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Phytoplankton Community of Elechi Creek, Niger Delta, Nigeria-A Nutrient-Polluted Tropical Creek

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Abstract: Problem statement: Elechi creek of the upper bonny estuary in the Niger Delta contributes to the rivers state fish resources. It is a sink receiving organic anthropogenic wastes from Diobu, Eagle Island and waterfront dwellers of Diobu areas. Fishing, car washing, bathing, swimming and other human activities are constantly going on within and around this creek. Based on these activities, there is urgent need to study the phytoplankton community that supports its fisheries. **Approach:** The study investigated the phytoplankton composition, diversity, abundance and distribution as well as surface water physico-chemical parameters. Phytoplankton and surface water samples were collected bi-monthly from October 2007-March 2008 at high tide from five stations according to APHA methods. These were analyzed for temperature, transparency, dissolved oxygen, salinity, alkalinity, chloride and nutrients. Phytoplankton was identified microscopically. Species diversity was calculated using standard indices. **Results:** A total of 169 species of phytoplankton, based on cell counts, was dominated by diatoms, 33255 counts mL^{-1} (36%) and blue-green algae, 32909 counts mL^{-1} (35.7%) were identified. The abundance of phytoplankton decreased downstream of this creek (1>2>3>4) except in station 5 with the highest phytoplankton abundance (23938 counts mL^{-1}). There was slight fluctuation in the measured physico-chemical parameters. The results of this study indicated the characteristic species and distribution of phytoplankton in Elechi Creek during the dry months. **Conclusion/Recommendation:** The high level of phosphate above the permissive limit showed that this creek is hypereutrophic and organic polluted. The high nutrients status favors the high abundance of phytoplankton. The municipal effluents (especially raw human and animal faces) discharges must be discontinued. Detergents with low concentration of phosphate are recommended for manufacturing and use. Municipal wastes must be treated and/or recycled before discharge into this natural aquatic body. Therefore, a continuous environmental surveillance of this creek is advocated to keep its biological integrity.

Key words: Diatoms, blue-green algae, species composition, hypereutropic, pollution

INTRODUCTION

The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers. Plankton communities serve as a base for the food chain that supports the commercial fisheries[1,2]. According to Wehr and Descy[3], phytoplankton communities are major producers of organic carbon in large rivers, a food source for planktonic consumers and may represents the primary oxygen source in many low-gradient rivers.

Phytoplankton are of great importance in bio-monitoring of pollution. The distribution, abundance, species diversity, species composition of the phytoplankton are used to assess the biological integrity of the water body[1]. Also, they reflect the nutrient status of the environment. They do not have control over their movements thus they cannot escape pollution and this makes them a good indicator of pollution in the environment. Barnes[4] reports that pollution affects plankton distribution, standing crop and chlorophyll concentration. This study was conducted to assess the

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characteristic phytoplankton species and their distribution in Elechi Creek. Also, it evaluated some surface water physico-chemical parameters.

MATERIALS AND METHODS

Study area: Elechi Creek, South-West of Port Harcourt metropolis, lies between longitude 6°45[11] E and 7°20"N and latitude 4°38"N and 5°5"E. The creek is a tributary of the upper limits of Bonny Estuary and includes its adjoining mangrove Creeks situated near the Eagle Island by the Rivers State University of Science and Technology, Nkpolu, Port Harcourt (Fig. 1). The vegetation is predominantly mangrove.

The low intertidal is dominated mostly by *Rhizophora racemosa*, *R. mangle* while the high intertidal is dominated by *Avicennia africana*, *Laguncularia racemosa*, *Nypa fruticans* and *Aecrostichum aureum*[5]. There are various fishing and transportation activities going on on Elechi Creek. Its vegetation provides logs of wood for domestic and building purposes. The area is also surrounded by numerous waterfront residential houses. The surrounding terrestrial environment is marked by various human activities such as saw milling of timber, free-range pig production, refuse dumping and car washing from Diobu and Eagle Island areas of Port Harcourt. Finally, the study area is a sink for numerous anthropogenic wastes from local industries.

Sampling stations: Samples were collected monthly for three months (October 2007-March 2008) from five sampling stations at high tide namely: (1) Waterfront residential buildings (Upstream), (2) UST brackish water fish pond, (3) A channel from UST female hostel, (4) Right timber market and (5) Left timber market (downstream) (Fig. 1). The six months samples were pooled according to sampling stations.

Sample collections and analyses: Field and laboratory measurements of some physico-chemical parameters of surface water were taken following standard methods[6].

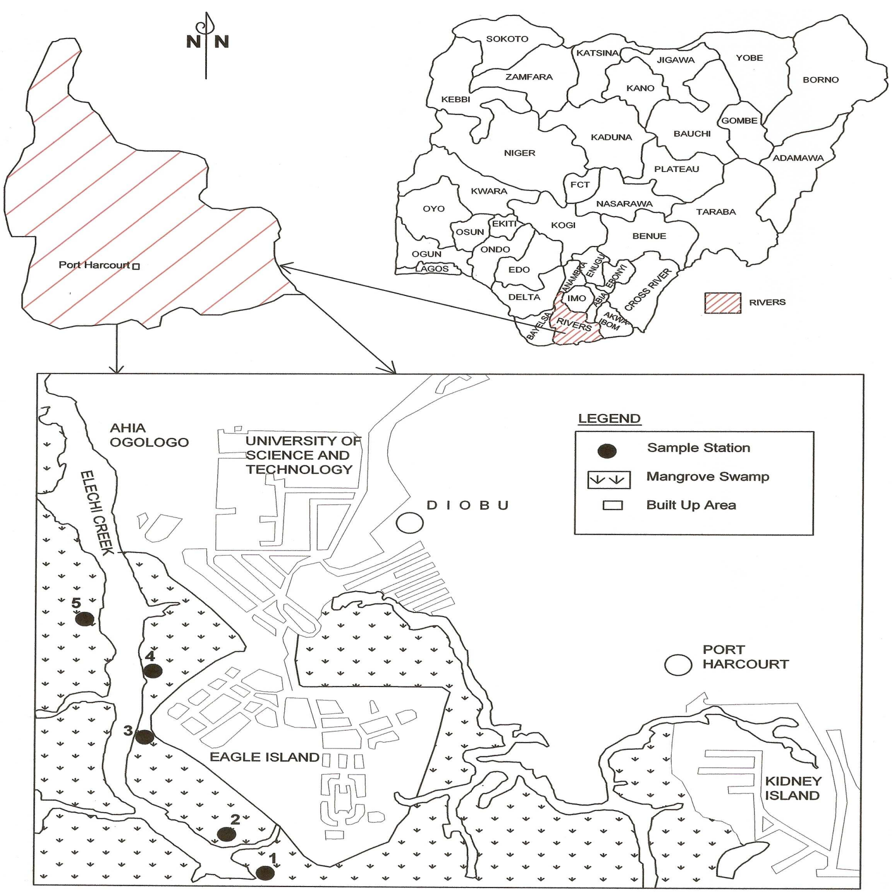

Fig. 1: Study area map

Phytoplankton samples were collected by using sterilized, one-liter wide mouth plastic container at each sampling station[7]. The filtered samples were washed into the sterilized collecting bottles and immediately fixed in 4% formalin. Identification and enumeration were done by using leitzuezier binocular microscope and keys by Newell and Newell[8], Han[9], Prescott[10] and Kadiri[11] .

RESULTS

Phytoplankton taxa: The recorded phytoplankton belonged to five taxa namely: Bacillariophyceae (diatoms), Cyanophyceae (blue-green algae), Euglenophyceae (euglenin), Chlorophyceae (green algae) and Dinophyceae (dinoflagellates). Diatoms 36.09% were the largest group of the phytoplankton and the least was dinoflagellates 0.02% (Table 1). One hundred and sixty nine species of phytoplankton were recorded. Phytoplankton abundance ranged between 13294 counts mL^{-1} (station 3) and 23938 counts mL^{-1} (station 5). A total of 108 species of diatoms were observed in the study stations (Table 2). The most dominant species was *Navicula placentula* (1167 counts mL^{-1}, 3.51%) followed by *Cyclotella comta* (1099 counts mL^{-1} 3.31%), *Nitzschia sigma* (1024 counts mL^{-1}, 3.08%) and *Melosira varians* (1022 counts mL^{-1}, 3.07%). The maximum number of species (108 species) was recorded in station 5 and the minimum (74 species) in station 1. The number of blue-green algae species ranged between 27 species (station 1) and 40 species (station 5) (Table 3). *Anabaena spiroides* (1712 counts mL^{-1}, 5.20%) was the most abundant blue-green algae species. Other prominent species were *Anabaena flos-aquae* (1657 counts mL^{-1}, 5.04%), *Oscillatoria limosa* (1627 counts mL^{-1}, 4.94%), *Anabaena affinis* (1568 counts mL, 4.77%) and *Rivularia plancton* (1502 counts mL^{-1}).

Table 1: Phytoplankton abundance in Elechi Creek

Phytoplankton taxa	Phytoplankton abundance (counts mL^{-1})	Percentage abundance (%)	No. of species	Station	Phytoplankton abundance (counts mL^{-1})
Bacillariophyceae	33255	36.09	108	1	20210
Cyanophyceae	32909	35.72	40	2	19644
Euglenophyceae	25868	28.08	9	3	15051
Chlorophyceae	83	0.09	7	4	13294
Dinophyceae	22	0.02	5	5	23938
Total	92137	100.00	169	5	92137

Table 2: Species composition and abundance of Bacillariophyceae in study stations

S. No.	Bacillariophyceae species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
1	*Achnanthes* sp.*	-	-	4	6	17	27
2	*Amphora ovalis*	50	84	55	56	63	308
3	*Amphipleura pellucida*	-	-	5	6	13	24
4	*Asterionella formosa*	48	82	23	24	28	205
5	*A. gracillima*	-	-	1	3	10	14
6	*Attheya zacharias*	41	75	46	48	55	265
7	*Bacillaria**	-	23	3	6	12	44
8	*Bacteriastrum**	-	34	5	8	15	62
9	*Biddulphia**	-	45	7	8	14	74
10	*Cymbella affinis*	35	69	40	42	47	233
11	*C. lacustris*	31	65	36	30	46	208
12	*C. lanceolata*	35	69	40	43	50	237
13	*C. amphioxys*	41	75	46	48	53	263
14	*C. hybrida*	29	63	34	37	41	204
15	*C. parva*	27	61	32	33	40	193
16	*C. cistula*	42	73	40	45	51	251
17	*C.tumida*	51	85	56	57	63	312
18	*C. cuspidata*	45	79	50	53	58	285
19	*C. lata*	48	82	53	55	62	300
20	*Cyclotella antiqua*	-	-	2	5	11	18
21	*C. comta*	211	245	211	213	219	1099
22	*C. kutzingiana*	-	-	-	3	9	12
23	*C. glomerata*	20	54	25	27	34	160
24	*C. meneghiniana*	135	169	140	142	148	734
25	*C. operculata*	153	187	158	160	165	823
26	*C. striata*	30	61	32	34	40	197
27	*Camphylodiscus hibernicus*	-	38	7	9	14	68
28	*Cocconeis diminuta*	28	62	33	34	39	196

Table 2: Continued

29	*C. placentula*	-	63	6	7	12	88
30	*C. scutellum*	-	-	-	3	8	11
31	*Corethron hystrix*	170	204	175	177	156	882
32	*Coscinodiscus excentricus*	42	76	47	49	54	268
33	*C.lacustris*	33	67	38	39	47	224
34	*C. radiata*	48	82	53	56	62	301
35	*Cylindrotheca gracillis*	-	-	-	4	10	14
36	*C.* sp.*	-	-	-	2	7	9
37	*Cymptopleura elliptica*	-	30	3	4	11	48
38	*Diatoma vulgare*	17	51	22	23	31	144
39	*Diploneis elliptica*	-	-	-	3	8	11
40	*Ditylum* sp.*	-	-	-	2	9	11
41	*Epithemia argus*	-	-	-	-	1	1
42	*E. turgida*	-	-	-	-	2	2
43	*E. zebra*	39	73	44	46	51	253
44	*Fragilaria capucina*	32	66	37	39	44	218
45	*F. construens*	41	75	41	43	50	250
46	*F. crotonesis*	-	-	2	4	10	16
47	*F. intermedia*	25	59	30	32	38	184
48	*F.* sp.*	26	60	31	34	40	191
49	*F. virescens*	-	-	-	4	9	13
50	*Frustulia rhomboides*	217	251	222	225	231	1146
51	*Gomphonema acuminatum*	5	39	2	4	8	58
52	*G. angustatum*	-	-	2	5	11	18
53	*G. parvulum*	20	54	25	26	32	157
54	*G* sp.*	-	-	2	5	12	19
55	*Gyrosigma acuminatum*	175	209	177	181	186	928
56	*G. attenuatum*	167	201	172	175	182	897
57	*G. paradox*	18	52	20	25	31	146
58	*G.* sp.*	-	37	8	11	37	93
59	*Hydrosera* sp.*	-	36	7	9	15	67
60	*Melosira distans*	128	162	133	134	140	697
61	*M. granulata*	34	68	39	41	46	228
62	*M. japonica*	-	-	1	3	10	14
63	*M. listans*	159	193	164	167	174	857
64	*M. nummuloides*	-	-	-	2	8	10
65	*M. pusilla*	160	184	155	157	163	819
66	*M.* sp.*	37	71	42	43	49	242
67	*M. undulata*	117	161	132	135	142	687
68	*M. varians*	188	222	193	207	212	1022
69	*Meridion* sp.*	-	-	3	6	14	23
70	*Navicula amphibola*	159	188	159	160	166	832
71	*N. bacillum*	170	199	170	173	181	893
72	*N. cuspidata*	159	193	164	167	173	856
73	*N. gracilis*	55	79	50	51	58	293
74	*N. microcephala*	167	206	177	178	182	910
75	*N. placentula*	233	225	233	235	241	1167
76	*Nitzschia bilobata*	147	181	152	153	185	791
77	*N. filiforms*	185	214	185	186	191	961
78	*N. lanceolata*	64	98	69	71	78	380
79	*N. linearis*	20	61	32	34	39	186
80	*N. longissima*	178	207	178	181	188	932
81	*N. paradoxa*	52	92	63	65	71	343
82	*N. sigma*	189	228	199	201	207	1024
83	*Pinnularia hemiptera*	9	43	14	15	21	102
84	*P. horealis*	5	39	10	11	15	80
85	*P. macilenta*	15	49	5	8	12	89
86	*P. major*	7	71	42	44	52	216
87	*P. mesolepta*	17	51	22	24	30	144
88	*P. viridis*	13	47	18	21	27	126
89	*Rhizolenia eriensis*	-	-	-	5	6	11
90	*R. longiseta*	37	71	42	45	51	246
91	*Skeletonema* sp.*	-	-	1	3	8	12
92	*Stauroneis acuta*	45	79	50	51	57	282
93	*S. parvula*	56	90	61	64	68	339

Table 2: Continued

94	*Stephanodiscus astrae*	29	60	31	32	38	190
95	*S.* sp.*	-	5	4	6	13	28
96	*Synedra acus*	80	114	85	86	92	457
97	*S. affinis*	171	205	176	178	182	912
98	*S. ulna*	201	236	206	207	215	1064
99	*Surirella elegans*	21	55	26	29	36	167
100	*S. robusta*	15	49	20	23	29	136
101	*S. tenera*	38	72	43	44	49	246
102	*S. spiralis*	24	58	29	31	37	179
103	*S.* sp.*	-	-	-	-	1	1
104	*Tabellaria binalis*	-	-	-	-	1	1
105	*T. fenestrata*	49	83	54	58	62	306
106	*T. flocculosa*	35	69	30	31	37	202
107	*Thalossiothrix longissimum*	-	32	3	5	13	53
108	*T.* sp.*	-	-	-	4	11	15
	Total (counts mL^{-1})	5643	8474	6015	6247	6876	33255
	No. of species	74	84	94	104	108	

-: Absent; *: Unidentified species; No: Number; S/N: Serial number

Table 3: Species composition and abundance of Cyanophyceae in study station

S. No.	Cyanophyceae species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
1	*Anabaena affinis*	734	351	185	150	148	1568
2	*A. circirolis*	-	180	136	101	35	452
3	*A.* sp.*	-	210	191	156	90	647
4	*A. spiroides*	827	406	197	162	120	1712
5	*A. flos-aquae*	826	361	194	159	117	1657
6	*Anabaenopsis arnoldii*	617	376	184	149	107	1433
7	*Anacystis* sp.*	615	381	186	151	109	1442
8	*Aphanothece stagnina*	-	-	113	38	32	183
9	*A. clathrata*	-	-	-	40	30	70
10	*Cochochloris stagnina*	-	-	190	155	89	434
11	*Lyngbya contoria*	-	-	155	120	54	329
12	*L. limtica*	170	105	153	118	52	598
13	*L. major*	182	98	134	99	33	546
14	*Merismopedia sp**	-	-	-	-	30	30
15	*Microcystis aeruginosa*	125	205	176	141	75	722
16	*M. flos-aquae*	100	176	187	152	86	701
17	*M. grevillei*	426	170	118	83	52	849
18	*M. pulverea*	502	190	173	138	72	1075
19	*Mougectia* sp.*	-	-	172	137	71	380
20	*Nodularia* sp.*	-	210	180	145	81	616
21	*Nostoc planctonicum*	-	160	138	103	67	468
22	*N. verrucosum*	130	225	144	109	43	651
23	*Oscillatoria lacustris*	572	411	193	158	116	1450
24	*O. limosa*	734	413	199	160	121	1627
25	*O. princeps*	447	150	145	110	60	912
26	*O. rubescens*	150	112	197	162	96	717
27	*O. tenuis*	500	391	180	145	103	1319
28	*Phormidium muciola*	201	117	122	87	21	548
29	*P.* sp.*	-	192	123	88	45	448
30	*P. tenue*	445	219	111	76	79	930
31	*P. valderiae*	-	-	-	-	39	39
32	*Raphidiopisis curvata*	122	140	120	85	88	555
33	*R. mediteranea*	-	-	143	108	77	328
34	*Rivularia plancton*	600	440	195	160	107	1502
35	*Spirulina laxissima*	590	378	198	163	121	1450
36	*S. major*	156	130	150	115	87	638
37	*S. princeps*	190	150	153	118	54	665
38	*S. subtilissima*	425	147	148	113	37	870
39	*Tolypothris distorta*	582	363	196	161	119	1421
40	*Trichodes lacastre*	451	160`	139	104	73	927
	Total (counts mL^{-1})	11419	7717	6018	4719	3036	32909
	No. of species	27	32	37	38	40	

-: Absent; *: Unidentified species; No: Number; S/N: Serial number

Table 4: Euglenophyceae species composition and abundance in study stations

S. No.	Euglenophyceae species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
1	*Euglena acus*	616	853	655	686	3067	5877
2	*E. convoluta*	290	323	280	208	2576	3677
3	*E. gracilis*	606	731	641	748	3082	5808
4	*E. oxyuris*	115	-	-	-	-	115
5	*E. viridis*	374	407	360	410	2744	4295
6	*E. wangi*	362	393	352	-	-	1107
7	*Lepocinclis ovata*	334	367	324	252	-	1277
8	*Phacus acuminatus*	200	378	404	-	-	982
9	*Trachelomona cylindrica*	224	-	-	-	2506	2730
	Total (counts mL^{-1})	3121	3452	3016	2304	13975	25868
	No. of species	9	8	7	5	5	

-: Absent; *: Unidentified species; No: Number; S/N: Serial number

Table 5: Species composition and abundance of Chlorophyceae in study stations

S. No.	Chlorophyceae species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
1	*Ankistrodesmus falcatus*	-	-	-	1	3	4
2	*Cosmarium granatum*	9	-	-	3	8	20
3	*Pithiphora* sp.*	-	-	-	-	2	2
4	*Scenedesmus acuminatus*	11	1	2	6	13	33
5	*Selenastrum* sp.*	-	-	-	2	4	6
6	*Stichococcus* sp.*	-	-	-	-	3	3
7	*Ulothrix sp**	7	-	-	3	5	15
	Total (counts mL^{-1})	27	1	2	15	38	83
	No. of species	3	1	1	5	7	

-: Absent; *: Unidentified species; No: Number; S/N: Serial number

Table 6: Species composition and abundance of Dinophyceae in study station

S. No.	Dinophyceae species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
1	*Ceratium furcas*	-	-	-	3	4	7
2	*Gymnodinium aeruginosum*	-	-	-	-	1	1
3	*Peridinium cinatum*	-	-	-	1	2	3
4	*P. hirudinella*	-	-	-	4	5	9
5	*P. umbonatum*	-	-	-	1	1	2
	Total (counts mL^{-1})	-	-	-	9	13	22
	No. of species	-	-	-	4	5	

-: Absent; *: Unidentified species; No: Number; S/N: Serial number

The maximum number of species of euglenin (9 species) was recorded in station 1 and the minimum (5 species) in stations 4 and 5 respectively (Table 4). *Euglena acus* (5877 counts mL^{-1}, 22.72%) was the most abundant euglenin. Generally, *Euglena* species had the highest abundance of the Euglenophyceae. The number of green algae ranged from 1 species (stations 2 and 3) to 7 species (station 3). *Scenedesmus acuminatus* (33 counts mL^{-1}, 39.76%) was the most abundant species (Table 5). Dinoflagellates were absent in stations 1-3. Only 5 species dominated by *Peridinium hirudinella* (9 counts mL^{-1}, 40.9%) were recorded (Table 6).

Species diversity: From Table 7, Bacillariophyceae was the most diversified phytoplankton in terms of Margalef species richness (d), Shannon (H^1), Evenness (E^1) and Dominance indices (D). The highest species richness of diatoms 12.11 was recorded in Station 5 and the lowest 8.45 in station 1. Generally, the dominance index was low (less than 1) for all taxa.

For Cyanophyceae, station 5 recorded the maximum d 4.86 and station 1 the minimum 2.78. H^1 ranged between 3.06 (station 1) and 3.62 (station 5). The highest d 0.99 for Euglenophyceae was observed in station 1 and the lowest d 0.42 in station 5 while station 1 recorded the maximum H^1 2.09 and station 4 the maximum 1.49. Stations 2 and 3 recorded zero species diversity indices for Chlorophyceae. In other stations, the observed diversity indices were d, 0.61 (station 1) and 1.65 (station 5) and H^1 1.08 (station 1) and 1.76 (station 5). Dinophyceae were absent in stations 1,2 and 3 hence zero species diversity were recorded. Station 5 d 1.56 and H^1 1.41 were higher than d 1.37 and H^1 1.22 of station 4 but an opposite trend was observed for E^1 and D.

Table 7: Phytoplankton species diversity indices in the study stations

Plankton taxa	Species diversity index	Station 1	Station 2	Station 3	Station 4	Station 5
Bacillariophyceae	d	8.45	9.18	10.69	11.79	12.11
	H^l	4.49	5.02	4.82	4.85	4.89
	E^l	2.08	2.21	2.15	2.12	2.09
	D	0.02	0.05	0.03	0.03	0.04
Cyanophyceae	d	2.78	3.46	4.14	4.37	4.86
	H^l	3.06	3.46	3.55	3.59	3.62
	E^l	0.93	0.95	0.97	0.99	1.03
	D	0.04	0.03	0.03	0.03	0.02
Euglenophyceae	d	0.99	0.74	0.75	0.52	0.42
	H^l	2.09	1.88	1.89	1.49	1.61
	E^l	0.95	0.97	0.97	0.93	1.00
	D	0.14	0.17	0.16	0.23	0.20
Chlorophyceae	d	0.61	0.00	0.00	1.48	1.65
	H^l	1.08	0.00	0.00	1.46	1.76
	E^l	0.98	0.00	0.00	0.91	0.90
	D	0.35	0.00	0.00	0.21	0.18
Dinophyceae	d	0.00	0.00	0.00	1.37	1.56
	H^l	0.00	0.00	0.00	1.22	1.41
	E^l	0.00	0.00	0.00	0.88	0.55
	D	0.00	0.00	0.00	0.25	0.22

d: Margalef species richness; H^l: Shannon index; E^l: Evenness index; D: Simpson dominance index

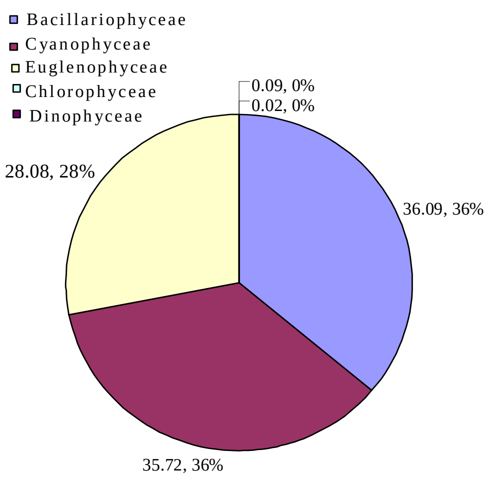

Fig. 2: Percentage contribution of phytoplankton groups in Elechi Creek

Phytoplankton contribution in Elechi Creek: Bacillariophyceae contributed the highest number of phytoplankton 36.09% in Elechi Creek followed by Cyanophyceae 35.72% and the lowest was Dinophyceae 0.02% (Fig. 2). From Fig. 3, the order of diatoms in the stations was 2>5>4>3>1. For Cyanophyceae, it was 1>2>3>4>5, for Euglenophyceae, the order was 5>2>1>3>4 and for Chlorophyceae, it was 3>1>4>3>1. Stations 4 and 5 had the same percentage contribution for Dinophyceae.

Physico-chemical parameters: Temperature variation in relation to station was insignificant (p>0.05) and ranged between 29.0°C (Station 5) and 30.7°C

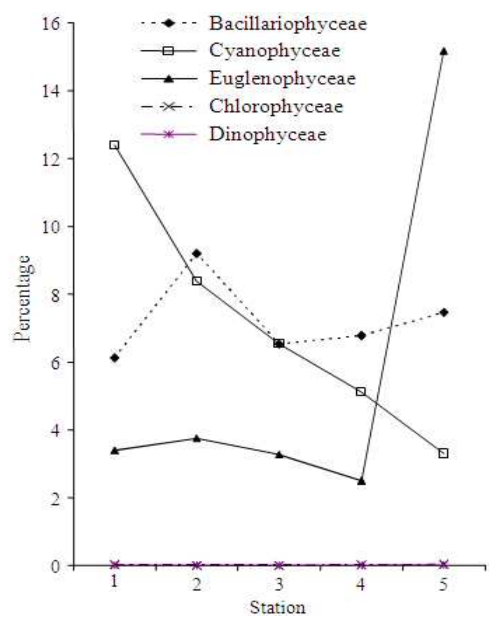

Fig. 3: Spatial percentage contribution of phytoplankton group in Elechi Creek

(station 1) (Table 8). The lowest transparency (0.27 m) was recorded in station 4 and the highest 0.67 m in station 2. Salinity ranged from 7.36% (station 4) to 22.73% (station 5). The maximum chloride 8430 mg L^{-1} was observed in Station 5 and minimum 2832 mg L^{-1} in station 4. The alkalinity ranged between 48 mg L^{-1} (station 1) and 80 mg L^{-1} (station 4). Sulphate was highest in station 1 1231.3 mg L^{-1} and lowest in station 4 (377.6 mg L^{-1}).

Table 8: Physico-chemical quality of surface water in the study stations

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5
Temperature (°C)	30.70±0.03[a]	3.03±0.04[a]	29.70±0.01[a]	29.00±0.01[a]	29.30±0.02[a]
Transparency (m)	0.48±0.01[b]	0.67±0.02[a]	0.59±0.02[b]	0.27±0.03[c]	0.75±0.10[a]
Salinity (‰)	20.50±0.83[a]	18.50±1.60[b]	1.27±1.22[c]	7.36±.0.10[d]	22.73±1.83[a]
Chloride (mg L^{-1})	69820.00±63.79[b]	6059.00±60.50[b]	4017.00±46.41[c]	2832.00±20.62[d]	8430.00±80.19[a]
Alkalinity (mg L^{-1})	48.00±0.75[c]	50.00±1.92[c]	56.70±3.94[b]	80.00±3.94[a]	52.00±2.78[c]
Sulphate (mg L^{-1})	1231.30±101.01[a]	767.00±42.77[b]	584.70±42.85[c]	377.60±43.86[d]	1147.20±90.26[a]

Means in the same row with the same letter are not significantly different (p>0.05)

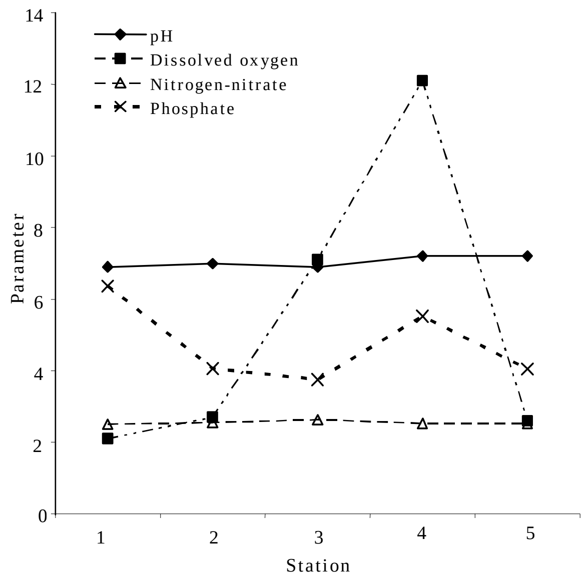

Fig. 4: Chemical quality of surface water in the study stations

pH values was maximum 7.2 in station 4 and minimum 6.9 in station 1 (Fig. 4). The highest dissolved oxygen 12.1 mg L^{-1} was recorded in station 4 and lowest 2.1 mg L^{-1} in station 1. Nitrogen-nitrate ranged between 2.50 mg L^{-1} station 1 and 2.63 mg L^{-1} (station 3). The highest phosphate level 6.36 mg L^{-1} was observed in station 1 and the lowest 3.75 mg L^{-1} in station 3.

DISCUSSION

The high phytoplankton species composition, diversity and abundance recorded for the entire study were more than the values reported for studies in other waters of Bonny Estuary and Niger Delta. This indicates that these phytoplankton will support commercial fisheries in this creek[1,2]. This might be attributed to the high nutrients status (phosphate, nitrate and sulphate). This creek receives enormous quantities of anthropogenic wastes (domestic and industries) such as raw human and animal faces from its surroundings. These wastes increase the nutrients capabilities of this creek. The present observation might be attributed to environmental influence like high temperature, low pH, transparency and dissolved oxygen. Phosphorus stimulates phytoplankton (algae) growth. According to Frankovick *et al*.[12], the epiphytic diatom assemblage of the Florida Bay Estuary was structured by nutrient availability particularly phosphorus. Phosphate might have structured the phytoplankton community of Elechi Creek. High temperature enhances photosynthesis and this is expected during the dry months. High phytoplankton growths lead to high photosynthetic activities thus enough food for organisms in higher trophic levels and for these algae. In addition, photosynthetic activities of the algae are usually higher during the dry months hence the present observation. Some of these algae are expected to die and decay. The decomposed matter will invariably increase the nutrients of this creek. The low pH makes nutrients (such as phosphate and nitrate) available to the primary producers.

The high abundance of phytoplankton in station 5 might be attributed to the large amounts of domestic and industrial wastes containing high level of phosphates from the Diobu and Eagle Island areas. The Diobu area of Port Harcourt is densely populated. The waterfront areas lack sanitary facilities.

The dominance of diatoms and blue-green algae indicate that Elechi Creek is polluted. Ruivo[13]states that natural unpolluted environments are characterized by balanced biological conditions and contains a great diversity of plants and animals life's with no one species dominating. The difference in the community structure despite the dominance by diatoms is mainly due to the importance assumed by Cyanophyceae, Chlorophyceae and Euglenophyceae in the phytoplankton community. However, the distribution of diatoms reflects the average ecological conditions of this aquatic environment[14]. Dinoflagellates were the least abundant and this might be attributed to their inefficiency to compete for nutrients[15,16].

The maximum number of diatoms species in station 5 might probably due to immense municipal wastes from the surroundings. The recorded dominant species could be as a result of high phosphate concentration and organic pollutants in these wastes. These species have been implicated with organic pollution. The same reason for highest number of diatom species in station 5 might be given for blue-green algae species in station 5. *Anabaena spiroides* had also been implicated with organic pollution[17]. The presence of dominant *Euglena* species further indicates organic pollution. However, the presence of *Ceratium furcas* in stations 4 and 5 also shows organic pollution in Elechi Creek. Dominant species might indicate that these species love nutrients-rich environment. The presence of all these indicator phytoplankton species serves as a warning to the rise in nutrient capabilities of Elechi Creek. It is possible that diatoms and blue-green algae possess resilient ability to withstand organic pollution. Organic pollution eliminates the enemies of the more tolerant species which in turn increase in numbers.

The observed spatial variations of the phytoplankton might be attributed to the varied physico-chemical parameters. The recorded high temperature and low transparency favored the high abundance of phytoplankton. This is expected in tropical water bodies and fell within the acceptable range[18]. The present range of transparency is characteristic of brackish environment[18]. The recorded salinity, chloride and alkalinity were suitable for phytoplankton growths. The recorded salinity shows brackish environment. Salinity is one of the major factors influencing algae zonation and distribution within estuaries, both in terms of range of values and rate of changes[12]. It might be responsible for the observed variations of phytoplankton in this creek.

One of the factors that is likely to play an important role in determining community productive levels is nutrients availability; nitrogen, phosphate and sulphate[12]. No station showed absence of nitrogen (nitrate-nitrogen) or phosphate (phosphate-phosphorus) but the concentrations seem limiting hence the varied diatoms density. This emphasizes the influence and significant role of nutrients in phytoplankton productivity in the stations. The phosphate level recorded was higher than the permissible concentrations in natural aquatic bodies (0.10 mg L^{-1})[19]. This might be attributed to the raw human and animal faces. The high sulphate concentration is characteristic of brackish water[18]. However, the high nutrients levels (phosphate, sulphate and nitrogen-nitrate) enhanced the growths of phytoplankton.

It could reasonably be concluded that Elechi Creek is hypereutrophic and organic polluted. The high nutrients status favors the high abundance of phytoplankton. The municipal effluents (especially raw human and animal faces) discharges must be discouraged or discontinued. Detergents with low concentration of phosphate are recommended for manufacturing and use. Municipal wastes must be treated and/or recycled before discharge into this natural aquatic body. Therefore, a continuous environmental surveillance of this creek is advocated to keep its biological integrity.

CONCLUSION

The high abundance of phytoplankton in Elechi Creek can support fisheries but its nutrients availability especially phosphate of Elechi Creek is very high. This high phosphate level indicates that this creek is under stress. Its biological integrity may completely be destroyed if remedial and surveillance measures are not promptly taken by the Rivers State government.

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