Ecological Studies of Phytoplankton Distribution and Abundance in River Shasha, Southwestern Nigeria

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Abstract:- **This study was undertaken to investigate the phytoplankton species composition, distribution, abundance and diversity in River Shasha, Ife North, Southwest Nigeria. The river was studies between February 2006 and February 2008 with the aim to captured 10 months duration. A total number of 121 species belonging to 13 taxonomic groups were recorded during the study and bacillariophyta was represented by 53 species and contributing 43.80% of the total phytoplankton groups recorded. Followed by chlorophyta with 29 species consisting 23.97%, charophyta and cyanophyta (8 species) both consisting 6.61%, euglenophyta (6 species) consisting 4.96%, ochrophyta (5 species) consisting 4.13%, chrysophyta and cryptophyta (3 species) both contributing 2.48%, dinophyta (2 species) consisting 1.65% while coelochaetophyta, haptophyte, rhodophyta and xanthophyta were represented by 1 species each and contributing 0.83%. High phytoplankton abundance and diversity observed in this study could be due to the level of pollution nature through the anthropogenic activities (containing high nutrients) that caused algal bloom. However, the Saprobic coefficient is 1.5 fall within 1.0-1.5 indicating a phase value saprobic water is located in the β-phase that means the water is mesosaprobic still contaminated organic materials in the lightweight polluted. The results are significant for the adequate management, monitoring and to conserved biodiversity of River Shasha.**

Keywords: **Phytoplankton, saprobic coefficient, pollution, management and biodiversity**

I. INTRODUCTION

Freshwater bodies served in various capacity in every development sectors globally like agriculture, industry, transportation, aquaculture, domestic and disposal purposes (Shiddamallayya and Pratima, 2008). Huge loads of waste materials from industries, domestic sewage and agricultural practices find their ways into waterbody, which results into deterioration of the water quality (Reddy and Ventateswarlu 1987). The growing problem of degradation of our aquatic ecosystem through anthropogenic activities introduces into it, has necessitated the monitoring of water quality of various freshwater bodies all over the world to evaluate their production capacity, utility potential and to plan restorative measures (Clausen and Biggs 1998). Aquatic ecosystems are affect by several health stressors that have significantly depletes on biodiversity (Kulshrestha and Sharma 2006). The plankton community (phytoplankton and zooplankton) response quickly to slightly changed in the physical and chemical properties of any waterbody and they are one of the most sensitive groups of organisms used in bio-assessment and monitoring of aquatic environment because the fluctuation affect their abundance and diversity which is used to estimate the water quality. Phytoplankton play major role as a primary producer, through such processes as photosynthesis (Knoll *et al*. 2003), calcification (Iglesias-Rodriguez *et al*. 2008), and nitrogen fixing (Howarth 1988), they are consumed by zooplanktons which are subsequently consumed by fish and the base line of the food chain in aquatic ecosystems. Phytoplankton is one of the most important organisms that occurred nearly all aquatic environment and they produce more than 50% of the oxygen and affected by environmental factors like light penetration, depth and turbidity (Helbling and Villafane 2009). Therefore, they are efficient in assessing the fishery potential of different regions (Berglund et al. 2007). However, phytoplankton can produce harmful bio-toxins and cause oxygen depletion, thereby increasing mortality rate and threatening the aquaculture industry and human health (Luckas *et al.* 2005; Rodgers 2008). Harmful phytoplankton include *Cyanophyta, which* produces geosmin; a harmful toxin that affect bottom dwellers fishes and *rhodophyta,* which causes red tides following massive fish kills. The beneficial and harmful importance of phytoplankton cannot be undermined and it necessary to determine the pollution impact on the natural water bodies that are based on the methods and ecological indices on point of view to the water and biota relationships.

This present study thus assesses the impact of human activities on the water quality status of River Shasha using phytoplankton occurrence as indicators and contribute to the existing knowledge on plankton ecology and distribution.

II. MATERIALS AND METHODS

2.1 Area of study

River Shasha is located in Ife-North Local Government Area of Osun State, Nigeria and it takes is source from Shasha village in Ile-Ife and empties into Lekki Lagoon at Imobi via Epe, it is one of the major rivers in the Ogun-Osun River Basin as presented in Figure 1. It drains Southwestern parts of Osun State through Ogun State and southwards to empty into Lekki Lagoon in Lagos State, Nigeria. Some of the major tributaries are River Opa, which discharges into Osun River in Ife North Local Government Area, River Owena and River Oni that empties into it, before empty into the lagoon. The

river serves as a great economic importance to the people of Southwest part of Nigeria. There are two distinct seasons in Ife north local government just the rest of the country, the wet and dry seasons. The rainfall pattern is characterize by two peaks; the first peck usually occurs between June and July while the second peck occurs in either September or October, while a short dry spell occurs in August between the two peaks (August break). About 75000 dwellers depends on it as their major source of water for drinking. Other domestic reliance and benefits derived from this river are for agricultural purposes like irrigation, fishing activities and recreation.

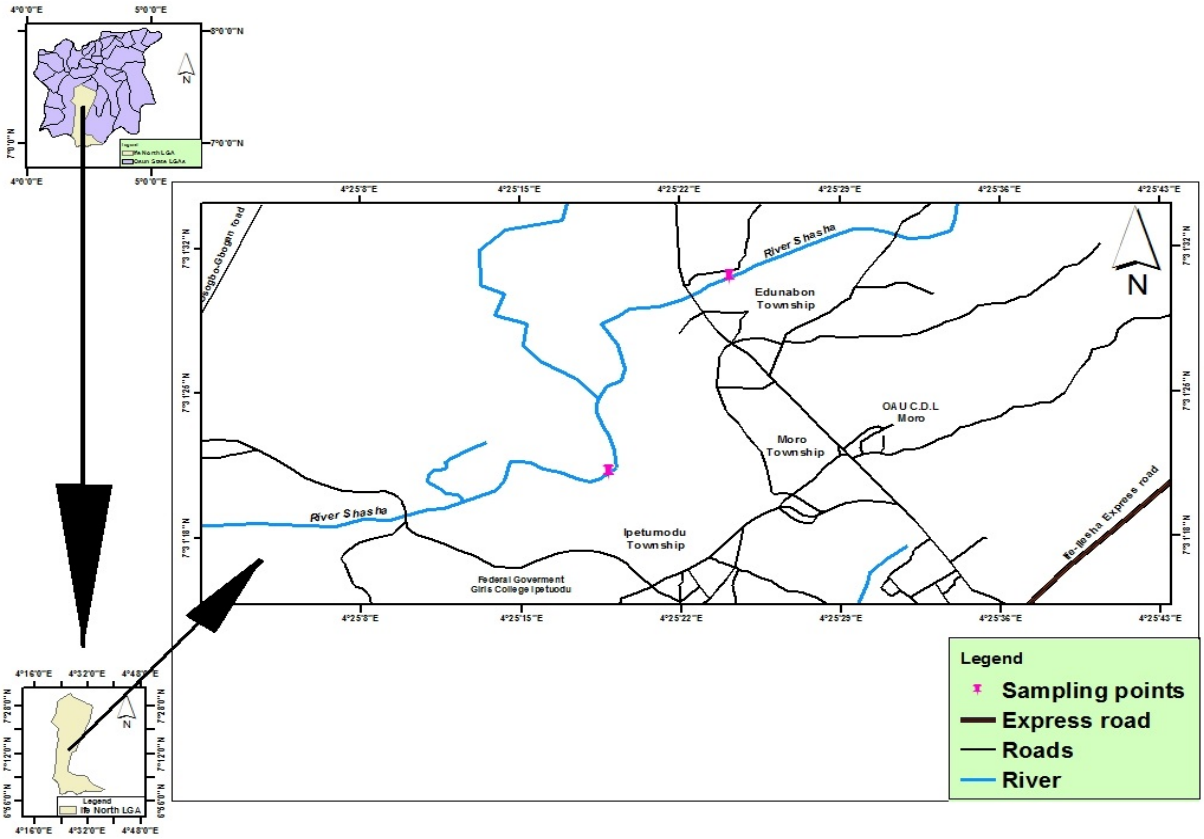

Figure 1: Map showing the sampling stations along the River Shasha, Southwestern Nigeria.

2.2 Sampling procedure and collections

Two sampling stations were established along River Shasha, which are: River shasha in Ipetumodu town with coordinate (Longitude 07° 52.182' N; latitude 004° 43.106') on altitude of 221 m above the sea level and River shasha in Edun-abon town with coordinate (Longitude 07° 31.915' N; latitude 004° 25.288') on altitude of 223m above the sea level. The coordinate of the sampling locations were determined with Global position system (GPS). Samples were collected bi-monthly between February 2006 to February 2008 with a mind of capturing various seasons during the period of study.

Plankton samples were collected quantitatively using 55µm Hydrobios plankton net. Samples for plankton analyses were collect by straining a known volume of water sample (30 litres) through a Hydrobios (fine meshed size) plankton net to a concentrated volume of 30 ml. Each sampling bottles were properly label and preserved with 5 % formalin solution in specimen bottles and 3-5 drops of Lugor's solution was added to it depending on the density observed. The preserved plankton bottles were left to stand for about 10-14 days so that the plankton content could sediment. The supernatant was then, decanted carefully leaving about 3ml. The resultant 3 ml concentrated volume which represents the plankton content of the original 30 litres of water was then examined. 1.5 ml of sample was put into the hydrobios counting chamber using a stamped pipette until the chamber was completely filled without any air bubble. This was carefully, placed on the light microscope stage and allowed to settle for 10 minutes to enable the planktons to settle at the bottom of each square of the chamber. Proper identification and enumeration of plankton was carried-out using x10 and x40 objectives of an Olympus binocular microscope according to the methods of Jeje and Fernando (1986). The plankton in each square of the chamber were identified to genus/species level based on the minute morphological details by observing them under the

microscope using the taxonomic guide and standard identification key as described by Jeje and Fernado (1986); Kadiri (1993); Kemdirim (2001); Kutikova (2002); Janse Van Vuuren *et al*. (2006); Brierley *et al.* (2007); Yamaguchi and Gould (2007); Suthers and Rissik (2009); Bellinger and Sigee (2010); Ekhator *et al.* (2014).

Saprobic Index calculation

Phytoplankton were identified to species level, tabulated in the table and are grouped into saprobic classes. The tabulating type also noted the average number of specimens per type of class were then, used to calculate the coefficient of saprobic phytoplankton as one of the parameters determining the level of pollution of the lake, especially organic contamination using the formula Drescher and Van der Mark 1976 and Putri Survani *et al*. 2018 as follows:

$$\mathbf{X} = \frac{C + 3D - B - 3A}{A + B + C + D}$$

Information:

X = coefficient of saprobic, ranging from -3 (Polisaprobic) to +3 (Oligosaprobic) A, B, C and D = number of different species in each group saprobic.

A = Phytoplankton classes that are found belong to class Polisaprobic.

B = Phytoplankton discovered class into α-mesosaprobic class.

C = Phytoplankton are found into β-mesosaprobic class.

D = Phytoplankton classes that are found belong to class Oligosaprobic.

If the value of X in the above equation has been obtain, then the way interpretation the level of contamination is by reading the following table:

Table 1: Interpretation of the level of pollution

Pollutants Materials	Pollutants Level	Saprobitic Phase	Saprobic Coefficient
Organic Material	Very heavy	Polisaprobic	(-3) - (-2)
		Poly / - mesosaprobic	(-2) - (-1.5)
	Quite heavy	α -meso / polisaprobic	(-1.5) - (-1)
		α –mesosaprobic	(-1) - (0.5)
Organic and	Moderate	α / β-mesosaprobic	(-0.5) - (0)
inorganic material		β / α –mesosaprobic	(0) - (0.5)
	Light	β-mesosaprobic	(0.5) - (1.0)
		β-meso / oligosaprobic	(1.0) - (1.5)
Organic and	Very Mild	Oligo / β-mesosaprobic	(1.5) - (2)
inorganic material		Oligosaprobic	(2.0) - (3.0)

Source: Awaludin *et al*, 2015

2.3 Statistical analysis

The datas were subject to appropriate statistical analysis with SPSS version 23, PAST, using the standard Bio-Statistical method including descriptive statistics, analysis of variance (ANOVA).

III. RESULTS

A total number of 13 taxonomic groups of phytoplankton were encountered during the period of study consisting 121 species were identified in River Shasha during the period of study. Ten 10 taxonomic groups was recorded from Edun-abon station and 11 taxonomic groups was recorded from Ipetumodu station. Bacillariophyta was represented by 53 species and contributing 43.80% of the total phytoplankton groups. Chlorophyte with 29 species consisting 23.97%, charophyta and cyanophyta (8 species) both consisting 6.61%, euglenophyta (6 species) consisting 4.96%, ochrophyta (5 species) consisting 4.13%, chrysophyta and cryptophyta (3 species) both contributing 2.48%, dinophyta (2 species) consisting 1.65% while coelochaetophyta, haptophyte, rhodophyta and xanthophyta were represented by 1 species each and contributing 0.83% as showed in Table 2. Bacillariophta was the most abundant among the taxa groups recorded with 51%, followed by chlorophyta (30%), cyanophyta (6%), charophyta (3%), euglenophta (2%) while cryptophyta and xanthophyta (1%) (Figure 2).

Edun-abon station: Bacillariophyta had the highest mean abundance during rainy season 16696 (309.19±108.72 Org/m^3) compared with dry season 12433 (230.24±57.30 Org/m^3) and there is significant different ($p < 0.05$) between the seasonal variation. Mean abundant for chlorophyta was higher in dry season 7103 (244.93±159.83 Org/m^3) than rainy season 6367 (219.55±143.93 Org/m^3) and there is significant different ($p < 0.05$) between the seasonal variation. Highest mean abundance was recorded during rainy season 1999(249.88±235.89 Org/m^3), 200(100±100 Org/m^3) and 201(40.2±16.14 Org/m^3) for charophyta, dinophyta, ochrophyta and there is significant different ($p<0.05$) between seasonal variation. Rhodophyta and xanthopyta had (133 Org/m^3 and 200 Org/m^3) (Table 3). Ipetumodu station: The highest mean abundance for bacillariophyta was recorded in rainy season 63599 (1177.76±616.61 Org/m^3) than dry season 39865 (738.24±238.82 Org/m^3) and there is significant different ($p<0.05$) between seasonal variation. Highest abundant of chlorophyte was observed in rainy season 28735 Org/m^3. Highest mean abundant for cyanophyta was record in dry season 9066 (1133.25±729.06 Org/m^3) and there is highly significant different ($p<0.001$) between seasonal variation. Euglenophyta, charophyta, dinophyta and ochrophyta 3167 (527.83±508.10 Org/m^3), 1834 (229.25±119.92 Org/m^3) and 200 (100±36.01 Org/m^3) had the highest mean abundant in rainy season. The highest abundant for coelochaetophyta and haptophyte (167 Org/m3 and 400 Org/m3) was recorded in rainy season while the chrysophyta and cryptophyta 267

(89±89 Org/m^3) and 933 (89±10.1 Org/m^3) in dry season (Table 3).

Rhodophyta and xanthophyta had 100% of occurrences among the phytoplankton groups observed in Edun-abon station, while 55% of charophyta, 58% of dinophyta, 39% of ochrophyta and less than 20% in percentage of occurrences for chrysophyta, euglenophyta, cyanophyta and bacillariophyta were record in Edun-abon. 100 percentage of occurrence was recorded for haptophyta, cryptophyta and coelochaetophyta while above 80 percentage of occurrence was recorded for bacillariophyta (81%), chlorophyte (82%), cyanophyta (83%), euglenophyta (83%), Charophyta (50%), and dinophyta (43%) (Figure 3). Coscindiscus contributing 15.63% and surirella (9.38%) among the species. Bacillariophyta contributing 75.0% of the total phytoplankton composition recorded during the period of study, followed by euglenophta (12.5%) while chlorophyta and charophyta contribute 6.25%. Among the bacillariophyta, *Coscindiscus* contribute 15.63%, followed by *Surirella* (9.38%), Ankistrodesmis (6.25%); belonging to Chlorophyta; *Euglena* and *Phacus* (6.25%) to euglenophyta and Spondylosium (6.25%) to Charophyta (Table 4). Bacillariophyta recorded the highest mean abundance in April 2007 (496.22±254.84 Org/m^3), chlorophyta in February 2006 (668±40.1 Org/m^3), cyanophyta in June 2006 (355±345 Org/m^3), euglenophyta in February 2006 (166.5±33.5 Org/m^3). Charophyta had the highest mean abundance in February 2007 (500±467 Org/m^3) and there is high significant difference ($p<0.01$) in monthly variation at Edun-abon station (Table 5). Bacillariophyta had the highest mean abundance in April 2007 (1978.82 ±1040.01 Org/m^3) while chlorophyte was observed in February 2007. The highest mean abundance for cyanophyta was observed in February 2006 and there is significant difference ($p<0.01$) in monthly variation. Charophyta recoreded highest mean abundance in February 2007 and there is very highly significant difference ($p<0.001$) in monthly variation at Ipetumodu station (Table 5). There are two major cluster diagram formed showing the relationship between phytoplankton groups: (i) dinophyta, cryptophyta, chrysophyta and chlorophyte with rhodophyta, xanthophyta, haptophyta and cyanophyta (ii) euglenophyta, ochrophyta with charophyta while bacillariophyta stand-alone (Figure 4).

Table 2: Percentage contribution of each taxonomic group of phytoplankton encountered during the period of study in River Shasha, Southwestern Nigeria

Taxonomic groups	Total No. of species	Percentage (%)
Bacillariophyta	53	43.80
Charophyta	8	6.61
Chlorophyta	29	23.97
Chrysophyta	3	2.48
Coelchaetophyta	1	0.83
Cryptophyta	3	2.48
Cyanophyta	8	6.61
Dinophyta	2	1.65
Euglenophyta	6	4.96
Haptophyta	1	0.83
Ochrophyta	5	4.13
Rhodophyta	1	0.83
Xanthophyta	1	0.83
Total	**121**	**100**

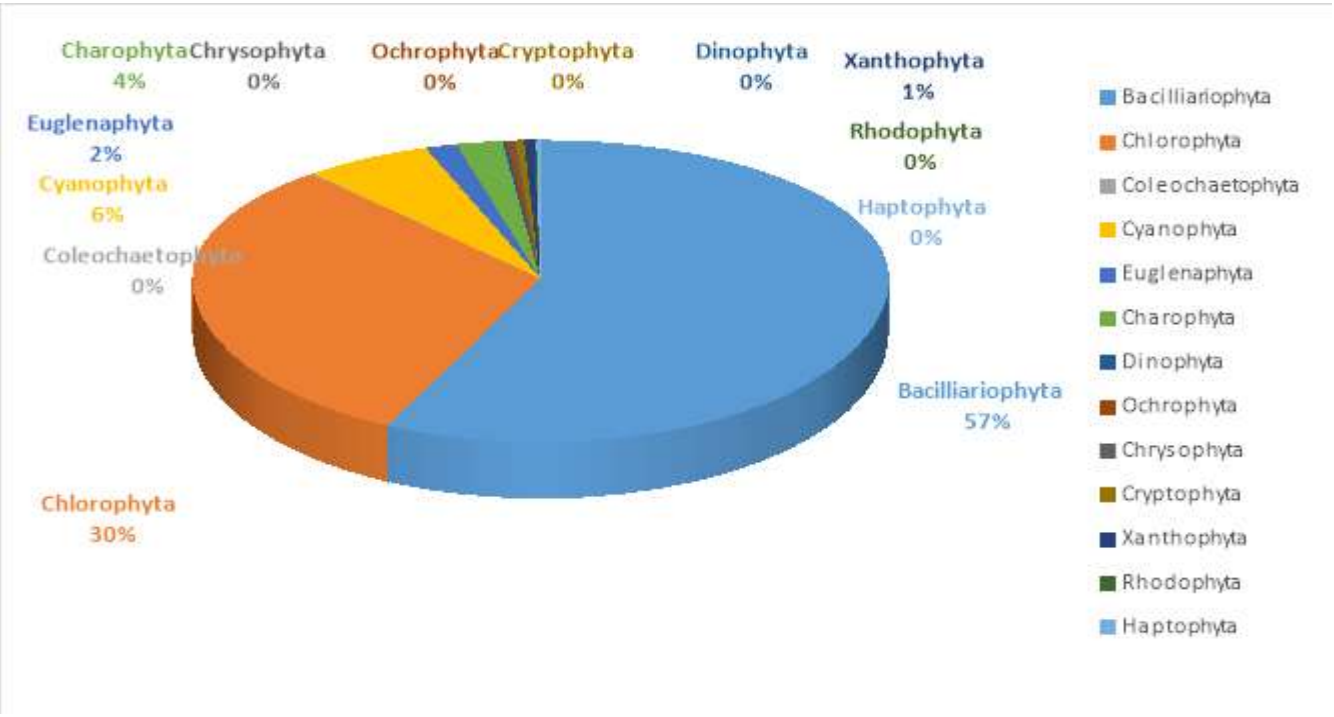

Figure 2: Percentage abundance of phytoplankton groups in River Shasha, Southwestern Nigeria.

Table 3: Seasonal variation of phytoplankton community of River Shasha, Southwestern Nigeria

Division	Station								Overall
	Edun-abon				Ipetumodu				
	Dry Season	Rainy Season	Anova		Dry Season	Rainy Season	Anova		
	Mean±Sem	Mean±Sem	F	P	Mean±Sem	Mean±Sem	F	P	
Bacilliariophyta	12433(230.24±57.30)	16696(309.19±108.72)	2.41	0.043	39865(738.24±238.82)	63599(1177.76±616.61)	4.442	0.032	132593(631.40±173.64)
Chlorophyta	7103(244.93±159.83)	6367(219.55±143.94)	3.64	0.031	27200(937.93±543.55)	28735(990.86±296.09)	0.007	0.932	69405(598.32±165.24)
Coleochaetophyta	0(0±0)	0(0±0)	0	0	0(0±0)	167 (0±0)	0	0	167(83.50±83.5)
Cyanophyta	1499(187.38±101.95)	1343(167.88±111.52)	3.53	0.038	9066(1133.25±729.06)	2966(370.75±225.91)	10.998	0.0002	14874(464.81±197.94)
Euglenaphyta	499(83.17±43.54)	266(44.33±32.81)	2.44	0.041	33(5.5±5.5)	3167(527.83±508.10)	1.057	0.328	3965(188.81±144.84)
Charophyta	1033(129.13±124.48)	1999(249.88±235.89)	3.78	0.032	966(120.75±88.37)	1834(229.25±119.92)	4.531	0.038	5832(208.29±82.79)
Dinophyta	100(50±50)	200(100±89.01)	0.20	0.699	0(0±0)	200(100±36.01)	1.990	0.045	500(125±47.87)
Ochrophyta	134(26.8±16.41)	201(40.2±16.41)	0.333	0.579	133(26.6±26.6)	333(66.6±66.6)	0.311	0.592	801(80.1±31.07)
Chrysophyta	100(33.33±33.33)	0(0±0)	0.98	0.378	267(89±89.0)	99(33±19.05)	0.3786	0.572	466(77.67±41.05)
Cryptophyta	0(0±0)	0(0±0)	0	0	933(89±10.1)	66(33±19.05)	0.379	0.572	999(166.5±117.35)
Xanthophyta	0(0±0)	1333(0±0)	0	0	0(0±0)	0(0±0)			1333(666.5±666.5)
Rhodophyta	0(0±0)	200(0±0)	0	0	0(0±0)	0(0±0)			200(100±100)
Haptophyta	0(0±0)	0(0±0)	0	0	67(0±0)	400(0±0)			467(233.5±166.5)

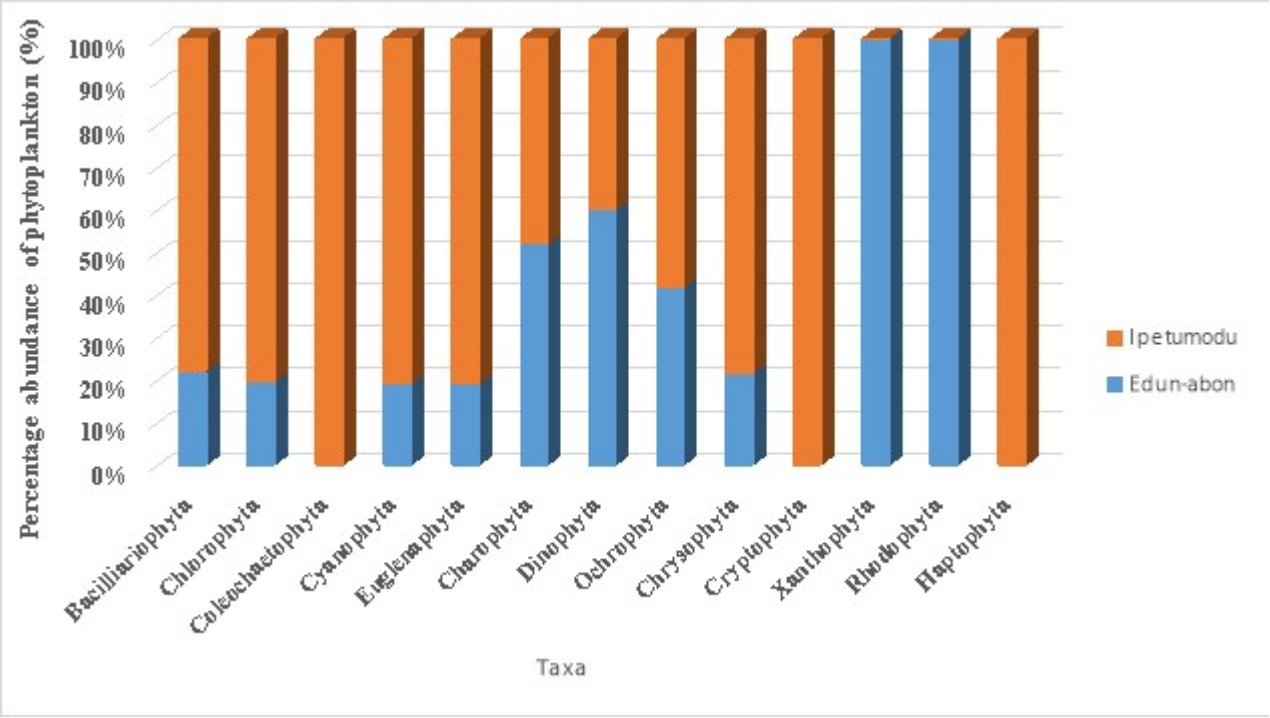

Figure 3: Spatial variation of phytoplankton distribution in River Shasha, Southwestern Nigeria

Table 4: Percentage abundance and composition of phytoplankton species of River Shasha, Southwestern Nigeria

Phytoplankton groups	Genus/Species	Genus/Species Abundance	Species % in Division	Division% in total phytoplankton (%)
Bacillariophyta	*Asterionella*	2	6.25	**75.0**
	Coscindiscus	5	15.625	
	Melosira	2	6.25	
	Navicula	2	6.25	
	Rhizosolenia	2	6.25	
	Stauroneis	2	6.25	
	Stephanodiscus	2	6.25	
	Surirella	3	9.375	
	Terpsine	2	6.25	
	Thalassionsina	2	6.25	
	total	**24**		
Chlorophyta	*Ankistrodesmis*	2	6.25	**6.25**
	total	2		
Euglenophyta	*Euglena*	2	6.25	**12.5**
	Phacus	2	6.25	
	total	4		
Charophyta	*Spondylosium*	2	6.25	**6.25**
	total	2		
Grand total		**32**	**100**	**100**

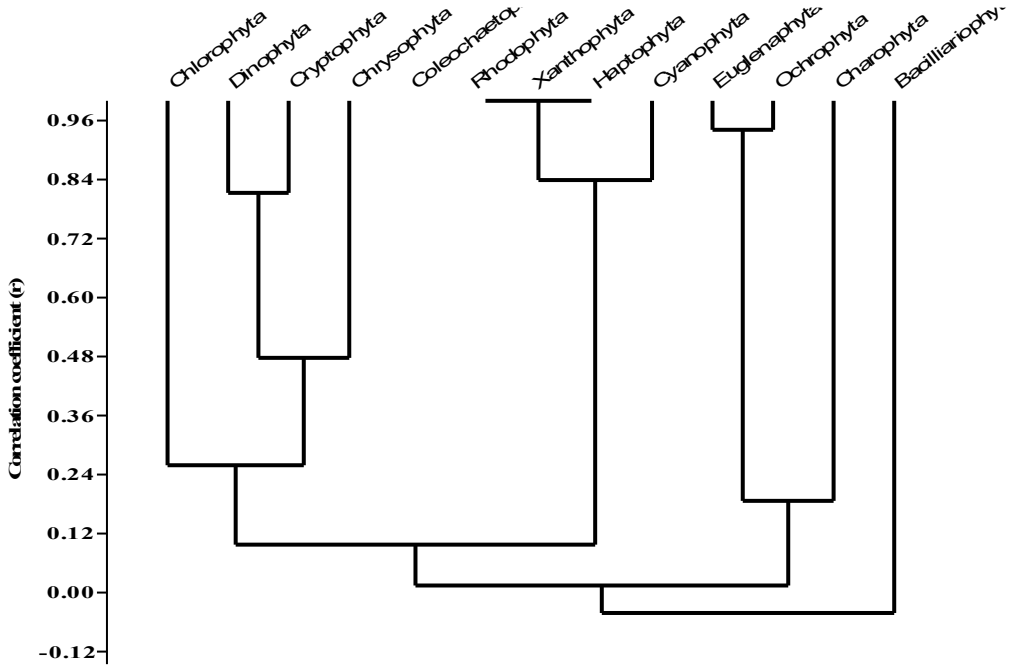

Figure 4: Cluster diagram showing relationship between the phytoplankton communities of River Shasha, Southwestern Nigeria.

Table 5: Monthly variation of phytoplankton groups recorded in River Shasha, Southwestern Nigeria

Division	Station										Anova	
	Edun-abon											
	Feb. 06	Apr. 07	Jun. 06	Oct. 07	Dec. 06	Feb. 07	Apr. 07	Aug. 07	Dec. 07	Feb. 08	F	P
Bacilliariophyta	260±132.35	466.57±235.00	324.09±106.86	337.50±164.52	310.89±136.71	447.57±163.26	496.22±254.84	337.38±159.37	303.78±138.69	164.53±50.67	0.5016	0.8691
Chlorophyta	668±401	249.75±184.92	375.25±176.49	66.5±33.5	420.20±206.76	111±40.22	586.8±310.17	400±333	258.25±192.07	575±319.25	0.519	0.8468
Cyanophyta	166.5±166.5	100±67	355±345	183.5±183.5	150±117	166.5±166.5	16.5±16.5	16.5±16.5	266.5±266.5	0±0	0.4369	0.8858
Euglenaphyta	166.5±33.5	0±0	34±33	17±16	17±16	0±0	67±66	17±16	0±0	33±0	2.814	0.101
Charophyta	0±0	0±0	0±0	33±0	0±0	500±467	1900±0	33±0	33±0	0±0	15.01	0.005422
Ochrophyta		67±0			67±0						0.03158	0.8703
	Ipetumodu											
Bacilliariophyta	1515.39±605.82	598.21±354.18	1445.21±951.07	400±115.47	117±50	695.75±410.09	1978.82±1040.01	1129.13±579.37	1215.09±720.32	124.88±69.83	0.6086	0.7866
Chlorophyta	941.5±560.48	751.78±318.23	449.83±196.96	166.5±133.5	0	2455.67±1387.24	1004±339.26	825.08±355.70	275±146.87	77.67±44.67	1.26	0.2786
Cyanophyta	2888.68±1390.78	133±100	200±100	0	16.5±16.5	150±150	77.67±44.67	447.71±161.21	0	33.5±33.5	4.058	0.003515
Charophyta	33±0	167±0	567±0	600±0	0	55.66667±11.33	333±0	0	700±0	33±0	1899	1.578x10-13

Table 6: Diversity indices of phytoplankton group recorded from Edun-abon station in River Shasha, Southwestern Nigeria

	Phytoplankton group									
	Bacilliariophyta	**Chlorophyta**	**Cyanophyta**	**Euglenaphyta**	**Charophyta**	**Dinophyta**	**Ochrophyta**	**Chrysophyta**	**Xanthophyta**	**Rhodophyta**
Taxa (S)	32	11	7	3	3	1	3	1	1	1
Individuals	29129	13470	2842	765	3032	300	335	100	1333	200
Dominance (D)	0.1022	0.44	0.3927	0.4475	0.9158	1	0.36	1	1	1
Simpson (1-D)	0.8978	0.56	0.6073	0.5525	0.08423	0	0.64	0	0	0
Shannon (H)	2.698	1.307	1.25	0.9033	0.2092	0	1.055	0	0	0
Evenness (e^H/S)	0.4642	0.3358	0.4986	0.8226	0.4109	1	0.9572	1	1	1
Brillouin	2.694	1.304	1.243	0.8949	0.2072	0	1.037	0	0	0
Menhinick	0.1875	0.09478	0.1313	0.1085	0.05448	0.05774	0.1639	0.1	0.02739	0.07071
Margalef	3.016	1.052	0.7545	0.3012	0.2495	0	0.344	0	0	0
Equitability (J)	0.7785	0.5449	0.6423	0.8222	0.1904	0	0.9602	0	0	0
Fisher alpha	3.551	1.177	0.8644	0.3965	0.3286	0.129	0.4542	0.1544	0.1059	0.1373
Berger-Parker	0.2186	0.6436	0.5866	0.5647	0.9565	1	0.4	1	1	1
Chao-1	32	11	7	3	3	1	3	1	1	1

Table 7: Diversity indices of phytoplankton group recorded from Ipetumodu station in River Shasha, Southwestern Nigeria

	Phytoplankton group										
	Bacilliariophyta	**Chlorophyta**	**Coleochaetophyta**	**Cyanophyta**	**Euglenaphyta**	**Charophyta**	**Dinophyta**	**Ochrophyta**	**Chrysophyta**	**Cryptophyta**	**Haptophyta**
Taxa (S)	30	22	1	4	3	6	1	1	3	3	1
Individuals	103464	55935	167	12032	3200	2800	200	466	366	999	467
Dominance (D)	0.1565	0.1663	1	0.4722	0.9197	0.2779	1	1	0.5728	0.5939	1
Simpson (1-D)	0.8435	0.8337	0	0.5278	0.08031	0.7221	0	0	0.4272	0.4061	0
Shannon (H)	2.378	2.221	0	0.8849	0.1962	1.391	0	0	0.7559	0.6793	0
Evenness (e^H/S)	0.3593	0.4191	1	0.6057	0.4056	0.6697	1	1	0.7099	0.6575	1
Brillouin	2.377	2.22	0	0.8838	0.1943	1.385	0	0	0.7408	0.6732	0
Menhinick	0.09327	0.09302	0.07738	0.03647	0.05303	0.1134	0.07071	0.04632	0.1568	0.09492	0.04627
Margalef	2.511	1.921	0	0.3193	0.2478	0.6299	0	0	0.3388	0.2896	0
Equitability (J)	0.6991	0.7187	0	0.6383	0.1786	0.7763	0	0	0.6881	0.6184	0
Fisher alpha	2.858	2.165	0.1413	0.3866	0.3264	0.7267	0.1373	0.1211	0.4472	0.3811	0.1211
Berger-Parker	0.3396	0.3272	1	0.59	0.9584	0.3454	1	1	0.7295	0.7337	1
Chao-1	30	22	1	4	3	6	1	1	3	3	1

Diversity indices results show that, among the phytoplankton groups: bacillariophyta has high number of individuals (S), followed by chlorophta in both stations. The high dominance values were showed by charophyta (0.9158) followed by euglenophyta (0.4475) and chlorophyte (0.44) at Edun-abon station while Ipetumodu station: euglenophyta (0.9197), cryptophyta (0.5939) and the least is bacillariophyta (0.1565) as presented in Table 6 and 7. Phytoplankton were group by grade and species level, then the waters saprobic coefficient calculation using the formula Drescher and Van der Mark in 1976. The obtained coefficient of saprobic index is 1.5 which indicate a phase value saprobic waters of River Shasha is located in the β-phase which means the water is mesosaprobic still contaminated organic material in the lightweight category.

IV. DISCUSSION

Phytoplankton

In this study, the phytoplankton occurrence in river Shasha was in the order: Bacillariophyta > Chlorophyta > Cyanophyta > Charophyta > Euglenophyta > Xanthophyta >Cryptophyta > Ochrophyta > Dinophyta > Haptophyta > Chrysophyta > Rhodophyta > Coleochaetophyta. These findings are similar to those of Wladyslawa *et al*. (2007); Sorayya *et al*. (2011) and Atobatele, (2013); Jan Van Vuuren and Taylor (2015); who reported Chlorophyta, Bacillariophyta, Cyanobacteria and Dinophyta are most dominant in the fresh water communities. The relative high abundance, distribution and diversity of phytoplankton recorded in River Shasha could be due to the availability of basic simple organic chemical nutrients such as phosphate and nitrate that support their growth. In addition to sunlight energy, oxygen and carbon in the form of carbon dioxide (CO_2). The most dominant phytoplankton abundant recorded during this study are typically those of Nigeria freshwater bodies in accordance with report of Ugwuba and Ugwumba (1993) that bacillariophyta (diatoms) predominate in unpolluted natural lotic waterbodies. The high abundance of bacillariophyta in this present study could be due to fact that their population tends to increases as a results of high concentration of silicon (silicate) because they have a glass-like shell and other limiting nutrient (nitrogen and phosphorus) as a surface run-off into the waterbody (Gupta, 2001; Shama and Rawat, 2009; Balogun and Ajani, 2015). Also, low salinity gradient, as salinity is one the major factors influencing algal zonation and distribution within freshwater both in terms of range of values and rate of changes (Passy 2007). The finding is similar to report of Atobatele, 2013 (Koluama area), Davies *et al*. 2009 (Elechi creek, Niger Delta), Achionye-Nzeh and Isimaikaye 2010 (Ilorin Reservoir). However, the differences in the community structure despite the dominance assumed by bacillariophyta is due to relative importance followed by chlorophyte, cyanophyta, charophyta, euglenophyta, xanthophyta, cryptophyta, ochrophyta, dinophyta, haptophyte, chrysophyta and rhodophyta could be link to allocthonus and autothonous materials from neighbouring towns, as these organisms are indicator of organic pollution. The occurrences of ochrophyta could be due to their ability to grow in conditions of low light penetration, low temperature and reduced nutrient concentration, which are typical of rainy season (Ganai and Parveen, 2014). Coleochaetophyta with minimal diversity was probably because their inefficiency to compete for nutrient and are not characteristically of freshwater phytoplankton.

Cyanophyta formed the third most abundant group of phytoplankton recorded during this study as a result of more efficient in utilizing carbon dioxide at high pH level and light availability and thus, their abundance indicate the eutrophic nature of waterbody (Lin, 1972). Contradict to the report of Gania and Parveen (2010) that the reason behind this result may be due to moderate temperature, alkaline, pH, low water and bright sunlight that created favourable condition for better propagation of this group of phytoplankton. Euglenophyta was represent by 2 genera: *Euglena* and *Phacus spp*. They are facultative heterotrophic and generally abundant in water rich in organic matter. In the present study, occurrence of *Oscillatoria, Cyclotella, Rhopalodia, Coscinodiscus, Compylodiscus* and *Ulothrix* as epilethic algae and certain diatoms like *Gyrosigma, Cymbella, Melsoria, Surriella, Terpsione, Chorella* and *Navicula* as epiphytic were recorded. Thus, algal communities can served as indicators of pollution for assessing the water quality of this lake of international importance (Nandan and Aher, 2005). The occurrence of *Oscillatoria* in this study indicates pollutants of biological origin agreed with the observations of Gadag *et al*. (2005).

Seasonally, the mean abundant of bacillariophyta, charophyta, coleochaetophyta, dinophyta, ochrophyta, xanthophyta, rhodophyta and Haptophyta were found to be higher prior rainy season. Similar report by Verma and Mohanty (1995); Denisov (2007); Jagadeeshappa and Kumara (2013) stated that alkaline pH is one of the important factors regulating the abundance of phytoplankton population. High abundant of phytoplankton species during rainy season maybe due to water stratification that caused by heavy rainfall, which result into nutrients recycling, accumulation of organic loads from surface run-off (autothonous and allocthonus), decrease in temperature, salinity and pH increased turbidity while low transparency and strong currents and clear sunshine may be the reasons for the dominance (Ugwumba and Ugwumba, 1993). Similarly, Hassan et al. (2010) observed phytoplankton density to be at its lowest during wet season (in Euphrates River, Iraq) and Devika *et al*. (2006) found high phytoplankton population after wet season and extrapolated that this might be owing to the variations in water physicochemical qualities such as temperature and transparency. The factors could have also led to the occurrence of charophyta only in this period, as these organisms are known to have a positive correlation with BOD_5 and pH and to be negatively related to temperature (Ngodhe *et al*. 2013). Chlorophyta, Cyanophyta, euglenophyta, chrysophyta and cryptophyta were observed high in dry season, at high temperatures and relatively

alkaline conditions. A possible explanation for the high density of phytoplankton prior to the dry season might be the prominence of diatoms, the increase in temperature and the subsequent rise in decomposition rate and evaporation, and increase the amount of nutrients and availability of food due to photosynthesis Gowda *et al*. (2001). Chlorophyta was high in dry season that could be due to related to concentration of water levels related to increasing the temperature and nutrient elements present in the waterbody. Blue-green algal (cyanophyta) abundance was find to the major portion in the phytoplankton community during dry season.

Diversity

An important application of diversity indices in phytoplankton studies is their usage in the assessment of pollution and productivity of a waterbody. Species diversity is a function of species richness and evenness with which the individuals are distribute in these species (Margalef, 1951, 1958 and 1978). Highest values of Shannon-Wiener Index was record for bacillariophyta in both stations. The Shannon-Weiner diversity index standard for freshwater bodied as proposed ranged of greater than 4 (> 4) is clean water; between 3-4 is mildly polluted water and less than 2 (< 2) is heavily polluted water (Shekhar *et al*. 2008). The Shannon-Weiner diversity index in the present study ranged between 0–2.698 (Edun-abon) and 0-2.378 (Ipetumodu) in the selected stations, therefore, this water body oscillates between moderately polluted to highly polluted. Shannon-Weaver index (H) affect both number of species and evenness of their population, diversity increases as both parameters increase. Diversity is maximum when all species that make up a community are equally abundant. Maximum evenness values were record for ochrophyta (0.9577) at Edun-abon station, being less species and evenly distributed and minimum for chrysophyta (0.7099) at Ipetumodu station. This reflects equitable abundance of various species throughout the study period. The value of evenness varies between 0 and 1. The closer the value to 1, the more even the population of phytoplankton species that form the community. Highest values for species dominance were recorded for euglenophyta (0.9197) at Ipetumodu station and lowest for chlorophyta (0.44). Phytoplankton groups indicate lower dominance with concurrent values. Simpson's index range between zero and one. Where zero represents an infinite diversity and one indicates no diversity. However, Simpson's index of diversity represent the probability that two individuals randomly selected from a sample will belong to different species. This index ranges from zero to one and the greater the value of Simpson's index of diversity, the greater the species diversity. The values of Simpson's reciprocal index start from 1 to represent a community with one species. The observation was similar to those of Lawson *et al*. (2008) in Majidun creek, Lagos, Nigeria and Ogamba *et al*. (2004) in Ikoli creek, Niger Delta, Nigeria.

The saprobic system is the oldest system used to detect water pollution from organic materials and good way to give an idea of the contamination level of an aquatic ecosystem. Measure by the biological parameters or bio-indicator as it can provide a picture of the waterbody in a vulnerable relatively long time and is not instantaneous parameters (PutriSurvani *et al*. 2018). Saprobes describe water quality associated with the organic matter content and composition of organisms in the water (PutriSurvani *et al*. 2018). In this system, an organism can act as an indicator and characterize itself. Saprobic system waters based on a zoning different experience enrichment of organic material which is characterized by plants (algae) and animals (benthic) specifically (Awaludin *et al*. 2015). Low value of saprobic coefficient recorded in river Shasha water during the period of study could be due to autothonous and allocthonus materials from surface run-off flow into the waterbody, where the source of the pollution in freshwater ecosystem more derived from agricultural and household activities carried-out within the area. Flowing of run-off surface water contain high organic pollution into this river in particular by rainwater that brings agricultural wastes and soil erosion surface brings many suspended solids (soil surface erosion and the remnants of organic fertilizer) Sahabuddin, (2012).

V. CONCLUSIONS

Phytoplankton abundance was high and diversity along the stations in River Shasha compared with other works on Nigeria freshwaterbody. High concentrations of nutrients brought into the waterbody through anthropogenic activities and surface run-off, as well as the presence of phytoplankton indicator species reveal the pollution level of this study. Future research will aim at investigating the impacts of the various anthropogenic activities on the physico-chemical parameters of this river and correlating them with the biota abundance in time and space. The study provides baseline data for future evaluation while recommending improved management of water sources in the municipality.

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