BENTHIC MACRO – INVERTEBRATES COMMUNITY OF GBALEGBE RIVER, DELTA STATE, NIGERIA

Supported by tetfund

[1]Ewutanure*, Somorhire Jacob and [2]Olaifa, Flora Eyibio

1. Department of Fisheries and Aquaculture Management, Faculty of Environmental Management, Nigeria Maritime University Okerenkoko, Delta State, Nigeria. E-mail: ewutanure@gmail.com; GSM: +2348101634482.
2. Department of Aquaculture and Fisheries Management, Faculty of Renewable Natural Resources, University of Ibadan, Ibadan, Nigeria. E-mail: floraolaifa@yahoo.com; GSM: +2348035509342.

*Corresponding author: E-mail: ewutanure@gmail.com

Received: February 11, 2023 Accepted: April 15, 2023

Abstract

Benthic macro – invertebrates (BMI) are good indicators of surface water qualitybutaquatic pollution in recent times threatens their existence.Information on anthropogenic effluents, BMI abundance and diversity in Gbalegbe River is limited, hence this study.Gbalegbe River (12.5 Km) was spatially divided into eight stations (S1, S2, S3, S4, S5, S6, S7 and S8) comprising three sampling units per station based on dominant anthropogenic activities.Water and BMI samples were collected from each station monthly for 24 months following standard methods. Water samples were analysed for Dissolved Oxygen (DO, mg/L) and Temperature (^{o}C) using standard procedures. The BMI samples collected were identified to species level and counted.Species abundance and diversity (Simpson and Shannon) indiceswere calculated. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.The highest (4.97±0.36) and least (3.12±0.17) DO levels were obtained in S1 and S2, while water temperature ranged from 25.68±3.34^{o}C to 27.91±0.03^{o}C in S 3 and S 2. Dry and wet seasons recorded 5.79±0.43 and 3.57±0.59 as highest and least DO, while water temperature ranged from 27.85^{o}C ±0.94 to27.99^{o}C ±5.06 in dry and wet seasons. A total of 1186 individual BMI belonging to 6 Orders, 15 Families and 16 Species were recorded. Stations 1 and 2 recorded the highest 236 (19.9 %) and least 64 (5.4 %) abundance of BMI. Wet and dry seasons recorded *Ephemerella doris* 55 (8.0 %) and *Tricorythodes albilineatus* 10 (2.0 %) as highest and least abundant BMI. Highest (0.99) and least (0.86) values of Simpson and Shannon (2.05, 2.98) occurred in S 2 and S1. Seasonally, Simpson (0.95, 0.92) and Shannon (2.74, 2.69) were higher in wet season than in dry season. Due to the relatively low levels of DO and Shannon diversity index obtained, BMI abundance of Gbalegbe River could be negatively affected.

Keywords: Surface water, Species diversity, anthropogenic effluents, Aquatic pollution.

Introduction

Gbalegbe River is the main river flowing through Ughelli Town, Delta State. The river serves as a means of transportation, fishing, water for agricultural activities and domestic purposes (Ewutanure and Olaifa, 2017). According to Ewutanure and Olaifa, (2018), Ughelli Town was initially known for farming activities but has been highly urbanized leading to the location Power Holding Company of Nigeria (PHCN) Nigeria Limited, oil (SHELL, Nigeria National Petroleum Company) and construction (Setraco Nigeria Limited, Julius BergerNigeria Limited), Glass (Beta glass Nigeria Limited), Rubber, Battery repairer, Sand mining and Cassava companies. In 1958, petroleum resources were detected within the town, but oil mining started in 1965. Since then, crude oil from the Ughelli fields has been transported through the 225Km Trans – Niger Pipeline South – Eastward to the Port of Bonny for export (Ochuko*et al*., 2008).

The location was chosen because it is the major area where PHCN, Petroleum, Glass, Rubber production, Gas flaring, Sand mining activities and Cassava were taking place in Delta State(Ewutanure and Olaifa, 2017). Anthropogenic effluents from these companiesare directly or indirectly discharged untreated through drainages into Gbalegbe River thereby polluting the breeding ground of both benthic macroinvertebrates and fishes(Ewutanure and Olaifa, 2018a). The cumulative effects of untreated effluents in the aquatic ecosystem have the potential of altering its physical, chemical and biological qualities(Salman *et al*. 2011).

Benthic macroinvertebrates are good indicators of surface water quality because they are affected by the physical, chemical and biological constituents of water bodies(Popoola and Otalekor, 2011). They show the impacts of acute, chronic and accumulative toxic effects of polluted environment (Bouldot, 2014). Rivers are vital aspects of the hydrosphere that provide habitats for diverse flora and fauna species (Salman *et al*. 2011). But, in recent times, they are being subjected to numerous anthropogenic activities capable of altering and modifying the aquatic ecosystem leading to a deviation from the natural ecological composition all over the globe (Ewutanure*et al.* 2022a).

Anthropogenic activities could bring about species and habitat loss, habitat fragmentation and a shift in community structure (Ewutanure and Binyotubo, 2021). Due to the relevance of the aquatic ecosystem to human survival, the significance of its biodiversity and the awareness that the aquatic ecosystem serve as the primary sink for pollutants of anthropogenic and natural origin becomes of major concern (Xiaodong*et al.* 2010).

Benthic macroinvertebratesinhabit the sediments of all aquatic ecosystem such as rivers, ponds, swamps, estuary, lakes, streams and oceans(Popoola and Otalekor, 2011; Lennie and Dean, 2013). The common groups of benthic macroinvertebrates are worms (polychaetes and oligochaetes), molluscs (bivalves), gastropods and crustaceans (amphipods and decapods) (Echols *et al.* 2010).

Based on the position that benthic macroinvertebrates occupy in the benthic ecosystem, they can be differentiated into: Infauna benthic macroinvertebrates that live in sediments by burrowing, almost all worms and bivalves belong to this category, and EpifaunaWhich are benthic macroinvertebrates that live on the surface of bottom sediments. Many crabs and gastropods are known to be epifauna (Shama and Rawat, 2009).

Some groups of the epifauna attached themselves to hard surfaces of the banks or pilings within water bodies (Xiaodong*et al.* 2010). Benthic macroinvertebrates play essential role in energy transfer through the ecosystems by filtering plankton and also acting as a food source to fish thereby linking primary production with higher trophic levels (Fengquing*et al.* 2012).

Bouldot (2014) reported that benthic organisms range from bacteria to plants (phytobenthos) and animals (zoobenthos) and are found within the different levels of the food web. However, with respect to sizes, benthic invertebrates can be classified into: Microbenthos, <0.063 mm; Meiobenthos, 0.063–1.0 mm; Macrobenthos>1.0 mm and Megabenthos> 10.0 mm.

Benthic macroinvertebrates degrade organic matter before bacteria remineralization, rework and oxygenate the bottom sediments through their activities (Friberg*et al.* 2010). They serve as biological indicators because they are capable ofgiving information on the health integrity of the aquatic ecosystem through the sensitivity of indicator species or through some features which might trigger environmental stress over a period of time (Amore *et al.* 2009).

The survival of benthic macroinvertebrates could be threatened when exposed to chemical contaminants in sedimentand hypoxia or anoxia situations as a result of organic materials break down, limited mobility that restricts their escape capability, taxonomic and functional diversity that make them suitable for detecting different types and levels of pollutants (Arimoro and Ikomi, 2008).

Previous studies on the use of benthic macroinvertebrates'community in assessing the health status and water quality of rivers in the tropics were limited elaborate (Oku *et al.* 2014; Popoola and Otalekor, 2011; Arimoro and Ikomi, 2008; Deliz – Quinones, 2005). Hence, this study aims at evaluating the benthic macroinvertebrate community of Gbalegbe River, Delta State, Nigeria.

Materials and methods

Location of Study Area

Gbalegbe River with total length of 12.5 Km is located within latitudes 05°10'N and 05°17'N of the Equator and Longitudes 005°56'E and 005°13'E of the Greenwich meridian. It has its source from the Asaba–Ase River, Delta State (Ewutanure and Olaifa, 2018a).

Climate and vegetation of the study area

The wet (March – October) and dry (November – February) seasons (Ewutanure and Olaifa, 2017) are the two climatic seasons prevalent in the study area. The wet season is characterized by heavy rainfall, while occasional downpour is experienced during the dry season (Ewutanure and Olaifa, 2017). The study area has a mean yearly rainfall of 2700mm, while the rainfall peaks in June/July and September with a mean annual temperature of 27 °C (Ewutanure and Olaifa, 2021a). According to Ewutanure and Olaifa, (2021b) the vegetation of the study area is rain forest with adjoining low-lying land that is permanently waterlogged.

Sampling Stations

Gbalegbe River was spatially stratified into eight stations (S1 – low human activities; S2 – glass production factory; S3 – power plant; S4 – rubber processing mill; S5 – Oil farm tanks; S6 – Battery repairer shops; S7 – Cassava processing mill and S8 – Sand mining) in relation to closeness to major anthropogenic activities (Ewutanure and Olaifa, 2018a). In each station, three sampling points were randomly selected. Temporal stratification covered wet (March – October) and dry (November – February) (Ochuko*et al*. 2008) seasons. Sampling was done monthly for 24 months.

Collection of water samples

Water samples from the surface (0 – 15cm) were collected using polyethylene bottles after sterilization with nitric acid and rising with the water from the sampling stations 3 – 4 times (AOAC, 1990; ASTM, 2006). Surface water samples were collected by lowering the polyethylene bottle just below the surface, opening and closing it by hands before taking it out (Ewutanure and Olaifa, 2018a).

Sampling Techniques

Determination of Physico-chemical parameters of water

Water Temperature was measured using mercury in glass thermometer, pH with digital pH meter (Hanna model: HI – 98107, USA) and dissolved oxygen was determined by Winkler's method (Gupta, 2001). Samples for biochemical oxygen demand (BOD_5) was determined as described by Boyd, (1979).Turbidity was measured by using a turbidometer in accordance with USEPA, (AOAC, 1990) standards.

Collection, preservation and identification of benthic macro – invertebrates

A modified van Veen bottom grab (van Veen, 1933) sampler was used for sediment collection for the identification of benthic macroinvertebrates.Since most of the benthic macroinvertebrates inhabit the top 5 – 10 cm below the river bed, the van Veen bottom grab option was considered suitable because it can dig up to 5 – 10 cm in depth on river beds (Eleftheriou and Holme, 1984).

Collected sediments were emptied into a stainless-steel bucket containing water (Popoola and Otalekor, 2011). Thereafter, the sediments were filtered thoroughly through a sieve of mesh size of 0.5 mm and the organisms with the debris stored in a wide-mouthed container and preserved in 10% formalin solution. In the laboratory, collected benthic macroinvertebrates were sorted from the debris and identified with the aid of a compound microscope (X 100), using relevant taxonomic keys and pictures (Macan, 1999; Heckman, 2002; Lynne, 2004) to species level.

Statistical analysis

Data obtained 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 to evaluate if their differences were significant at $\alpha_{0.05}$, while Shannon–Wiener (Pielou, 1969), Simpson (Simpson, 1949), Richness, Evenness and Margalef (Margalef, 1969) indices were calculated by using Paeleontological Statistics (Past), version 3.16.

Results and Discussion

Physico – chemical parameters recorded among stations and between seasons are presented in Tables 1 and 2. Compared with Station 1, significant differences (P> 0.05) were visible.Spatially, DO concentration was highest in Stations 1 and least inStation 2. Levels of Temperature, BOD and Turbidity were highest in Station 2, while their leastconcentrations were recorded in Stations 3 and 1, respectively.

Concentration of dissolved oxygen obtained throughout this study ranged from 3.12 – 5.79 mg/L. These values were within the recommended ranges for warm water fish (Boyd, 1979). This report agrees with earlier reports on Okerenkoko Estuary (Ewutanure and Olaifa, 2021a); Gbalegbe River Delta State, Nigeria (Ewutanure and Olaifa, 2017); Sagbama Creek, Niger Delta (Seiyabohet *al.* 2017);Nun River (Ogambaet *al*. 2015); River Areba at Olomoro, Delta State (Idodo – Umeh, 2003). The slight fluctuation in the level of DO observe could be associated with the untreated anthropogenic effluents from PHCN, Oil (SHELL, Nigeria National Petroleum Company), construction (Setraco Nigeria Limited, Julius Berger Nigeria Limited), Glass (Beta glass Nigeria Limited), Rubber, Battery repairer, Sand mining and Cassava companies(Ewutanure and Olaifa, 2018a).

Mean water temperature recorded during the sampling period ranged from 25.77ºC to 27.91ºC. This is in consonance with the temperature range (25 – 30 ºC) for tropical water fisheries (Boyd, 1979; FEPA, 1991). The report also corroborates the observations from Okerenkoko Estuary (Ewutanure*et al.* 2022b); Gbalegbe River (Ewutanure and Olaifa, 2018a); rivers and creeks in the Niger Delta region (Kwen*et al*. 2012); Igbedi Creek (Seiyaboh*et al*. 2013) and Epie Creek in Bayelsa State (Seiyaboh*et al*. 2016).

Concentrations of BOD recorded during the study were within the recommended range of 5.0 mg/L of BOD (Boyd, 1979; FEPA, 1991), but significant differences were observed among stations. Elevation in BOD could be associated with increased anthropogenic activities in Gbalegbe River (Ram *et al.* 2011; Ewutanure*et al.* 2022b). An increased level of BOD could cause a decrease in the concentration of DO (Ewutanure and Olaifa, 2021b). A sustained and prolonged elevation in the value of BOD could lead to an anoxic condition in an aquatic ecosystem (Ewutanure and Olaifa, 2021c).

The levels of pH recorded during this study were within the established pH range of 6.6 – 9.0 (FEPA, 1991) and 6.5 – 8.0 (Boyd, 1979). Variation in pH levels recorded was in agreement with report on Gbalegbe River, Delta State (Ewutanure and Olaifa, 2018b); New Calabar River Ekeh and Upper Nun River of the Niger Delta Region of Nigeria (Kwen *et al*. 2012).

Wet season recorded higher concentration of turbidity than in dry season. Higher turbidity values than10 FTU as recommended by Boyd, (1979) and FEPA, (1991) could be attributed to the increased presence of suspended solids, organic and inorganic compounds present in the River (Ewutanure and Olaifa, 2021d). Seasonally, increased concentrations of Temperature, BOD and Turbidity recorded in the wet season than in the Dry Season could be attributed to increased rate of sand mining activities and heavy rainfall (Ogaga*et al*. 2015; Ayandirana*et al*. 2018).

The compositions, distribution and abundance of benthic macroinvertebrate species among stations and between seasons are presented in Tables 3 and 4, respectively. A total of individual numbers of 1186 benthic macroinvertebrates belonging to 6 orders, 15 families and 16 species were recorded throughout the study period. Spatially, Station 1 recorded the highest abundance of benthic macro – invertebrates 236 (19.9 %). Stations 8 and 7 ranked next with the abundance of benthic macro – invertebrates sampled as 206 (17.4 %) and 203 (17.1 %), while the least 64 (5.4 %) occurred in Station 2. Highest 409 (34.5 %) and least 53 (4.5 %) abundant benthic macro – invertebrates recorded among stations were *Ephemeroptera* and *Coleoptera*.

Seasonally, highest 689 (58.1 %) and least 497 (41.9 %) individual number of benthic macro – invertebrateswere recorded in wet and dry seasons, respectively. Ephemeroptera 245 (35.6 %); 169, (34.0 %) occurred as highest orders in wet and dry seasons, while the least orders were Coleoptera 33 (4.8 %) and Tricoptera 20 (4.0 %), respectively. Tricorythidae 75 (10.9 %) and Libelluidae 20 (2.9 %) occurred as most and least abundant families of macro – benthic invertebrates in the wet season, but Corixidae and Ephemerellidae 45 (9.15 %) occurred as most abundant families, while the family Culicidae 10 (2.0 %) was recorded as the least abundant.

Wet season recorded *Ephemerelladoris* 55 (8.0 %) as most abundant macro – benthic invertebrates, *Hesperocorixacastanea* 54 (7.8 %) ranked next, while the least abundant was *Pantataflarescens* 20 (2.9 %). The most 44 (8.9 %) and least 10 (2.0 %) abundance benthic macro – invertebrates recorded in the dry season were *Tricorythodesalbilineatus* and *Aedesaegypti*. Conducive water quality parameters determine the spatial and seasonal distribution of benthic macro – invertebrates' compositions and abundance in any aquatic water environment (Davies and Ekperusi, 2021; Seiyaboh*et al*. 2017).

Table 1. Mean Physico – chemical parameters of water from Gbalegbe River

	Stations							
Parameters	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8
DO (mg/L)	4.97±0.36[a]	3.12±0.17[b]	3.75±0.71[a]	3.89±0.15[a]	3.41±0.35[a]	3.98±0.24[a]	3.44±0.70[a]	3.81±0.39[a]
Temp(ºC)	27.02±1.25[b]	27.91±0.03[a]	25.68±3.34[c]	26.40±0.98[b]	26.95±0.15[b]	27.23±0.00[b]	27.37±0.24[b]	25.77±0.15[c]
BOD (mg/L)	0.48±0.19[b]	1.46±0.13[a]	1.06±0.16[a]	1.14±0.01[a]	1.29±0.09[a]	1.03±0.19[a]	0.87±0.14[c]	1.40±0.11[a]
pH	7.17±0.41[a]	6.25±0.79[a]	7.67±0.16[a]	7.30±0.32[a]	7.79±0.37[a]	7.50±0.14[a]	7.58±0.10[a]	7.11±1.05[a]
Turbidity (FTU)	7.81±1.87[c]	45.49±10.21[a]	32.13±7.54[c]	37.15±8.09[b]	36.01±4.54[b]	25.19±3.54[c]	40.02±7.42[b]	35.54±9.79[b]

Note: S 1 – S 8 = Station 1 to Station 8. DO = Dissolved oxygen, Temp = Temperature, BOD = Biological oxygen demand

Table 2. Mean Physico – chemical parameters of Gbalegbe River monitored in wet and dry seasons

Parameters	Seasons		Boyd, (1979)	FEPA, (1991)
	Wet	Dry		
DO (mg/L)	3.57±0.59[b]	5.79±0.43[a]	5 –10	> 5
Temp. (°C)	27.99±5.06[a]	27.85±0.94[a]	25 – 32	20 – 33
BOD (mg/L)	1.98±0.32[a]	1.56±0.07[a]	5.0	5.0
pH	7.61±0.16[a]	7.98±1.35[a]	6.5 – 8	6.5 – 9
Turbidity (FTU)	35.35±0.91[b]	31.17±2.34[a]	10.0	10.0

Note: DO = Dissolved oxygen, Temp. = Temperature, BOD = Biological oxygen demand

Table 3. Compositions, distribution and abundance of benthic macro – invertebrates of Gbalegbe River among stations

Orders	Families	Genus and Species	Numbers of benthic macro – invertebrates collected per station								Total	% Abundance
			1	2	3	4	5	6	7	8		
Hemiptera	Corixidae	*Hesperocorixacastanea*	0	7	21	11	1	1	1	57	99	8.3
Hemiptera	Gerridae	*Gerrisremiges*	0	8	1	4	23	2	2	21	61	5.1
Hemiptera	Cicadellidae	*Lonaturamegalopa*	0	8	3	12	34	8	3	18	86	7.3
		Sub-total	**0**	**23**	**25**	**27**	**58**	**11**	**6**	**96**	**246**	**20.7**
Ephemeroptera	Epemerellidae	*Ephemerelladoris*	30	0	2	9	2	11	23	23	100	8.4
Ephemeroptera	Ephemeridae	*Hexagenialimbata*	11	0	2	3	1	9	7	19	52	4.4
Ephemeroptera	Heptageniidae	*Stenonemaexiguum*	14	0	1	2	9	7	5	4	42	3.5
Ephemeroptera	Isonychiidae	*Isonychiaarida*	19	0	1	2	1	3	10	7	43	3.6
Ephemeroptera	Polymitarcyidae	*Tortopusincertus*	15	0	1	14	1	4	13	5	53	4.5
Ephemeroptera	Tricorythidae	*Tricorythodesalbilineatus*	19	0	3	2	3	4	76	12	119	10.0
		Sub-total	**108**	**0**	**10**	**32**	**17**	**38**	**134**	**70**	**409**	**34.5**
Trichoptera	Hydropsychidae	*Hydropsychids*sp.	10	0	2	8	12	3	9	1	45	3.8
		Sub-total	**10**	**0**	**2**	**8**	**12**	**3**	**9**	**1**	**45**	**3.8**
Odonata	Aeshnidae	*Helocorduliaselysii*	0	9	13	7	16	2	3	4	54	4.6
Odonata	Libelluidae	*Pantataflarescens*	0	5	16	11	12	3	9	7	63	5.3
Odonata	Aeshnidae	*Ashnainterrupta*	0	4	7	6	9	5	1	8	40	3.4
		Sub-total	**0**	**18**	**36**	**24**	**37**	**10**	**13**	**19**	**157**	**13.2**
Diptera	Culicidae	*Aedesaegypti*	7	1	4	3	6	5	8	3	37	3.1
Diptera	Culicidae	*Culexpipiens*	3	5	2	2	3	7	12	4	38	3.2
		Sub-total	**10**	**6**	**6**	**5**	**9**	**12**	**20**	**7**	**75**	**6.3**
Coleoptera	Gyrinidae	*Gyrinus narrator*	1	7	2	20	13	3	2	5	53	4.5
		Sub-total	**1**	**7**	**2**	**20**	**13**	**3**	**2**	**5**	**53**	**4.5**
	Others	Fish larvae	54	0	3	4	7	2	8	5	83	7.0
		Fish eggs	21	2	5	2	0	0	4	2	36	3.0
		Worms	32	8	7	13	9	5	7	1	82	6.9
		Sub-total	**107**	**10**	**15**	**19**	**16**	**7**	**19**	**8**	**201**	**16.9**
		Total	236	64	96	135	162	84	203	206		
		%Abundance	**19.9**	**5.4**	**8.1**	**11.4**	**13.7**	**7.1**	**17.1**	**17.4**		

Table 4. Compositions, distribution and abundance of benthic macro – invertebrates of Gbalegbe River wet and dry seasons

Order	Families	Genus/species	Wet season total	% Wet season	Dry season total	% Dry season
Hemiptera	Corixidae	*Hesperocorixa castanea*	54	7.8	45	9.1
Hemiptera	Gerridae	*Gerris remigis*	28	4.1	33	6.6
Hemiptera	Cicadellidae	*Lonatura megalopa*	47	6.8	40	8.0
		Sub-total	**129**	**18.7**	**118**	**23.7**
Ephemeroptera	Epemerellidae	*Ephemerella doris*	55	8.0	45	9.1
Ephemeroptera	Ephemeridae	*Hexagenia limbata*	37	5.4	22	4.4
Ephemeroptera	Heptageniidae	*Stenonema exiguum*	28	4.1	14	2.8
Ephemeroptera	Isonychiidae	*Isonychia arida*	25	3.6	26	5.2
Ephemeroptera	Polymitarcyidae	*Tortopus incertus*	25	3.6	18	3.6
Ephemeroptera	Tricorythidae	*Tricorythodes albilineatus*	75	10.9	44	8.9
		Sub-total	**245**	**35.6**	**169**	**34.0**
Trichoptera	Hydropsychidae	*Hydropsychids* sp.	39	5.7	20	4.0
		Sub-total	**39**	**5.7**	**20**	**4.0**
Odonata	Aeshnidae	*Helocordulia selysii*	31	4.5	23	4.6
Odonata	Libelluidae	*Pantata flarescens*	20	2.9	43	8.7
Odonata	Aeshnidae	*Ashna interrupta*	24	3.5	16	3.2
		Sub-total	**75**	**10.9**	**82**	**16.5**
Diptera	Culicidae	*Aedes aegypti*	27	3.9	10	2.0
Diptera	Culicidae	*Culex pipiens*	26	3.8	12	2.4
		Sub-total	**53**	**7.7**	**22**	**4.4**
Coleoptera	Gyrinidae	*Gyrinus narrator*	33	4.8	20	4.0
		Sub-total	**33**	**4.8**	**20**	**4.0**
	Others	Fish larvae	40	5.8	23	4.6
		Fish eggs	23	3.3	13	2.6
		Worms	52	7.5	30	6.0
		Sub-total	115	16.7	66	13.3
		Total	689		497	
		% Abundance	**58.1**		**41.9**	

Tables 5 and 6 show the spatial and seasonal benthic macroinvertebrate diversity index of Gbalegbe River. Spatial trend of Dominance index for Gbalegbe River ranged from 0.01 (S 1) to 0.14 (S 2); Simpson (0.86, 0.99); Shannon (2.05, 2.98) in S 2 and S 1; Evenness (0.10, 0.75) in S 8 and S 3 and Margalef (2.02, 3.51) in S 2 and S 1.Seasonally, Simpson, Shannon and Evenness were higher in wet season than in dry season, while Dominance and Margalef values were higher in dry season than in wet season, respectively. Benthic macro – invertebrates' species diversity is expressed as the number or combined abundance of the species (Usman *et al.* 2014).

Table 5. Diversity index of benthic macro – invertebrates of Gbalegbe River among stations

Index	Stations							
	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8
Individuals	236	64	96	135	162	84	203	206
Dominance (D)	0.01	0.14	0.06	0.07	0.08	0.07	0.05	0.03
Simpson (1 – D)	0.99	0.86	0.94	0.93	0.92	0.93	0.95	0.97
Shannon (H)	2.98	2.05	2.10	2.74	2.33	2.49	2.52	2.70
Evenness (E)	0.42	0.54	0.75	0.54	0.41	0.51	0.48	0.10
Margalef	3.51	2.02	2.53	2.42	2.25	2.22	2.53	2.12

Table 6. Diversity index of benthic macro – invertebrates of Gbalegbe River between seasons

	Wet Season	Dry Season
Individuals	689	497
Dominance (D)	0.05	0.08
Simpson (1 – D)	0.95	0.92
Shannon (H)	2.74	2.69
Evenness (E)	0.42	0.54
Margalef	2.11	3.09

Maximum value of Dominance obtained in S 2 depicted complete dominance of few species (Chessman, 2009). In biological communities, Shannon – Wiener indices ranged from 0 to 5 (Shannon – Wiener, 1949). With regards these indices, values less than 1 represent heavily polluted state, values ranging from 1 to 2 are equivalent to areas of moderate pollution, while values greater than 3 depicts stable and healthy environmental state (Durance and Ormerod, 2009).

It has been reported that, Simpson index ranges from 0 to 1 (Ewutanure and Binyotubo, 2021). It has been established that in relatively undisturbed aquatic ecosystem, diversity index rangesfrom 0.6 to 0.9, while surface water impacted by anthropogenic effluents shows very low diversity which could be near zero value (Boudot, 2014). It has been reported that Simpson diversity index is always higher where the community is dominated by less number of species and when the dominance is shared by large number of species (Popoola and Otalekor, 2011). Whenever Simpson diversity index increases towards higher values, the evenness index goes in a reversed order and vice versa (Xiaodong*et al.* 2010). Hence, it is believed that Simpson and Evenness possess an inverse relationship (Lennie and Dean, 2013; Suleman*et al.* 2015).

The low diversity obtained in S 2, as described by the Shannon and Margalef index, may be due to fewer numbers of species and persistent environmental perturbation due to increased anthropogenic activities (Salman *et al*. 2011). Margalef is highly sensitive towards sample size (Echols *et al.* 2010). Evenness is the inverse of the proportion of individuals in the community that belong to the single most common species (Chessman, 2009). Hence, it is determined by its sensitivity to sample size as Margalef's index (CASQA, 2014). Like Shannon index, this index does not provide any information regarding the rare species in the population (Ewutanure*et al.* 2022b).

It is an established fact that Margalef index has no specified value as a limit but it could show some fluctuation in values depending on the number of species, hence, it could be applied in comparison among stations or study sites (Shama and Rawat, 2009). Margalef index only considers species richness which reflects species sensitivity to sample sizes (Margalef, 1968; Fengquing*et al.* 2012). Margalef has a value greater than 1 unlike the Simpson index whose values range from 0 to 1 and it could compare favourably with species richness of various study area over Simpson index (Ewutanure and Olaifa, 2018a).

Conclusions

Generally, species composition, distribution and abundance for benthic macro – invertebrates of Gbalegbe River showed significant variations among stations and between wet and dry seasons, while the information provided by majority of the diversity indices could be used to determine (i) the habitat qualities of benthic macroinvertebrate communities of a river (ii) aquatic ecosystem component with regard toEvenness and their interactions with benthic macro invertebrate communitiesthat are predominant in an area. Diversity indices could indicate high values for a relatively undisturbed aquatic ecosystem, while degraded ones exhibit low values in such a way that environmental quality could threaten the existence of macroinvertebrate communities in river.

It was observed that as Shannon – Weiner and Simpson index increase, evenness also increases but with varying trends. It is therefore recommended that regular and consistent bio – monitoring of Gbalegbe River should be done to ensure the sustenance and species abundance stability of its benthic macroinvertebrates communities.

References

American Society for Testing and Materials (ASTM), 2006. Standard guide for conducting laboratory toxicity tests with freshwater mussels. E2455-06, Philadelphia.*Annual Book of America Society for Testing and Materials Standards* 11 (6): 1393–1444.

Amore, V., Belardinelli, M., Guerra, L., Buonocore, F., Fausto, A.M., Ubero-Pascal, N., Fochetti, R., 2009. Do all stoneflies nymphs have respiratory proteins? Further data on the presence of hemocyanin in the larval stages of plecoptera species.*Insect Molecular Biology*. 18, 203–211.

Arimoro, F.O. and Ikomi, R. B., 2008.Ecological Integrity of upper Warri River, Niger Delta using Aquatic insects as bioindicators.*Ecological Indicators* 395: 1 – 7.

Association of Official Analytical Chemists (AOAC), (1990).Methods of experimental analyses.*Journal of Official Method of Analyses* 8.1: 551 – 573.

Ayandirana, T.A., Fawole, OO, Dahunsi SO. 2018. Water quality assessment of bitumen polluted Oluwa River, South-Western Nigeria. *WatResour Ind*. 19:13-24. doi: 10.1016/j.wri.2017.12.002

Boudot, J.P. 2014. *Coenagrionornatum.* The IUCN Red List of Threatened Species 2014:

e.T165520A19158182. http://dx.doi.org/10.2305/IUCN. UK.2014-1.RLTS.T165520A19158182.en. Downloaded on 10 November 2017.

Boyd, C.E., 1979. Water quality in warm water fish ponds. 4th ed. Auburn University, Uburn

California Stormwater Quality Association, CASQA., 2014. Stormwater best management practice handbook portal: Industrial and commerical. Retrieved from https://www.casqa.org/sites/default/files/casqa-handbook-industrial/full_ handbook_2014.pdf.

Chessman, B.C., 2009.Climatic changes and 13-year trends in stream macroinvertebrate assemblages in New South Wales. Australia. *Global Change Biologia*. 15, 2791–2802.

Davies, C.I, Ekperusi, A.O., 2021. Evaluation of Heavy Metal Concentrations in Water, Sediment and Fishes of New Calabar River in Southern Nigeria, *LimnoFish*. 7(3): 207-218. doi: 10.17216/ *LimnoFish*816030

Deliz-Quiñones, K.Y. 2005.Water quality assessment of a tropical Freshwater marsh using Aquatic insects.M.Sc. Project Research in the Dept of Biology.University of Puerto Rico.xii+148Pp.

Durance, I., Ormerod, S.J., 2009. Trends in water quality and discharge confound long-term warming effects on river macroinvertebrates. *Freshwater Biology* 54, 388–405.

Echols, B. S., Currie, R. J., & Cherry, D. S., 2010. Preliminary results of laboratory toxicity tests with the mayfly, Isonychiabicolor (Ephemeroptera: Isonychiidae) for development as a standard test organism for evaluating streams in the Appalachian coalfields of Virginia and West Virginia. *Environmental Monitoring and Assessment* 169: 487–500.

Eleftheriou, A. & Holme, N.A., 1984.Macrofauna Techniques. In: N.A. Holme and A.D. McIntyre (eds). Methods for the study of Marine Benthos.Blackwell Scientific Publications.Handbook 16, Second Edition. 140 – 216.

Ewutanure, S.J. &Binyotubo, T.E. 2021.Impacts of Anthropogenic Activities on the Fish Compositions and Diversity of Okerenkoko Estuarine, Delta State, Nigeria.*Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference.University of Ghana/Academic City University College, Accra, Ghana*. December 2021. Pp 9-8 www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021-V2-P2

Ewutanure, S.J. and Olaifa, Flora E. (2017).Length–Weight Relationships and Condition Factor of *Clariasgariepinus*fromGbalegbe River, Delta State, Nigeria.*Proceedingsof the 32nd Annual Conference of FISON* held at NnamdiAzikiwe University, Awka, Anambra State. 23 -28th October, 2017. Pp. 329 – 332.

Ewutanure, S.J. and Olaifa, Flora.E. 2018a.Phytoplankton Species Composition, Distribution, Abundance and Diversity in Gbalegbe River, Delta State, Nigeria.*Proceedings of 6th NSCB Biodiversity Conference*. University of Uyo, 164 – 170.

Ewutanure, S. J. and Olaifa, F. E. 2018b.Heavy metal concentrations in water and sediment of Gbalegbe River, Delta State, Nigeria.*The 2nd SETAC Central/West Africa Regional Conference, Environmental sustainability and pollution control through science.*Book of Abstract, 4 Pp.

Ewutanure, S.J. &Olaifa, F.E., 2021a.Spatial and Temporal Fluctuations of Physico – Chemical Parameters, Nutrients and Primary Productivity of Gbalegbe River, Delta State, Nigeria.*Proceedings of the 28th iSTEAMSIntertertiary Multidisciplinary Conference.* American International University West Africa, The Gambia Series 28, Vol 3 October, 2021. Pp 137-1 www.isteams.net/gambia2021.DOI - https://doi.org/ 10.22624/AIMS/iSTEAMS-2021/V28N3P11 2 Proceedings of the 28th SMART-iSTEA.

Ewutanure, S.J. &Olaife, F.E., 2021b. Temperature, Salinity, Electrical Conductivity, Dissolved Oxygen, Total Suspended Solids and pH Conditions in OkerenkokoEstuarine, Delta State, Nigeria. *Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference.*University of Ghana/Academic City University College, Accra, Ghana. December 2021. Pp 133-140 www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021P10

Ewutanure, S.J. &Olaife, F.E. 2021c: Effects of effluents from Gbalegbe River, Delta State, Nigeria on the Breeding Performance of *Clariasgariepinus* (Burchell, 1822). *Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference.*University of Ghana/Academic City University College, Accra, Ghana. December 2021. Pp 163-178 www.isteams.net/ghanabespoke2021.DOI https://doi.org/ 10.22624/AIMS/ABMIC2021P13.

Ewutanure, S.J. &Olaife, F.E. 2021d.Sediment Characteristics of Gbalegbe River, Delta State, Nigeria.*Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference.*University of Ghana/Academic City University College, Accra, Ghana. December 2021. Pp 105-120 www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021P8

Ewutanure, S.J., Eyo, V.O., Binyotubo, E.T. &Eriegha, O.J. (2022a): Heavy metal and total petroleum hydrocarbon concentrations in water, sediment and fauna of Okerenkoko Estuarine, Delta State, *Nigeria. Journal of Digital Innovations & Contemporary Research in Science, Engineering & Technology.*Vol. 10, No. 2. Pp 1-12

Ewutanure, S.J., Eyo, V.O., Binyotubo, E.T. &Eriegha, O.J. (2022b) Phytoplankton abundance and diversity of Okerekoko Estuarine, Delta State, Nigeria. *Advances in Multidisciplinary and Scientific Research*.Vol. 8. No. 1, Pp 63-74 DOI: dx.doi.org/10.22624/AIMS/V8N1P6. Available online at www.isteams.net/aimsjournal.

Federal Environmental Protection Agency (FEPA), 1991.Guidelines and Standards for Environmental Pollution Control in Nigeria.National Environmental Standards-Parts 2 and 3, Government Press, Lagos. 1 – 238.

Fengqing, Li., Qinghua, C., Wanxiang, J., Xiaodong, Q., 2012. Macroinvertebrate relationships with water temperature and water flow in subtropical monsoon streams of Central China: implications for climate change. *Fundamental of Applied Limnology* 180, 221–231.

Friberg, N., Skriver, J., Larsen, S.E., Pedersen, M.L., Buffagni, A., 2010. Stream macroinvertebrate occurrence along gradients in organic pollution and eutrophication.*Freshwater Biology* 55, 1405–1419.

Gupta, P. K. 2001. Methods in environmental analysis: Water, Soil and Air. AGROBIOS (India) Publisher. 408pp.

Hecman, (2002). Encyclopedia of South American Aquatic Insects: Ephemeroptera. Illustrated keys to known families, genera and species in South America, Viii+419.

Idodo – Umeh, I. 2003. *Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, diet and utilization)*. IdodoUmeh Publishers Limited, No. 52, Ewah Road, P.O.Box 3441, Benin City, Edo State, Nigeria. E-mail: idodoumeh@yahoo.com. 1 – 232.

Kwen, K., Davies, O.A. and Okaeme, A.N. (2012). Temperature, dissolved oxygen, hydrogen ion concentration and transparency conditions in the Upper Nun River, Niger Delta. *Journal of Aquatic Sciences*, 2(2): 135-145.

Lennie, R. and Dean, J. (2013). Temperature increases and respiratory performance of macroinvertebrates with different tolerances to organic pollution, *Limnologica* 43:510 – 515.

Lynne, M.W. 2004.*Practical guide to identifying freshwater crustaceans*.Cooperative freshwater ecology unit.2nd ed. Dept. of biology, Laurentian University, Canada, 1-50.

Macan, T.T. (1999). *A guide to freshwater invertebrate animals*. 2nd ed. Printed in Hong Kong by Wing Tai Cheun Printing Company Limited. 1 – 115.

Margalef, R (1968). Perspectives in Ecological Theory. University of Chicago City, Chicago Press,

Ochuko, A.U., Wi, R. and Akpan, D.G. 2008. Liquid waste management Warri, Nigeria.*Journal of Emerging Trends in Engineering and Applied Sciences* 3.1: 132-153.

Ogaga, A.A., Oyelese, O.A. and Ohimain, E.L. (2015). Heavy metal levels in water and sediment of Warri River, Niger Delta, Nigeria. *International Journal of Geology, Agriculture and Environmental Sciences*3.1: 20- 24.

Ogamba, E.N., Izah, S.C. and Ebiowe, R.G. 2015.Bioconcentration of Hg, Pb and Cd in bones and muscles of *Citharinuscitharus*and *Synodontisclarias*from the Amassoma axis of River Nun, Niger Delta, Nigeria.*Research Journal of Pharmacology and Toxicology*1.1: 21-23.

Oku, E.E., Andem, A.B., Arong, G.A. and Odjadjare, E. (2014). Effect of water quality on the distribution of aquatic entomofauna of Great Kwa River, Southern Nigeria.*American Journal of Engineering Research* 3.4:265 – 270.

Pielou EC (1969). An Introduction to Mathematical Ecology.Wiley and Sons, New York.

Popoola, K.O.K and Otalekor, A. (2011). Analysis of Aquatic Insects' Communities of Awba Reservoir and its Physico-Chemical Properties.*Research Journal of Environmental and Earth Sciences* 3.4: 422-428.

Ram, S., Lokkhande, P. U. and Singare, D.S.P. (2011). Study on physicochemical parameters of wastewater effluents from Taloja Industrial Area of Mumbai, India. *International Journal of Ecosystem* 1.1: 1 – 9.

Salman, A. A., Che, S. M. R., Abu, H. A., Suhaila, A. H. and Siti, A. M. N., (2011). Influence of anthropogenic stresses on the species diversity of macroinvertebrates in Juru River Basin, Penang, Malaysia.*Ecotoxicology and Environmental Safety* 74.5: 1195 – 1202.

Seiyabo, E. I., Izah, S. C. and Oweibi, S., (2017). Physico-chemical characteristics of sediment from Sagbama Creek, Nigeria.*Biotechnological Research*, Vol. 3 (1): 25-28.

Seiyaboh, E. I., Inyang, I. R., and Izah, S. C., (2016). Spatial variation in physic-chemical characteristics of sediment from Epie Creek, Bayelsa State, Nigeria.*Greener Journal of Environment Management and Public Safety*, 5 (4): 45-49.

Seiyaboh, E. I., Ogamba, E. N. and Utibe, D. I., (2013). Impact of dredging on the water quality of Igbedi Creek, Upper Nun River, Niger Delta, Nigeria.*IOSR Journal of Environmental Science, Toxicology and Food Technology,* 7 (5): 51-56.

Shama, R. C. and Rawat, J. S. 2009.Monitoring of aquatic macroinvertebrates as bioindicator for assessing the health of wetland: A case study in the Central Himalayas, India.*Ecological Indicator*, 9: 118 – 128.

Shannon, C. E and Wiener, W. 1949.*The Mathematical theory of communication*. 3rded. University of llinoio press, Urbana. 1 – 117.

Simpson EH (1949).Measurement of diversity.*Nature,* 163:688.

Suleman, W., John, D. and Atu, E.Y., 2015. The influence of sawmill wastes on phytoplankton population of Ologbo River, Nigeria. *Nigeria Journal of Botany* 23: 18 -29.

Usman, A., Solomon, S. G. and Okayi, R. G., 2014.Diversity indices of zooplankton in Lake Alau, North – East Arid Zone, Nigeria. *Nigeria Journal of Fisheries* 11 (1&2): 704-709.

vanVeen, J. (1933). Onderzoek near hetz and transport von rivierren. *De Ingenieur* 48: 151 – 159.

Xiaodong, Q., Naicheng, W., Tao, T., Qinghua, C. and Young-Seuk, P. (2010). Effects of heavy metals on benthic macroinvertebrate communities in high mountain streams. *International Journal of Limnology* 46: 291–302.