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PRELIMINARY STUDY ON THE DIVERSITY OF PLANKTON FLORA AND WATER QUALITY OF A TROPICAL MANGROVE ESTUARINE SYSTEM, AKWA IBOM STATE, NIGER DELTA AREA, NIGERIA

Udeme Effiong Jonah[1] and Samuel Edet Etteokon[2]

[1]Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]Department of Animal and Environmental Biology, University of Uyo, Akwa Ibom State, Nigeria.

ABSTRACT: *Plankton and water quality of Qua Iboe River Estuary, south-south Nigeria, were studied between November, 2018 and August, 2019. The samples were collected monthly, from five sampling stations across the water body. Standard methods were used in collection and analyses of the water samples. Plankton samples were collected using plankton net. The range values of physico-chemical parameters were: water temperature (26.11-28.43), pH (6.7-8.9), transparency (32.0-99.3cm), electrical conductivity (3472.53-3961.68us/cm), salinity (2.167-4.916ppt), ammonium (10.28-18.96 mg/L), nitrate (4.91-9.15mg/L), sulphate (208.07-363.31mg/L), phosphate (5.13-8.34), alkalinity (48.77-88.44mg/L). Analysis of variance showed significant difference ($p<0.05$) in salinity, ammonium, nitrate, sulphate and phosphate. A total of 3,320 individuals from 44 taxa, belonging to 5 taxonomic groups were identified. Bacillariophyceae was the highest recorded group, constituting 34.8%, Cyanophyceae (28.3%), Chlorophyceae (21.9%), Chrysophyceae and Dinophyceae (7.8%) each. Higher species was recorded in station 1 and 2, while station 5 had the least. Species Anacystis cyanae was the most dominant species, accounted for 3.74% of total population, followed by Goeocapsa minima and Micrasterias foliacea (3.46%) each. The findings revealed that the water body is polluted owing to anthropogenic activities within the estuary.*

KEYWORDS: Diversity, Plankton flora, Water Quality, Pollution, Nigeria

INTRODUCTION

Plankton composition is a useful alternative to evaluate the ecological integrity of aquatic ecosystems for fish growth and productivity. Phytoplankton is the autotrophic components of plankton community that live suspended in the open water, with low capacity to counteract the movement of water current (Jonah *et al.*, 2020a). They are eukaryotic or prokaryotic photosynthetic plankton that contain chlorophyll; exists as single calls, chains and in colonies as well as filamentous forms. They form the basic live feed to a wide range of aquatic creatures including zooplankton, larval forms of crustaceans, mollusks and herbivorous fishes; and they are the base of the food web in deep waters; also capable of producing organic compound and generate oxygen into the water body (Lalli and Parsons,1997). However, phytoplanktons are considered also as hydrobionts whose function as indicators of environmental conditions since they are sensitive to change in water quality (Mitrofanova, 2008; Brettum and Anderson, 2015). Olasehinde and Abeke (2012) and Kutama *et al*. (2014)

reported that the water quality is determined by the available plankton, as it gives more information in relation to its prevailing environment; changes in water quality parameters than the mere nutrient concentrations (Medupin, 2011). Studies affirm that the density and diversity of phytoplankton are biological tools for assessing the environmental status, water quality and the degree of eutrophication (Shekhar *et al*., 2008; Uttah *et al*., 2013). Qua Iboe River Estuary is known for its high productivity and rich biodiversity just like other brackish water body reported by Moses (2000) for Cross River Estuary and Akpan *et al.* (2019) for Uta Ewa Estuary, Nigeria; the estuary serves as fishing ground for several near-shore fishing settlements, it located in the urban area, receiving wastes from municipal runoff, industrial and agricultural activities. The proliferation of urban and commercial establishments along the shores of estuary resulted in addition of allochthonous complex mixtures into the water body which could have a substantial effect on the water quality integrity and the biological characteristics of water body. Therefore, the objective of this paper is to ascertain the environmental status of the Qua Iboe River Estuary, Akwa Ibom State, Nigeria, utilizing the findings of water quality characteristics and checklist of phytoplankton species composition.

MATERIALS AND METHODS

Study area and Sampling stations: Qua Iboe River Estuary is located in Niger Delta area of Akwa Ibom State, Nigeria. It lies within latitude 4^0 45'31 North and longitude 7^0 55'0 East (Figure 1). The river flows from Ikwuamo Local Government Area of Abia State into Akwa Ibom State through Usaka community in Obot Akara Local Government Area and traverse in many communities. The area is characterized by fluctuation of water current and mangrove plants such as *Avicennia*, *Rhizophora* and *Nypa palm*. Human activities observed were fishing in large and small scale, farming, dredging, boat making, laundry, logging of mangrove vegetation and other domestic activities within the watershed. In this study, five sampling stations were selected, which the criteria were based in anthropogenic activities and the ecological settings in each sampling stations. Station 1 was located at the upper estuary; the identified activities were fishing in large and small scale. The station is closed to market and residential area featuring sandy to muddy substrate. Station 2 is located at the middle zone of the estuary 3km away from station 1; characterized by high anthropogenic activities such as off-loading of refine petroleum product, laundry and fishing. The station received wastes from inhabitant of the watershed and other domestic activities. The observed mangrove vegetation was *Nypa fructicans*, *Avicennia* a*fricana* and *Rhizophora*; substrate is muddy and clay. Station 3 also located at the middle zone, 2km away from station 2. It characterized by large anthropogenic activities ranging from boat construction, fishing, sand mining. The station receives waste from the market via surface runoff and direct discharge of household waste. Station 4 was at the lower zone, 2km distance from station 3. The observed activities were lumbering, dredging, boat construction, fishing and laundry. All these contribute to accumulation of organic pollutants in the station. Station 5 is located also at the Lower region of the coastline, 3km distant from station 4; a human activity here is fishing. The identified vegetation was *Nypa frutican*, *Rhizophora*, and *Avicenna Africana.*

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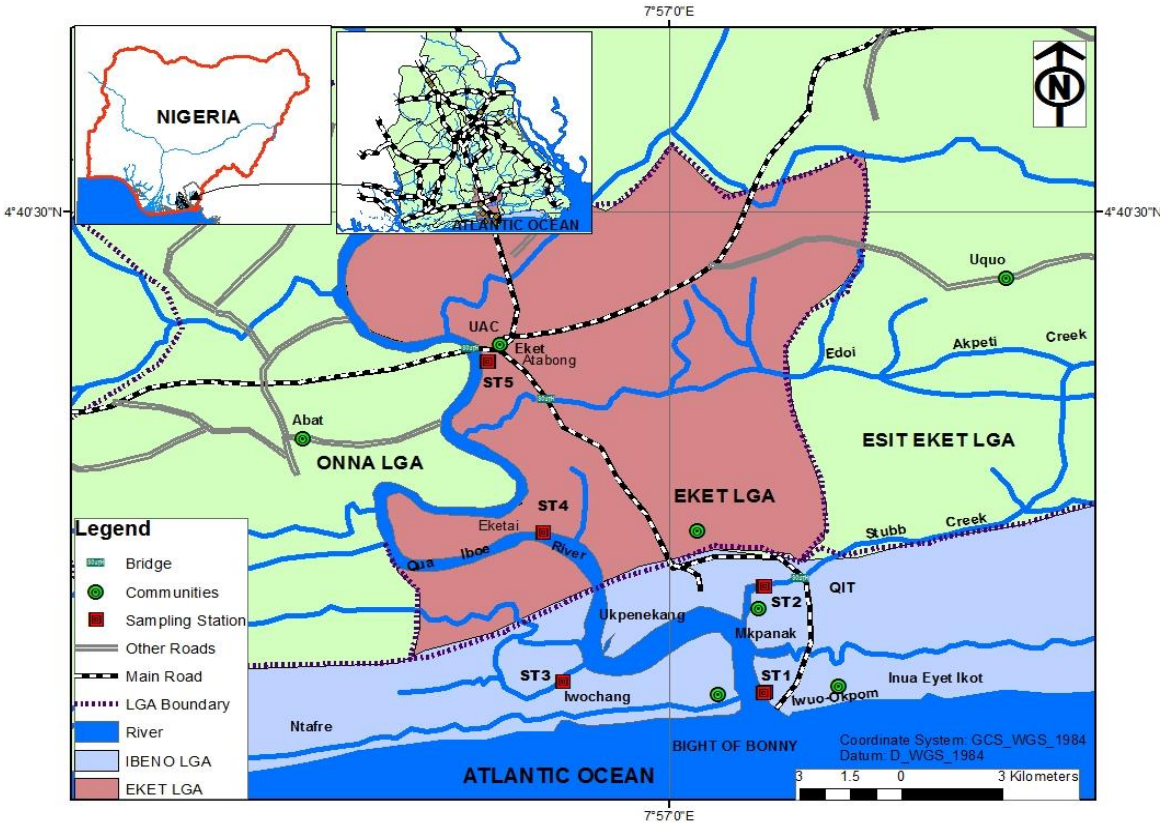

Figure 1: Map of Quo Iboe River Estuary Showing the Sampling Location

Samples Collection and ANALYSIS

***Water samples*:** Water samples for physico-chemical analysis were collected for ten (10) months (November, 2018-August, 2019). The samples were collected using washed and sterilized plastic bottles (1litre). Some parameters (water temperature, transparency, electrical conductivity and salinity) were determined *in situ*; temperature was determined using mercury in glass thermometer; transparency with calibrated Secchi disc, conductivity and salinity were recorded with HACH meter (CO150 model), while ammonium, nitrate, sulphate, phosphate, and alkalinity were analyzed *ex-situ*. Nitrate was determined by cadmium reduction and conventional colorimetric method, phosphate was by Molybdenum blue method, sulphate by turbidemetric method while alkalinity was by titration. All parameters were determined according to standard methods for examination of water and wastewater (AOAC, 2000 and APHA, 2005). The data obtained were summarized with Microsoft excel, while test for significant differences among the sampling station was carried out with One-way analysis of variance (ANOVA) at 0.05 probability level; significant variations were isolated using Least Significant (LSD) test.

***Plankton samples*:** The water samples of about 100L for plankton isolation was fetch by using metal bucket; each sample was then filtered through standard plankton net of 55µm mesh size of 20cm diameter. Also, quantitative samples were collected by trawling horizontally in slow moving vessel for about five (5) minutes on the water column at each sample stations. The concentrated samples at the tip of the net from each sampling station

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was emptied into well- labeled 250ml polyethylene bottles and made to 100ml. The samples were fixed immediately with two drops of 4% formalin solution to preserve the organisms before transported to the laboratory for further analysis. In the laboratory, the quantitative samples were allowed to stand for at least 24 hours for the phytoplankton to settle. Sub-samples of 1 ml were taken with 2ml Hensen-stempel pipette and put on the Sedgewick-Rafter counting chamber and allowed to settle for 5 before view under a light microscope (Nikon 400 binocular microscope) based on the methods and procedure of Lund *et al*. (1958) using a low magnification of x10. Phytoplanktons were sorted into different groups and the cells per ml were counted. Samples were identified using standard keys of Cander-lunder and Lund (1959); Newell and Newell (1966), Opute (1991), Prasad (2000) and Sverdrup *et al*. (2006). The diversity of phytoplankton was determined using ecological indices (Shannon-Weiner index (H), Margalef's index (d), Simpson index (D) and Pielous's evenness index). All calculation was based on the methods employed by Magurran (1988), Job *et al*. (2019), Jonah and George (2019), George *et al*. (2020).

RESULTS

***Physico-chemical parameters*:** The mean values, standard error and range of physico-chemical parameters are shown in Table 1.

Table 1: The range, mean variation and standard error of physico-chemical parameters (November, 2018 –August, 2019)

[Parameters	X± SEM* (STN 1)	X±SEM* (STN 2)	X±SEM* (STN 3)	X±SEM* (STN 4)	X±SEM* (STN 5)	WHO (2011)
Temperature (^oC)	28.43±0.41 (24.9-29.4)	26.22±0.27 (24.0-28.8)	27.28±0.24 (24.6-28.0)	26.11±0.3 (25.0-27.8)	27.37±0.49 (25.0-27.3)	25 ^oC
Hydrogen ion concen.	6.8±0.11 (6.2 – 8.8)	8.9±0.21 (6.3 – 8.3)	7.6 ±0.18 (6.5 – 8.0)	7.3±0.34 (6.2- 8.8)	6.7 ±0.16 (6.3 – 7.9)	6.5 – 9.0
Conductivity (µS/cm)	39611.68 ±529.12 (76.34-39642.2)	3472.53± 512.2 (58.00-48934.3)	3715.74 ±463.4 (67.30-52931.2)	3614.48 ±551.8 (86.42-51637.8)	3548.26 ±641.3 (56.00-49971.3)	1400µs/cm
Transparency (cm)	46.0±0.18 (31.0 – 64.0)	43.00±0.12 (27.0 – 45.0)	32.0±0.03 (33.0 - 50.0)	66.0±0.08 (37.0 – 63.0)	99.3±0.15 54.0 – 114.0	NI
Salinity (ppt)	2.342±0.22[a] (1.800 – 3.200)	4.916±0.11[b] (2.600 – 3.900)	3.321±0.15[b] (2.400 – 3.600)	4.170±0.19[b] (2.300 – 3.900)	2.167±0.30[a] (2.300 – 3.600)	NT
Ammonium (mg/L)	17.44±0.34[a] (13.68 – 29.3)	10.28±0.58[b] (14.0 – 26.0)	11.45±0.32[b] (9.3 – 28.7)	15.64±0.44[a] (11.00 – 18.41)	18.96±0.31[a] (16.34 – 28.00)	0.5mg/l
Nitrate (mg/L)	6.44±0.16[a] (1.99 – 5.54)	7.33±0.19[a] (2.46 – 6.06)	8.16±0.13[a] (2.82 – 6.86)	9.15±0.32[a] (2.20 – 6.33)	4.91±0.12[b] (1.42 – 5.13)	10mg/l
Sulphate (mg/L)	347.48±0.39[a] (160.9 – 311.5)	363.31±0.51[a] (124.8 – 342.1)	233.18 ±0.42[b] (104.4 – 297.7)	253.03±0.56b (193.41-264.2)	208.07±0.65c (182.48 – 276.5)	500mg/l
Phosphate (mg/L)	5.55±0.27[a] 2.12 – 8.36	8.34±0.22[b] 3.10 – 9.24	6.22±0.09[b] 2.96 - 9.01	8.14±0.16[b] 3.64 – 8.12	5.13±0.30[a] 2.86 – 7.38	5.0mg/
Alkalinity (mg/L)	63.03±0.68 53.0 – 100.0	72.13±0.43 58.0 – 128.0	88.44±0.53 58.5 – 93.4	57.38±0.41 40.6 – 119.0	48.77±0.18 44.0 – 99.0	500mg/l

X= mean values; SE= standard error of mean; a, b, c = means with different superscripts across the rows are significantly different at p<0.05

Water temperature had it ranged from 24.01 to 29.43^{0}C. The lowest mean value of 26.11^{0}C was recorded in station 4, while the highest of 28.43^{0}C was observed in station1. All values obtained were within the documented range (24-30^{0}C) acceptable for survival of aquatic organisms set by World Health Organization (2011). Hydrogen–ion concentration (pH) had its mean range between 6.7 and 8.9, with the highest value in station 2 (8.9). Electrical conductivity had its highest mean values ranging from 3472.53 to 3961.68µs/cm; with higher value in station 1(3961.68µs/cm). Transparency had its range between 32.0 and 99.3 cm; with highest mean value in station 5 (99.3 cm). Salinity ranged was between 1.800 and 3.900 ppt); highest mean value of 4.916 ppt was recorded in station 2, while the lowest was in station 5 (2.167 ppt) with significant difference between the sampling stations at $p<0.05$ level. Ammonium values varied across the stations; high mean value was recorded in all the stations, far above the recommended range of 0.5 mg/L set by WHO (2011) (Table 1). Nitrate range values were between 1.42 and 6.86 mg/L; the higher mean value of 9.15 mg/L was recorded in station 4, while lowest mean value was in station 5 (4.91mg/L). Sulphate had it range from 104.4 to 311.3mg/L); the mean values during the study was high in station 2 (363.31mg/L) and the lowest (208.07mg/L) was recorded in station 5. Phosphate values were in the same trend with sulphate; highest mean value was recorded in station 2 (8.34mg/L), while alkalinity had it values from 40.06 to 128.0 mg/L; and the highest mean value of 88.44 mg/L was in station 3.

***Phytoplankton composition*:** Checklist of phytoplankton species and denoted classes are presented in Table 2. A total of 3,320 individuals comprises of 44 species from five (5) taxonomic groups (classes) were identified; *Tabellaria flocculosa* of Bacillariophyceae, *Gloeocapsa minima* of Cyanophyceae and *Micrasterias foliacea* of Chlorophyceae were the most occurring and abundance species. Among the classes, Bacillariophyceae constituted the highest bulk of phytoplankton with 18 species and 1158 individuals representing 34.8% from the total population, followed by Cyanophyceae (11 species and 939 individuals) accounted for 28.3%; Chlorophyceae (9) species, individuals of 727 constituted 21.9%; Chrysophyceae were represented by 3 species (*Asterionella, Crystochrisis ., Dinobryon bavaricum*), 257 individuals; accounted for 7.8% of total population while Dinophyceae made up 7.1 % of total phytoplankton population and represented by 3 species (*Dinophysis rotundata, Gonyaulax, Peridinium cintum*), 239 individuals (Table 3). In term of spatial composition, the highest numerical abundance was recorded in station 1(760) individuals, followed by station 2 (708), station 4 (665), station 3 (639) and the least was obtained in station 5 (548) individuals made up of 3,320 total individuals obtained during the study period. Regard to diversity among the classes, Cyanophyceae was the abundance group in station 1and 4 (282 and 229) individuals; Bacillariophyceae was dominated in station 3 (303) and the least was in station 4 and 5 (190 and 198) while Chlorophyceae were dominated in station 1 and 2 (137 each). Chrysophyceae was the least abundance group in station 5 with 41 individuals' species; Dinophyceae was high in station 1 with 71 individuals and while the least was recorded in station 5 (32) individuals respectively (Table 3). Most species recorded in this study belonging to pollutant tolerant group. Diversity index like Shannon – Weiner had it range from 0.599 to 0.627; higher value was observed in station 1, while the least was in station 3; Margalef's index ranged between 5.335 and 5.882, with high value in station 3. Simpson index had it range between 0.697 and 0.738, while Evenness index ranged from 0.635 to 0.173, with higher value in station 2 (Table 4).

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Table 2: Checklist of phytoplankton composition obtained during the study period (November, 2018 –August, 2019)

PHYTOPLANKTON SPECIES	ST1	ST2	ST3	ST4	ST5	TOTAL
BACILLARIOPHYCEAE						
Achnanthes exigma	19	-	39	13	-	71
Amphiprora oxalis	15	11	8	13	18	65
Asterionella Formosa	-	13	14	16	-	43
Bidulphia sinensis	11	-	17	4	19	51
B. favus	16	-	3	-	28	47
Bacillaria paradoxa	10	18	18	16	18	80
Cymbella ventricosa	-	15	18	19	-	52
C. stelligra	-	14	43	13	-	70
Coscinodiscus rothii	19	13	8	3	-	43
C. granii	14	2	11	7	10	44
Eucampia zoodiacus	14	7	25	11	14	71
Epithermia zebra	6	21	13	15	22	77
Flagilaria striatula	13	17	8	14	8	60
Gomphonema olivecium	13	40	26	-	-	79
Pleurosigma nobilis	30	28	9	-	-	67
Surirella robusta	10	18	11	21	18	78
Tabellaria flocculosa	11	34	24	17	28	114
T. fenestrate	15	-	8	8	15	46
CYANOPHYCEAE						
Anabaena affinis	-	15	-	20	13	48
Anabaena spiroides	34	-	31	18	9	92
Anacytis cyanae	39	32	14	28	11	124
Aphanotheca clathrata	71	-	7	14	-	92
Aphanotheca stagnina	14	39	18	-	26	97
Chrroococcus minor	22	31	-	36	-	89
Gloeocapsa minima	28	33	15	18	21	115
Oscillatoria tenuis	17	17	10	-	-	44
O. rubiscens	10	27	-	33	19	89
Microcystis acrugiriosa	28	14	18	31	-	91
M. grevillei hass	19	8	-	31	-	58
CHLOROPHYCEAE						
Closterium longissima	19	13	11	14	13	70
C. Cynthia	10	18	11	10	22	71
Euastrum elegans	14	28	17	19	20	98
Gonatozygon aculeatum	18	21	23	14	22	98
Micrasterias foliacea	24	33	10	19	29	115
Scenedesmus acutus	-	-	23	14	23	60
S. qaudricauda	-	-	16	29	18	63
Pediastrum duplex	19	8	-	35	31	93
Xanthridium sp.	33	16	10	-	-	59

CHRYSOPHYCEAE						
Asterionella sp.	16	26	10	19	13	84
Crystochrisis sp.	19	21	13	18	11	82
Dinobryon bavaricum	19	13	23	19	17	91
DINOPHYCEAE						
Dinophysis rotundata	30	13	23	13	15	94
Gonyaulax sp.	25	10	15	13	17	80
Peridinium cintum	16	21	18	10	-	65

Table 3: Summary of numerical and relative abundance of phytoplankton classes obtained during investigated period (November, 2018 –August, 2019)

Phytoplankton classes	Number of species	Sampling stations					Total	Relative composition (%)
		1	2	3	4	5		
Bacillariophyceae	18	216	251	303	190	198	1158	**34.8**
Cyanophyceae	11	282	216	113	229	99	939	**28.3**
Chlorophyceae	9	137	137	121	154	178	727	**21.9**
Chrysophyceae	3	54	60	46	56	41	257	**7.8**
Dinophyceae	3	71	44	56	36	32	239	**7.2**
Total abundance	**44**	**760**	**708**	**637**	**665**	**548**	**3320**	**100**

Table 4: Species diversity of phytoplankton obtained during the preliminary study (November, 2018 –August, 2019)

Diversity Indices	STN1	STN1	STN3	STN4	STN5
Number of species (taxa)	38	36	39	38	38
Number of individuals	760	708	639	665	548
Shannon- Weiner index (H)	0.627	0.621	0.599	0.621	0.6087
Margalef's index (D)	5.572	5.335	5.882	5.701	5.692
Simpson diversity index (D)	0.737	0.715	0.697	0.738	0.723
Evenness index (E)	0.1724	0.1732	0.1635	0.1708	0.1673

DISCUSSION

Hydrological characteristics of any water body and biotic composition are governed by the prevailing environmental conditions and anthropogenic factors. The ranged values of water temperature obtained within the study period corroborates with the reports of Ukpatu *et al.* (2018) in Okoro River estuary and George and Akpan (2020) for Qua Iboe River Estuary. Slight variability in temperature values as recorded could be attributed to the weather condition at the time of sampling and location of each station. The pH values obtained varied

across the stations; the higher value recorded in station 2 may suggest to the buffering capacity of seawater (Desai *et al*., 2020). The range values of pH obtained were consistent with the reports of Ukpatu *et al*. (2018) and George and Akpan (2020) and contradict with the report of Jonah *et al*. (2020b) for Qua Iboe River Estuary. The mean values of EC recorded across the stations were significantly higher when compared with WHO limits (1400µs/cm). This could be certified to the consistent discharge of wastes from various anthropogenic sources into the water body. High values of EC have been reported associated with sand mining activities and dredging (Ohimain *et al*., 2008; Seiyaboh *et al*., 2013; Akankali *et al*., 2017). Similar values were reported by George *et al*. (2017). Water transparency is essential for phytoplankton growth; it controls the degree of light penetration in to the water column. The high transparency noticed station in 5 is not unprecedented as this devoid of substantial waste contamination and human activities. Dredging resulted in re-suspension of organic debris deposited at the sediment to the water surface; this could be responsible for the low values recorded in station 1, 2 and 3. Jonah et al. (2020b) confirms that low transparency is associated with sand mining activities and increased precipitation resulted in high surface runoff. The remarkable elevated values of salinity recorded in station 2 and 3 may perhaps attribute to evaporation of water. The values recorded in this study were of the same ranged reported by Akpan *et al*. (2019) for Uta Ewa Estuary. High value of Ammonia was recorded in station 1 and 5; this may suggest to high surface runoffs and corresponds with the agricultural land used with the stations. Jonah *et al.* (2020b) for Qua Iboe River affirmed that increased precipitation and subsequent runoffs from the surrounding lands increased the concentration of ammonium compound. High nitrate values noticed in stations 3 and 4 and phosphate in station 2 and 4 may be linked to combined effects of precipitation, land used for agricultural activities and other coastal activities. The findings are in agreement with the reports of Mandal *et al*. (2012), who propose that phosphate contamination is as a result anthropogenic activity like laundry, discharge of contaminated sewage, and runoffs laden with fertilizers and pesticides. The finding values of nitrate and phosphate were relatively higher than values recorded by Kuniz *et al*. (2014) in Merbok Estuary, Kedah, Malaysia. Nitrate values in this study were within acceptable limit (<10mg/l), while phosphate values in this study were above the acceptable limit (5.0mg/l) set by WHO (2011). The significant difference observed in sulphate values may be related to the consistent discharged of sulphate-rich wastes in to the water. The findings are contradicted with the reports of Jonah *et al.* (2020a) in Ikpe Ikot Nkon River. According to Edokpayi (2005), alkalinity of water body is a measure of the capacity to neutralize acid to designated pH. The observed range values of alkalinity in this study corroborate with the findings from other estuarine environment (Nweke 2000; Chinedah and Braide, 2001; Ebere, 2002). However, the higher values recorded I station 2 and 3 might be connected to the natural carbonates, bicarbonates as well as organic and inorganic substance brought in via surface runoffs.

Water quality characteristics have enormous impact on the growth and abundance of plankton (Essien-Ibok and Ekpo, 2015). The excessive nutrient loading from agricultural runoffs support a higher phytoplankton population (Jiyalalram, 1991), while Alexander (2012) suggested that occurrence of plankton depends on certain factors such as climate change, habit structure in term biotic and abiotic factors. In this study, certain factors like variability of water quality, time of sampling and anthropogenic perturbations influenced the species composition, abundance and distribution of phytoplankton. Although the 44 species (taxa) recorded in this study was higher when compared with 26 taxa reported by Antai and Joseph (2015) in Great Kwa River, Cross Rivers State, Nigeria; 5 species of Kather Bee *et al*.

(2015) from Ambattur Lake, Tamil Nadu, India; 38 taxa reported by George *et al*. 2017 in a tropical estuarine mangrove swamp, South-South, Nigeria and 12 species of Jonah *et al.* (2020a) Ikpe Ikot Nkon River, Nigeria and lower than the 105 species reported by Ekwu and Sikoki (2006) in Cross River Estuary; 49 species reported by Medupin (2011) in Hollingsworth Lake, UK. The 3,320 individuals recorded in this study was far lower than the 5,878 phytoplankton individuals recorded by Utta *et al*. (2013) from Bonny Estuary and 26,129 individuals documented by Komala *et al*. (2013) from Arkavathi River and 5,279 of George *et al.* (2017). The phytoplankton species recorded were dominated by Bacillariophyceae group, which is in line with the study of Ekwu and Sikoki (2006), Onyema and Nwankwo (2006), Davies *et al*. (2009), Utta *et al*. (2013), Antai and Joseph (2015) and George *et al*. (2017). The findings deviated from the report of Onyema *et al*. (2013) in Onijedi lagoon, Nigeria which reported Cyanophyceae as the dominant group. Similar observation of Cyanophyceae being the group was reported by Ekeh and Sikoki (2014) from New Calabar River. The dominance of Bacillariophyceae may be attributed to the diplontic nature of life cycle exhibited by species belonging to this group; although Nwankwo (1998) reported that most species of phytoplankton belonging to Bacillariophyceae are capable of surviving in the estuarine environment irrespective of the variable salinity. The highest abundance of phytoplankton recorded in station 1 and 2 which could be ascribed to favourable conditions of the water quality and food availability which favoured their development. In this study, phytoplankton community structure showed that the water quality has been adversely impacted by the anthropogenic activities. Olawusi-Peters and Ajibare (2014) reported that comparison of communities to identify biotic disturbances or level of stability can be done with species diversity indices as useful tools. The Shannon-Weiner diversity index values recorded across the stations indicating unstable environment with heavily polluted substances (Mason 2002). The index categories indicated that values of < 1 is for heavily polluted conditions, values of 1 to 2 is for moderate polluted conditions and values of > 3 for stable environmental conditions (Mason 2002). The values recorded in this study are low when compared with 4.48 and 4.53 values recorded by Antai and Joseph (2015) in Kwa River, Cross River State, Nigeria. The Margalef indices values were high in stations 3 and 4; indicating some level of stability (Mason, 2002; Shah and Pandit, 2013). The values recorded in this study were higher than the recorded values of Antai and Joseph (2015) for Kwa River, cross river state, Nigeria. The pielou's evenness values were low in all the stations, indicating that there is no uniformity or evenly distribution in phytoplankton species. According to Leinster and Cobbold (2012), evenness is an important aspect of diversity indices showing how evenly distributed the individuals are within the different species.

CONCLUSION

The studies indicate that the water quality of Qua Iboe River estuary is deteriorating owing to anthropogenic activities within the water body. The variability in phytoplankton composition occurs across the stations and the dominance of Bacillariophyceae and other polluted tolerance species is an indication of increasing environmental degradation. This study underscores the need for continuous monitoring of our water bodies for early diagnosis of pollution and mitigation measures implemented to avert loss of biodiversity

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