
Source: Ewutanure and Olaifa, (2018).

2.3 Experimental procedure

Sampling Techniques:
Gbalegbe River (12.5 Km) was spatially stratified into eight stations (S1, S2, S3, S4, S5, S6, S7, and S8) based on closeness to major anthropogenic activities. In each station, three sampling points were randomly selected. Temporal stratification covered wet (March - October) and dry (November – February) seasons. Water samples were collected from each. Station forth – nightly for 24 months following standard methods. Water samples were analysed for Total suspended solids (TSS, mg/L), Turbidity (FTU), Temperature (^oC), Dissolved Oxygen (DO, mg/L) and pH.

2.4 Sample collection and analysis
Surface water temperature was measured by using mercury in glass thermometer (^oC) as described by Boyd (1979; APHA, 1998). Dissolved oxygen was determined ex – situ following Winkler's method as described by Gupta, (2001). The formula stated below was used to calculate DO.

$$\text{DO (mg/L)} = \frac{V1 \times N \times 8 \times 1000}{V2 - V} \quad \text{(Gupta, 2001).}$$

Where:
V_1 = Volume of titrant (ml); N = Normality of titrant (0.025N)
V_2 = Volume of Sampling bottle after placing the stopper (ml)
V_3 = Volume of manganous sulphate + potassium iodide solutions added (ml)

Total suspended solids (TSS) was determined as described by AOAC, (1990).

2.4.1 Calculation:

$$\text{TSS (mg/L)} = \frac{A-B}{C} \text{ X } 1000{,}000 \quad \text{(AOAC, 1990)}$$

Where:
A = Dry weight of residue + filter paper
B = Dry weight of filter paper alone
C = Total ml of water filtered

pH was determined by using digital pH meter (Hanna model: HI – 98107, USA), while Turbidity was measured by using a turbidometer in accordance with USEPA, (1993) standards.

2.5 Sampling and preservation of zooplankton from Gbalegbe River, Delta State

Evaluation of zooplankton production in any water body depends largely on the use of correct zooplankton methodology that involves collection of samples, fixation, preservation, analysis and computation of data (Wiafe and Frid, 2001). Zooplankton samples were collected by using a recommended mesh size net of 0.2 mm in a horizontal hauling (Margalef, 1968). A recommended towing speed of 5 to 10 minutes was observed, while a sampling duration of 6:30 am – 7:30 am (Ogbuagu, 2013) was observed. This was done because zooplanktons migrate in response to light (Ewutanure and Olaifa, 2018).

Collected samples of zooplankton were fixed and preserved in 5% formalin within the recommended time of 5 minutes to avoid damage to animal tissue by microbial action and autolysis. The samples were properly labelled, dated and taken to the laboratory for further analysis and identification (Ewutanure and Olaifa, 2018). Formalin was necessitated because it is widely used, kills the organisms quickly and can preserve zooplankton samples for number years (AOAC, 1990). In the laboratory, zooplankton were identified to order, family and genus/species levels using standard keys such as Jeje and Fernando, (1986).

2.5.1 Abundance and diversity index

Percentage species abundance = $\frac{\text{Number of individual per species}}{\text{Total number of organisms}} \times \frac{100}{1}$ % was calculated to point out the most abundance zooplankton species.

Margalef diversity index

$$\text{Ri} = \frac{\text{S}-1}{\ln(\text{N})}$$ Margalef, (1968)

Where S = Total number of species, N = Total density of species,
Dominance, (D)

$$\text{D} = \left(\text{S}\left(\frac{\text{ni}}{\text{n}}\right)2\right)$$ Simpson, (1949)

It ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely)
n_i = number of individuals of taxon.
Simpson's index (S_i)

$$\text{Si} = \frac{\text{D}}{\text{Dmax}}$$ Shannon and Weaver, (1949)

Simpson's index (S_i) = 1 – Dominance, measurement of evenness. It measures the evenness of the community from 0 – 1, D = Species diversity, Dmax = Maximum amount of the species' diversity index.

Shannon-Wiener Index

$H' = -\sum_{i=1}^{n} Pi \log 2Pi$ Shannon and Weaver, (1949)

It takes into account the number of individuals as well as the number of taxa. It varies from 0 (community with only a single taxa) to high values (community with many taxa) each with few individual. n = Total number of species i, P_i = Ratio of the species i.

2.5.2 Statistical analysis

Data recorded from this study were subjected to descriptive and inferential statistics by using SPSS (version, 20). Microsoft Excel, (version 2010) was used to calculate species abundance. Data were pooled and presented as spatial and temporal mean variances in order to evaluate if their difference was significant (p-value > 0.05).

3. RESULTS AND DISCUSSION

In comparison with Station 1 (area of minimum anthropogenic activities), there were significant differences (p > 0.05) among the physico – chemical parameters measured (Table 1). The highest mean of TSS, Turbidity and Temperature were recorded in Station 2 (area of highest anthropogenic activities). Temporarily, dry season recorded the highest mean of TSS, Turbidity and Temperature, while the least mean DO was recorded in dry season, respectively (Table 2). Higher values recorded in dry season than in wet season could be associated with intensed inflow of effluents from anthropogenic activities (sand mining, effluents from oil, glass and rubber industries) within the study area. This report agrees with Ewutanure and Olaifa, (2018).

A total number of 1070 of zooplankton species belonging to 6 orders and 9 families were identified and recorded (Table 3). The most and least abundance zooplankton species recorded were Diaptomus augustaensis (14.6 %) and Moinodaphnia macleaya (2.2 %), respectively. Spatially, S 1 recorded the highest (27.0 %) followed by S 8 (15.9 %), while S 2 recorded the least (2.2 %) abundance of zooplankton. The order of abundance of other organisms identified were Fish eggs (6.6 %) closely followed by Fish larvae (4.3 %), while the least was Flat worm (2.0 %), respectively.

Temporally (Table 4), the most abundant species of zooplankton was Calanoid copepod (6.1 %), closely followed by Brachionus caudatus (5.8 %), while the least was Daphnia magna (1.5 %) in the rainy season. Wet season recorded Calanoid copepod (8.4 %) as the highest zooplankton species followed by Bosmina longirostris (5.2 %), while Brachionus caudatus (1.9 %) was recorded as the least, respectively. The abundance of fish eggs was higher (7.0 %) in dry season than in wet (6.6 %) season, while Flat was higher (2.3 %) in rainy season than (1.6 %) in dry season.

MEDITSSTRADTable 1. Spatial variation in physico-chemical parameters of Gbalegbe River, Delta State

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8
TSS (mg/L)	23.98±10.51^{c} (18.38-29.58)	98.60±06^{a} (27.51-119.69)	31.18±56^{b} (12.67-37.93)	25.91±16.17 ^{c} (17.29-34.53)	32.55±9.37 ^{b} (27.57-37.55)	47.93±48.79 ^{b} (21.94-73.93)	48.39±64.15^{b} (45.21-83.58)	31.36±374.66^{b} (11.72-56.01)
TUR (FTU)	6.96±2.17^{c} (6.71-9.67)	43.59±16.29^{a} (23.91-45.27)	30.15±17.74^{b} (20.70-39.61)	36.08±18.04^{b}(26.47-25.70)	35.21±14.84^{b}(27.30-43.12)	25.62±12.35^{d} (19.04-32.20)	39.00±16.62^{b} (30.14-47.86)	33.74±16.57^{b} (24.92-42.57)
Temperature (^{o}C)	26.62±1.75^{a} (25.69-27.55)	28.45±2.06^{a} (24.35-29.55)	24.28±5.84^{a} (21.16-27.39)	25.49±1.59\$^{a}$ (24.64-26.33)	25.93±1.75^{a} (25.00-26.87)	26.14±2.00^{a} (25.07-27.21)	26.30±1.34^{a} (25.58-27.01)	24.81±1.53^{a} (23.99-25.62)
DO (mg/L)	4.25±0.56^{a} (3.95-4.55)	3.13±0.67^{ab} (3.10-4.11)	3.45±0.48^{b} (3.19-3.71)	3.88±0.85^{b} (3.43-4.34)	3.91±0.77^{b} ^{c} (3.50-4.32)	3.68±0.64^{bc} (3.34-4.02)	3.94±0.74^{bc} (3.54-4.34)	3.55±0.69^{bc} (3.18-3.92)
pH	7.15±0.61^{b} (6.82-7.48)	6.99±0.79^{ab} (6.87-7.71)	7.21±0.62^{b} (6.88-7.54)	7.31±0.52^{a} ^{b} (7.03-7.59)	7.12±0.57^{b} (6.82-7.43)	7.77±0.84^{a} (7.32-8.22)	7.45±0.79^{b} (7.03-7.87)	7.03±0.37^{b} (6.83-7.22)

Means with the same alphabth across the stations are not significantly different from each other at 0.05 level of significance. Note:TSS=total suspended solids, TUR=turbidity and DO=dissolved oxygen.
Source: Adapted from Ewutanure and Olaifa, (2018)

MEDITSSTRAD Table 2. Temporal variation in physico-chemical parameters of Gbalegbe River

	Rainy season	Dry season	FEPA, (1991)	Boyd, (1979)
TSS (mg/L)	41.29±3.11^{b} (25.07-47.51)	47.25±5.43a (27.47-53.02)	30.00	< 10
TUR (FTU)	27.89±4.93^{a} (22.51-33.27)	30.41±4.29^{a} (25.26-35.57)	10	10
Temperature (^{o}C)	25.94±1.97^{a} (25.33-26.75)	26.43±1.86^{a} (25.37-26.70)	20 – 33	25 – 32
DO (mg/L)	4.00±0.66^{a} (3.77-4.24)	3.79±0.71^{a} (3.54-4.05)	>5	5 – 10
pH	7.22±0.70 ^{a} (6.97-7.47)	7.15±0.78^{a} (7.16-7.73)	6.5 – 9.0	6.5 – 8

Note: Means with the same alphabeth across the seasons are not significantly different from each other at 0.05 level of significance. TSS=total suspended solids, TUR=turbidity, DO=dissolved oxygen and BOD=biological oxygen demand.
Source: Adapted from Ewutanure and Olaifa, (2018)

Table 3. Compositions, distribution and abundance of zooplankton species among stations in Gbalegbe River, Delta State, Nigeria

Order	Families	Genus & species	Number of Zooplankton collected per Stations								Total	% Abundance
			1	2	3	4	5	6	7	8		
Cyclopoida	Cyclopoidae	Cyclops bicuspidatus	19	1	3	5	3	4	6	2	43	3.9
		Eucyclops speratus	15	2	3	9	3	5	6	3	46	4.2
		Sub – total	34	3	6	14	6	9	12	5		
Calanoida	Diaptomidae	Calanoid nauplius	9	1	2	4	8	7	7	8	46	4.2
		Diaptomus augustaensis	12	1	3	7	52	2	23	56	156	14.6
		Calanoid copepod	25	1	2	9	9	24	1	3	74	6.8
		Sub – total	46	3	7	20	69	33	31	67		
Anomopoda	Daphniidae	Calanus finmarchicus	5	0	2	1	7	1	3	6	25	2.3
		Daphnia magna	8	1	2	0	2	4	2	8	27	2.5
		D. longispina	14	0	3	7	2	2	4	5	37	3.4
		D. similies	9	1	2	2	8	9	7	7	45	4.1
		Simocephalus vetulus	21	1	2	1	2	9	3	3	42	3.8
		Sub – total	57	3	11	11	21	25	19	29		
	Chydoridae	Moinodaphnia macleaya	5	1	3	0	2	1	2	10	24	2.2
		Alona monacantha	7	2	1	2	3	7	7	9	38	3.5
		Sub – total	12	3	4	2	5	8	9	19		

Table 3. Cont´d

Order	Families	Genus& Species	Number of Zooplankton per Station								Total	% Abundance
			1	2	3	4	5	6	7	8		
	Bosminidae	A. davidi	9	0	2	3	3	9	3	7	36	3.3
		Bosmina longirostris	11	1	3	3	4	9	6	0	37	3.4
		Sub – total	20	1	5	6	7	18	9	7		
Cladocera	Moinidae	Moina micrura	3	2	2	1	8	3	5	4	28	2.6
		Sub – total	3	2	2	2	8	3	5	4		
Ploimida	Brachioniidae	Brachionus caudatus	17	1	2	7	4	6	3	7	47	4.3
		Sub – total	17	1	2	7	4	6	3	7		
Phasmida	Phasmidae	Haplopus evadne	9	1	3	2	9	6	4	9	43	3.9
		Sub – total	9	1	3	2	9	6	4	9		
Harpacticoida	Ectinosomatidae	Harpacticoid copepod	7	2	1	0	7	1	1	8	27	2.5
		Harpacticoid nauplius	10	1	2	4	7	9	1	2	36	3.3
		Sub – total	17	3	3	4	14	10	2	10		
		Others										
		Round worms	1	0	2	4	7	9	6	1	30	2.7
		Flat worms	1	1	1	7	3	2	5	2	22	2.0
		Fish larvae	29	1	2	2	1	4	6	2	47	4.3
		Fish eggs	33	0	2	5	8	6	9	9	72	6.6
		Crustacean larvae	17	2	3	5	7	3	2	3	42	3.8
		Sub – total	81	4	10	23	26	24	28	17		
		Grand – total	296	24	53	90	169	142	122	174		
		% Abundance	27.0	2.2	4.8	8.2	15.4	13.0	11.1	15.9		

Table 4. Compositions, distribution and abundance of zooplankton species between seasons in Gbalegbe River, Delta State, Nigeria

Order	Families	Genus & species	Rainy season total	Rainy season % Abundance	Dry season total	Dry season % Abundance
Cyclopoida	Cyclopoidae	Cyclops bicuspidatus	27	3.9	16	4.2
		Eucyclops speratus	36	5.2	10	2.6
Calanoida	Diaptomidae	Calanoid nauplius	26	3.8	20	5.1
		Diaptomus augustaensis	100	14.6	56	14.2
		Calanoid copepod	42	6.1	32	8.4
Anomopoda	Daphniidae	Calanus finmarchicus	17	2.5	8	2.1
		Daphnia magna	10	1.5	17	4.4
		D. longispina	26	3.8	11	2.9
		D. similies	38	5.5	7	1.7
		Simocephalus vetulus	23	3.3	18	4.7
	Chydoridae	Moinodaphnia macleaya	13	1.9	11	2.9
		Alona monacantha	21	3.1	18	4.7
	Bosminidae	A. davidi	26	3.8	10	2.6
		Bosmina longirostris	17	2.5	20	5.2
Cladocera	Moinidae	Moina micrura	19	2.8	9	2.3
Ploimida	Brachioniidae	Brachionus caudatus	40	5.8	7	1.9
Phasmida	Phasmidae	Haplopus evadne	27	3.9	16	4.2
Harpacticoida	Ectinosomatidae	Harpacticoid copepod	17	2.5	10	2.6
		Harpacticoid nauplius	20	2.9	16	4.2

Order	Families	Genus & species	Rainy season total	Rainy season % Abundance	Dry season total	Dry season % Abundance
		Others				
		Round worms	20	2.9	10	2.6
		Flat worms	16	2.3	6	1.6
		Fish lavae	29	4.2	18	4.7
		Fish eggs	45	6.6	27	7.0
		Crustacean larvae	32	4.7	10	2.6
		Grand – total	687		383	
		% Abundance	64.2		35.8	

Table 5. Diversity indices of zooplankton species among stations

Parameters	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8
Individuals	296	24	53	90	169	142	122	174
Dominance, D	0.16	0.43	0.07	0.19	0.14	0.08	0.15	0.33
Simpson, 1-D	0.84	0.57	0.93	0.81	0.86	0.92	0.85	0.67
Shannon_H	3.95	3.51	4.08	2.59	2.67	3.89	3.67	4.11
Evenness	0.75	0.49	1.00	0.21	0.22	0.63	0.22	0.71
Margalef	4.37	2.98	2.75	2.63	2.60	2.79	2.82	2.69

Note: S = Station

Table 6. Diversity indices of zooplankton species between seasons

Parameters	Wet season	Dry season
Individuals	687	383
Dominance, D	0.28	0.32
Simpson, 1 – D	0.72	0.68
Shannon, H	3.11	2.99
Evenness	0.77	0.65
Margalef	3.98	2.73

Diversity index among stations (Table 5) and between seasons (Table 6) showed the characteristics features of zooplankton distribution and abundance in Gbalegbe River. The mean of TSS value recorded during the study were high than the recommended values < 10 mg/L (Boyd, 1979) and 30 mg/L (FEPA, 1991), which could be associated with the high rate of effluents emanating from anthropogenic activities along the Gbalegbe River. Turbidity values recorded during the study were greater than the recommended level of 10 FTU (Boyd, 1979; FEPA, 1991) except in Station 1. Turbidity indicates that water contains suspended materials which interferes with light penetration.

Higher values recorded than recommended could be attributed to increased sand mining activities in Gbalegbe River and effluents from various industries (Ewutanure and Olaifa, 2018). Water temperature of the study area ranged from 24.81 ^{o}C – 28.45 ^{o}C. This report agreed with the recommended Temperature ranges for tropical water fisheries by Boyd, (1979). The report compared favourably with earlier report on Gbalegbe River by Ewutanure and Olaifa, (2018). These values also agreed with the results from other rivers and creeks in the Niger Delta region Kwen et al. (2012). For instance, Seiyaboh et al. (2013), reported temperature range from 26.60 ^{o}C – 32.0 ^{o}C in Igbedi Creek; Seiyaboh et al. (2016) recorded a temperature range of 24.0 ^{o}C – 28.0 ^{o}C in Epie Creek Stream Bayelsa state. The range of dissolved oxygen recorded in this study is in agreement with levels earlier reported by Ewutanure and Olaifa (2018). These values are within the recommended range for warm water fish production by Boyd, (1979) and (Ovie et al., 2015).

Ogamba et al. (2015) reported DO concentration of 3.6 to 7.79 mg/L in the Nun River, Seiyaboh et al. (2017) recorded a range of 4.4 to 7.9mg/L in the Sagbama Creek, Niger Delta. Adeleke and Babalola (2014) observed the range of 1.18 – 2.95 mg/L, Idodo-Umeh (2003) recorded range of 6.73 – 34.0 mg/L in River Areba at Olomoro, Isoko South, Delta state and associated it with high dissolved oxygen caused by natural environmental conditions. The pH concentration observed in this study were within the established pH range of 6.5 – 8.0 (Boyd, 1979) and 6.6 – 9.0 (FEPA, 1991). Variation in pH levels recorded were in consonance with the work of Ewutanure and Olaifa, (2018) on Gbalegbe River, Delta State; Ekeh and Sikoki (2003) in New Calabar River and Kwen et al. (2012) in the Upper Nun River of the Niger Delta Region of Nigeria.

The main taxonomic groups of zoopalnkton recorded during this study were Cyclopoida, Calanoida, Anomopoida, Cladocera, Ploimida, Phasmida and Harpacticoida. Copepods (Diaptomus augustaensis) recorded the most abundant species throughout the duration of the study. This observation agreed with the report of Kwen et al. (2019) in River Nun; Ovie et al. (2015) in the Kontogora Reservoir. The highest population of zooplankton recorded during this study occurred in Station 1, which could be attributed to reduced effluent discharge as a result of minimal anthropogenic activities. According to Ekwu and Udo, (2013); Ovie et al., (2015), Copepods exhibit good thriving ability and flourish in relatively undisturbed water condition. Zooplankton are useful indicators of the state of the productivity of a water body and the abundance of its fish stock. Zooplankton biomass, abundance and species diversity are useful in the determination of the conditions of the aquatic environment. It has been reported that, copepods dominate the zooplankton community in most aquatic ecosystems (Ekwu and Udo, 2013).

The compositions and distribution of zooplankton varies with respect to places and seasons as a result of the dynamic of natural phenomenon in the aquatic ecosystem (Ewutanure and Olaifa, 2018). The differences in the characteristics of zooplankton species are sometimes vital to scientists in distinguishing one water mass from another (Popoola and Otalekor, 2011). The productivity and stability of any aquatic ecosystems with respect to fish production is a function of the quality and quantity of planktonic organisms present in it. Margalef indices > 3 indicate clean water condition, < 1 indicates heavy pollution while values ranging from 1 – 3 indicate moderately polluted conditions of the aquatic environment (Popoola and Otalekor, 2011). The highest Margalef index recorded was at Station 1 (4.37), while the least was at Station 5 (2.60).

With exception of Station 1, Margalef index indicated that the river was moderately polluted due to the nature of the various petroleum, glass, rubber and sand mining industries in conjunction with agricultural and other anthropogenic activities within and around it. Diversity index of similarity obtained from this study showed that zooplankton species among stations and between seasons exhibited similar variation throughout the duration of the period of study. Higher diversity index recorded at Station 1 than other stations could be as a result of favourable water quality levels that gave rise to their survival and growth (Offem et al., 2014). Conducive water quality parameters determine the spatial and seasonal distribution of zooplankton compositions and abundance in any aquatic water environment (Seiyaboh et al., 2017).

4. CONCLUSION AND RECOMMENDATION

Higher levels of TSS and Turbidity recorded could be due to increased anthropogenic effluents in Gbalegbe River, while the values of Temperature, DO and pH recorded are within the acceptable levels. The high diversity of zooplankton recorded in Gbalegbe River may be due to a rise in nutrient concentration in the river as a result of increased agricultural activities ongoing in the area. The relatively stable DO concentration also favoured the growth of zooplankton. However, a more detailed, consistent, comprehensive and yearly study is recommended to be carried out on Gbalege River so as to ascertain the extent of its zooplankton species abundance, distribution and diversity. Such study would provide essential benefits for better understanding of Gbalegbe River ecosystem structure, function and management.

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