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Phytoplankton abundance and diversity of Okerekoko Estuarine, Delta State, Nigeria

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ABSTRACT

Surface water bodies serve as the main sources of phytoplankton and fish production. But their quality and productive capacity are being hampered by anthropogenic effluents in recent times. Information on phytoplankton distribution, abundance and species diversity of Okerenkoko (62.79 Km) Estuarine is limited. Therefore, this study was carried out to investigate the phytoplankton species composition, distribution abundance and diversity of Okerenkoko Estuarine, Delta State, Nigeria. Okerenkoko Estuarine was spatially stratified into five stations (Z1 – Z5) based on key anthropogenic activities. Three sampling points per station were randomly chosen according to standard procedures. Temporal stratification covered wet (March – September) and dry (October – January) seasons. Water and flora samples were collected from each station monthly for 12 months according standard procedures. Samples analysed were Temperature ^{o}C, Dissolved oxygen (DO, mg/L), Abundance (%) and Shannon – Wiener (H). Data were analysed by using descriptive and inferential statistics at $\alpha_{0.05.}$ Spatially, significantly highest and least Temperature were 29.41±0.78 and 24.52±0.28; DO (4.35±0.75, 3.87±0.98) in Z 5 and Z 1, respectively. Seasonally, Temperature ranged from 25.50±0.21 to 31.50±4.87 in wet and dry seasons, while highest (5.70±0.45) and least (4.90±2.67) DO occur in wet and dry seasons, respectively. A total of 188 individual number of phytoplankton comprising 3 orders 3 families, while 12 and 11 phytoplankton species were recorded for both wet and dry seasons, respectively. Highest (1.84) and least (1.31) H were obtained in Z 5 and Z 1, it ranged from 1.15 to 2.57 in wet and dry seasons, respectively. The trend of diversity indices of Phytoplankton species of Okerenkoko Estuarine depicted moderate pollution with H. Thus, its rich flora biodiversity could be threatened.

Keywords: Phytoplankton abundance, Diversity indices, Anthropogenic activities, Okerenkoko Estuarine, Surface water.

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1. INTRODUCTION

Phytoplankton are free floating or slowly mobile (with the aid of flagella) and single celled algae (Ewutanure and Olaifa, 2018a). Their free-floating ability is determined by the water current, while their sizes range from 1/1000 to 2 mm (Ogbuagu, 2013; Okoye and Iteyere, 2015). They are mainly found in the upper 100 m of water bodies due to abundant sunlight energy required for photosynthetic activities (Balogun and Ajani, 2015). Phytoplankton also require oxygen, phosphate (PO_4), nitrate (NO_3) carbon in the form of carbon dioxide and silicon (silicate, SiO_4) because they have a glass like shell (Suleman et al. 2015).

1.1 Relevance of phytoplankton

Phytoplankton serves as primary energy source for consumers and generate about 1 – 2% of the total global biomass as well as 30 – 60% annual fixation of carbon on earth (Suleman et al. 2015; Ewutanure and Olaifa, 2018a). Phytoplankton enhances the process of biological build up by which carbon dioxide in the atmosphere is deposited into surface water and sequestered in sediments which contribute immensely to the reduction in global warming (Ewutanure and Olaifa, 2021a).

Phytoplankton regulate atmospheric carbon dioxide, act as a basis for aquatic food web and produces aquatic biotoxins which are released into the environment ((Ewutanure and Olaifa, 2021b). Phytoplankton represents the nutrient status of the aquatic environment and play significant roles in bio – monitoring of surface water pollution (Ewutanure and Olaifa, 2018b). They also generate several aquatic biotoxins that can only be detected through laboratory analysis (Salman et al. 2011; Balogun and Ajani, 2015). Some of these aquatic toxins are released into the surrounding water and which finally gets in contact with the food web and accumulate in fish and other aquatic organisms (Steven, 2015).

Okerenkoko Estuarine (Figure 1) is an inland water body receiving anthropogenic effluents and sewage from petroleum producing industries, agriculture and markets (Ewutanure and Binyotubo, 2021). The rise in the oil companies, gas flaring, rural and urban development along the shores of Okerenkoko Estuarine introduces crude oil, carbon soot and organic wastes into its water (Ewutanure and Olaifa, 2021a). Several studies have been done in the Niger Delta Region of Nigeria on phytoplankton species distribution, compostions and abundance by Ewutanure and Olaifa, (2018a); Suleman et al., (2015); Balogun and Ajani, (2015) and Ogbuagu, (2013), but information on phytoplankton species abundance and diversity of Okerenkoko Estuarine are scarce. This study was therefore undertaken to investigate the phytoplankton species composition, distribution, abundance and diversity of Okerenkoko Estuarine, Delta State, Nigeria.

2. MATERIALS AND METHODS

Okerenkoko Estuarine (Figure 1) has a total length of 62.79 Km and a mean depth of 35 m (Ewutanure and Binyotubo, 2021). It is located on latitudes 5°30′0″N and 5°50′0″N of the Equator and Longitudes 5°10′0″ E and 5°40′0″ E of the Greenwich meridian. The study area has a common link with the Eschravos River situated in Delta State, Niger Delta Region of Nigeria (Ewutanure and Olaifa, 2021). Most of the oil and gas companies in Nigeria accounting for about 70 % of the federal government revenue are located within the Niger Delta Region (Ewutanure and Olaifa, 2018b). The Okerenkoko Estuarine is located in a mangrove swamp forest. The type of soil found in the study area is the alluvials type. This type of soil is commonly found in mangrove areas along the coast of the Niger Delta States (Ewutanure and Binyotubo, 2021). The area has an annual amount of rainfall of 2869.7 mm with an average temperature of 29.3 ^oC (Ewutanure and Olaifa, 2021a).

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The major species of mangrove identified were the red and white types. Rhizophora racemose (red), Avicennia africana (white) and flood plain border the estuarine and its surrounding creeks, while the major occupation of the Okerenkoko inhabitants is fishing (Ewutanure and Olaifa, 2021a).

2.1 Sampling techniques

Spatially, Okerenkoko Estuarine was stratified into five stations (Z1, Z2, Z3, Z4 and Z5) based on proximity to key anthropogenic activities. Three sampling points per station were randomly selected. Temporal stratification covered wet (March – September) and dry (October – January) seasons. Water samples for the determination of physical chemical parameters and phytoplankton analyses were collected from each station monthly for 12 months by following methods described by APHA, (1991), while the exact locations of all sampling stations were determined by using Garmin GPSMAP eTrex 10 type sensors.

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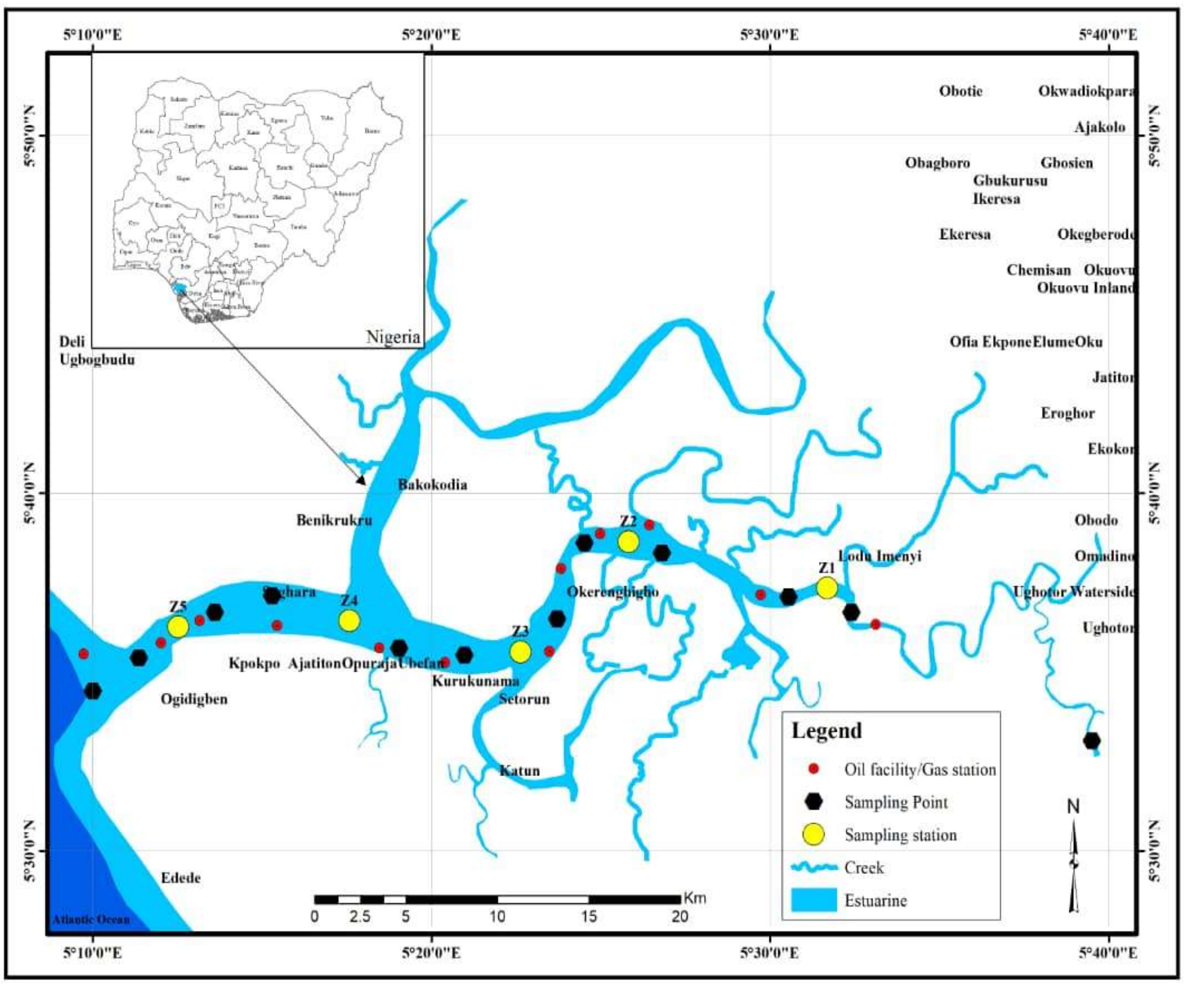

Figure 1. Map of Okerenkoko Estuarine, Delta State, Nigeria
Source: Ewutanure and Binyotubo, (2021)

2.2 Experimental procedures

Physical and chemical parameters determined were Dissolved oxygen, total suspended solids, temperature, pH and salinity. Dissolved oxygen was determined ex – situ following Winkler's method as described by Gupta, (2001). The formula stated below was used to calculate DO.

DO (mg/L) = $\frac{V1 \times N \times 8 \times 1000}{V2 - V3}$ (APHA, 1998). ....(1)

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)
The TSS level was determined as described by AOAC, (1990) and Gollenman et al. (1978) method

Calculation:
TSS (mg/L) = $\frac{A-B}{C}$ X 1000,000 (AOAC, 1990) ....(2)

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

Surface water temperature was measured by using mercury in glass thermometer (^oC) as described by Boyd, (1979) and APHA, (1998), pH was determined by using digital pH meter (Hanna model: HI – 98107, USA), while salinity (‰) was measured by a Salinometer (Thermo Electron Corporation, model: Orion 150A+, USA).

2.2 Sampling and preservation of phytoplankton of Okerenkoko Estuarine

A net of mesh size of 25µm was used for the sampling of phytoplankton (Gupta, 2001). Sampling for phytoplankton was done by towing the net horizontally on the water, the samples were immediately fixed and preserved in 40% formalin as described by (Verlencar and Somshekar et al. 2004). The samples were then labelled, dated and transported to the laboratory for further analysis and identification (ASTM, 2006). Phytoplankton identification samples were identified to species level by using standard keys such as Okusami and Odu, (1992); Gupta, (2001). The formula below was used to calculate phytoplankton species abundance identified.

Phytoplankton species abundance = $\frac{\text{Number of individual per species}}{\text{Total number of organisms}} \times \frac{100}{1}$ % (Gupta, 2001)...........(3)

2.3 Statistical analyses

Data from this study were subjected to descriptive, inferential statistics and diversity index analyses by using SPSS (version, 20), Paeleontalogical statistics (past – version 3.6) and Microsoft Excel (2010) $p < 0.05$.

3. RESULTS AND DISCUSSION

Physico – chemical parameters of Okerenkoko Estuarine recorded during the study period among stations and between seasons are presented in Figure 1 and Table 1, respectively. Spatially, it was observed from the results obtained that an increased in the concentration of TSS resulted in a decrease in the level of DO and a corresponding increase in surface water temperature (Figure 1). Ewutanure and Olaifa, (2021c) associated it to the retention of sun light energy by the high level of TSS in an aquatic environment. The concentration of TSS found in Okerenkoko Estuarine is a mixture of crude oil, clay, colloids and other related particles. It has been reported that the presence of crude oil in water bodies could cause a deflection of sunlight rays from water surface thereby causing a reduction in primary production (Ewutanure and Olaifa, 2017), while the relative decrease in pH level could be attributed to a steady and rapid increase in the concentration of salinity in the study location (Ewutanure and Olaifa,2021a).

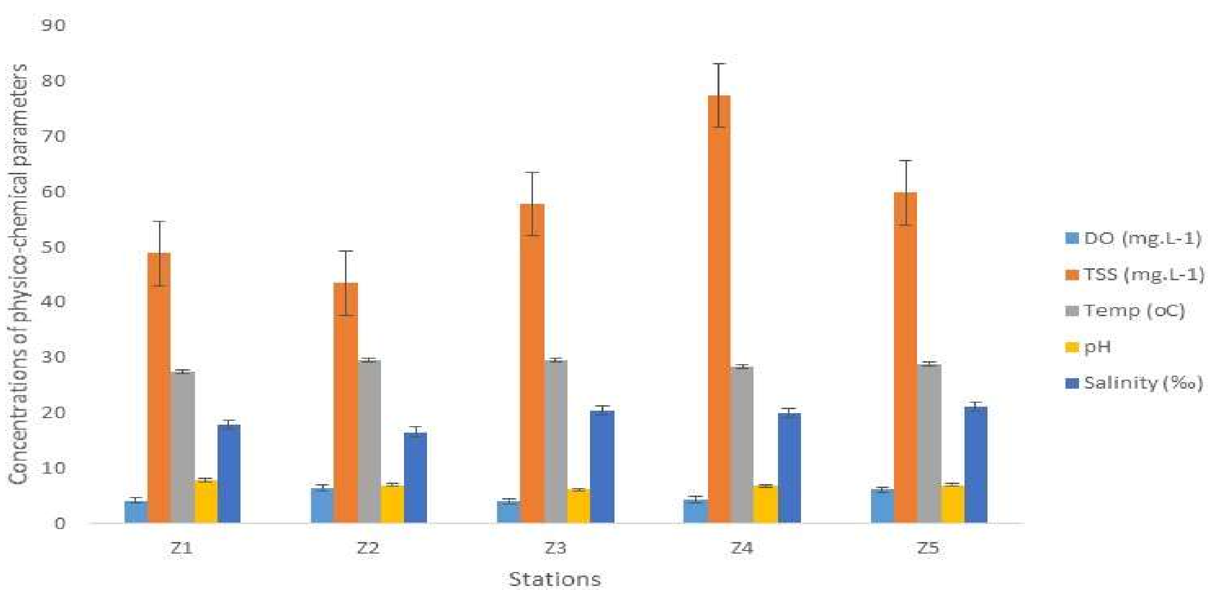

Figure 1. Table 1. Mean physico – chemical parameters of Okerenkoko Estuarine among stations

Table 1. Mean Physico–Chemical Parameters Of Okerenkoko Estuarine Among Stations

	Parameters				
Seasons	DO	TSS	Temp	pH	Salinity
Wet	5.70±0.45	32.89±3.90	25.50±0.21	6.50±0.11	21.56±0.55
Dry	4.90±2.67	25.32±0.90	31.50±4.87	6.90±1.09	18.89±2.65
P – values	0.043**	0.011**	0.039**	0.027**	0.032**
Boyd, (1979); Whitfield et al. (1981)	5 – 10	< 10	25 – 32	6.5 – 8.9	0 – 90

Note: ** = There are no significant differences (p>0.05) between means along the rows,
DO = Dissolved oxygen, TSS = Total suspended solids, Temp = Temperature

The composition, distribution and abundance of phytoplankton species of Okerenkoko Estuarine among stations and between seasons are shown in Tables 2 and 3. A total of 188 individual number of phytoplankton belonging to 3 orders, 3 families, 12 and 11 phytoplankton species were recorded for both wet and dry seasons, respectively. A total of 101 and 87 individual numbers of phytoplankton were recorded in the wet and dry seasons, respectively.

Table 2: Composition, Distribution And Abundance Of Phytoplankton Of Okerenkoko Estuarine Among Stations

Families	Species	Stations					Total	% Abundance
		Z1	Z2	Z3	Z4	Z5		
Fragillariaceae	Fragillaria striatula	5	4	2	0	0	11	5.8
	Ceratium horridum	0	3	5	0	1	9	4.8
	Pseudo-Nitzschia autralis	1	8	4	5	7	25	13.2
	Sub – total	**6**	**15**	**11**	**5**	**8**	**45**	(23.8)
Bidulphiceae	Biddulphia autita	0	0	12	8	0	20	10.6
	Ceratophyllum demersum	0	3	0	6	1	10	5.3
	Sub – total	**0**	**3**	**12**	**13**	**1**	**30**	(15.9)
Soleniceae	Lauderia annulate	9	6	4	0	7	26	13.8
	Proboscia alata	2	8	6	0	0	16	8.5
	Nitella turcata	0	0	1	1	0	2	1.1
	Potamogeton pectinatus	1	2	2	7	6	11	9.5
	Pinnularia viridis	1	0	2	1	0	4	2.1
	Ttichophyton ajelloi	1	8	0	2	1	12	6.3
	Lioloma pacificum	0	2	1	4	7	14	7.4
	Sub – total	**15**	**28**	**16**	**15**	**21**	**92**	(48.7)
	Others							
	Fish larvae	0	1	0	0	2	3	1.6
	Fish eggs	5	0	4	3	1	13	6.9
	Mosquito larvae	0	3	1	0	1	5	2.6
	Sub – total	**5**	**4**	**5**	**3**	**4**	**21**	(12.2)
	Grand total	26	48	44	37	34		
	% Abundance	13.3	25.5	23.4	19.7	18.1		

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Table 3: Composition, distribution and abundance of phytoplankton of Okerenkoko Estuarine between seasons

Families	Species	Wet season	% Abundance	Dry season	% Abundance
Fragillariaceae	Fragillaria striatula	7	3.7	4	2.1
	Ceratium horridum	6	3.2	3	1.6
	Pseudo-Nitzschia autralis	12	6.4	13	6.9
	Sub – total	**25**	**13.3**	**20**	**(10.6)**
Bidulphiceae	Biddulphia autita	10	5.3	11	5.9
	Ceratophyllum demersum	8	4.3	2	1.1
	Sub – total	**18**	**9.6**	**13**	**(7.0)**
Soleniceae	Lauderia annulate	16	8.5	10	5.3
	Proboscia alata	7	3.7	9	4.8
	Nitella turcata	2	1.1	0	0.0
	Potamogeton pectinatus	8	4.3	10	5.4
	Pinnularia viridis	3	1.6	1	0.5
	Ttichophyton ajelloi	2	1.1	4	2.1
	Lioloma pacificum	6	3.2	5	2.7
	Sub – total	**44**	**23.5**	**39**	**(20.8)**
	Others				
	Fish larvae	3	1.6	8	4.3
	Fish eggs	5	2.7	3	1.6
	Mosquito larvae	6	3.2	4	2.1
	Sub – total	**14**	**7.5**	**15**	**(8.0)**
	Grand total	**101**		**87**	
	% Abundance	**53.7**		**46.3**	

Results of the diversity index of phytoplankton species among stations and between seasons are shown in Tables 4 and 5, respectively. Spatially, Dominance ranged from 0.11 to 0.35 in Z3 and Z5; Simpson (0.65, 0.89) in Z5 and Z3; Shannon (2.31, 3.84) and Evenness (0.51, 0.87) in Z1 and Z5 and Margalef (2.99, 3.98) in Z5 and Z3, respectively.

Seasonally, highest and least Dominance were 0.42 and 0.38; Shannon (4.15, 3.57); Evenness (0.49, 0.38) and Margalef (3.52, 3.23) were recorded in wet and dry seasons, while Simpson recorded 0.62 and 0.58 as highest and least in dry and wet seasons, respectively.

Table 4. Diversity indices for phytoplankton species among stations

Diversity index	Stations				
	Z1	Z2	Z3	Z4	Z5
Individuals	25	48	44	37	34
Dominance (D)	0.34	0.21	0.11	0.12	0.35
Simpson (1-D)	0.66	0.80	0.89	0.88	0.65
Shannon (H)	2.31	2.54	3.01	3.34	3.84
Evenness (E)	0.51	0.65	0.76	0.79	0.87
Margalef	2.42	1.98	1.67	2.87	2.99

Table 5. Diversity indices for phytoplankton species between stations

Diversity index	Wet season	Dry season
Individuals	101	87
Dominance (D)	0.42	0.38
Simpson (1-D)	0.58	0.62
Shannon (H)	4.15	3.57
Evenness (E)	0.49	0.38
Margalef	2.52	2.84

Station 2 had the highest individual number comprising 48 (25.5 %) phytoplankton, while Stations 3 and 4 ranked next with individual number of phytoplankton as 44 (23.4 %) and 37 (19.7 %). Station 1 recorded the least 26 (13.3 %) individual numbers of phytoplankton. Lauderia annulate, 26 (13.8 %) and Nitella turcata 2 (1.1 %) were recorded as the most and least abundant phytoplankton among stations, while Pseudo – Nitzchia australis, 13 (6.9 %) and Ceratophyllum demersum 2 (1.1 %) were recorded as highest and least between seasons, respectively. Spatially, other organisms (fish larvae, fish eggs and mosquito larvae) recorded during the study period accounted for 12.2 % (21), 14 (7.5 %) and 15 (8.0 %) of the total phytoplankton population among stations and between seasons (wet and dry), respectively. Fish eggs 13 (6.9 %) and fish larvae 3 (1.6 %) were spatially recorded as highest and least organisms, while 8 (4.3 %) and 3 (1.6 %) were recorded as highest and least for fish larvae and fish eggs between seasons, respectively.

Five diversity indices used were Dominance; Simpson (1 – D); Shannon – Wiener index, (1949); Evenness and Margalef, (1968) to find out the interrelationship between them (Tables 4 and 5). Shannon (1948) and Simpson (1949) are the most widely used diversity index in ecological studies. But evenness and richness are integral parts of diversity (Pielou, 1975). Dominance is assessed by Simpson index, but does not give a vivid clue about species richness (Liu et al., 2008). Shannon – Wiener index is used to evaluate the attributes of evenness and richness (Melo, 2008) but could not provide reasonable knowledge on the scarce species which are very significant in biodiversity studies.

This provides the impression that diversity cannot be usefully calculated by using only one indices (Purvis and Hector, 2000). While evaluating phytoplankton community of Okerenkoko Estuarine throughout the study period, dominance was highest (0.35) at Z5 and least (0.11) at Z 3, signifying a total dominance of few species at Z 5. In biological systems, Shannon – Wiener diversity indices ranges from 0 to 5. Based on this range, values less than 1 indicate heavily condition, values ranging from 1 to 3 represent area of moderately polluted condition, while the values greater than 3 indicate stable aquatic environmental conditions (Mason, 1988). The values of Shannon – Wiener indices obtained varied from 2.31 to 3.84 at Z 1 and Z 5. Evenness indices range from 0.51 to 0.87 at Z 1 and Z 5. Margalef index is used for comparison of the stations and only considers species richness thereby reflecting its sensitivity to sample size.

Margalef index has the benefits of comparing with the richness of different study stations over the Simpson index whose values are greater than 1 unlike the Simpson index with values ranging from 0 to 1. The low diversity associated with site Z 1, as described by Shannon and Margalef indices, may be attributed to lesser number of species and environmental degradation due to increased anthropogenic pressures. The results indicated that all the stations sampled were heavily polluted. This could be attributed to the constant discharge of petroleum effluent into Okerenkoko Estuarine (Ewutanure and Olaifa, 2018b). These effluents laced with higher concentrations of heavy metals than recommended by FEPA, (1991) contain toxic elements which could cause harm to aquatic flora and fauna communities of Okerenkoko Estuarine and the alteration of its physico – chemical parameters. It has been reported that poor water quality could decrease primary production in an aquatic ecosystem (Popoola and Otalekor, 2011). Ewutanure and Olaifa, (2021d) reported that effluents discharged into a water body can negatively impairs the its quality and cause a decrease in its fishery abundance (Taiwo et al. 2012).

4.CONCLUSIONS

The information generated by the diversity index could be used to estimate the quality of the aquatic ecological habitat and give required information on the community strata in terms of evenness and species richness (quantitative analysis) and their interrelationship with the biotic and abiotic factors predominant in the area. Most of the diversity index possessed great diversity values representing low and unstable community of phytoplankton species due to the degradation of Okerenkoko Estuarine.
With respect to the above discussed facts, it can be inferred that Simpson and Shannon – Weiner diversities increased as richness increase for a given pattern of evenness, and increase as evenness increases for a given richness, but they could not constantly followed similar pattern. Simpson diversity is less sensitive to richness but highly sensitive to evenness than Shannon index that changed proportionately with evenness.

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