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 river 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 bimonthly 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 Desce\(^{[3]}\), phytoplankton communities are major producers of organic carbon in large rivers, a food source for planktonic consumers and may represent 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\(^{[4]}\). 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\(^{[5]}\) reports that pollution affects plankton distribution, standing crop and chlorophyll concentration. This study was conducted to assess the
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'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](image-url)
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 placenta* (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\(^{-1}\), 4.77\%) and *Rivularia plancton* (1502 counts mL\(^{-1}\)).

| 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                                          | 0.90                      | 7              | 4       | 13294                                       |
| Dinophyceae        | 22                                          | 0.02                      | 5              | 5       | 23938                                       |
| Total              | 92137                                       | 100.00                    | 169            | 5       | 92137                                       |

Table 1: Phytoplankton abundance in Elechi Creek

| S. No. | Bacillariophyceae species | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Total |
|--------|---------------------------|-----------|-----------|-----------|-----------|-----------|-------|
| 1      | *Achnanthes sp.*          | -         | -         | 4         | 6         | 1         | 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. gracilima              | -         | -         | 1         | 3         | 10        | 14    |
| 6      | Atheye zacharias          | 41        | 75        | 46        | 48        | 55        | 265   |
| 7      | Bacillaria*               | -         | 23        | 3         | 6         | 12        | 44    |
| 8      | Bacteriastrum*            | -         | 34        | 5         | 8         | 15        | 62    |
| 9      | Bidulphia*                | -         | 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. kutzogiana             | -         | -         | -         | 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 diminata        | 28        | 62        | 33        | 34        | 39        | 196   |
Table 2: Continued

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 29 | C. placenta | - | 63 | 6 | 7 | 12 | 88 |
| 30 | C. scutelatum | - | - | - | 3 | 8 | 11 |
| 31 | Corethron hystricetus | 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 | Cympodiscus elliptica | - | 30 | 3 | 4 | 11 | 48 |
| 38 | Diatoma vulgaris | 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. virens | - | - | - | 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 | 33 | 67 | 38 | 39 | 47 | 224 |
| 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. paradoxa | 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. ululata | 117 | 161 | 132 | 135 | 142 | 687 |
| 68 | M. varians | 188 | 222 | 193 | 207 | 212 | 1022 |
| 69 | Meridion sp.* | - | - | 3 | 6 | 14 | 23 |
| 70 | Navicula amphibia | 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. placenta | 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 | Rhizosolenia eriensis | - | - | 5 | 6 | - | 11 |
| 90 | R. longiseta | 37 | 71 | 42 | 45 | 51 | 246 |
| 91 | Skeletonema sp.* | - | - | 1 | 3 | 8 | 12 |
| 92 | Stauroctonia acuta | 45 | 79 | 50 | 51 | 57 | 282 |
| 93 | S. parvula | 56 | 90 | 61 | 64 | 68 | 339 |
### Table 2: Continued

| S. No. | Species Name                          | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Total |
|--------|---------------------------------------|-----------|-----------|-----------|-----------|-----------|-------|
| 94     | Stephanodiscus astraæ                 | 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. uta                                | 201       | 236       | 206       | 207       | 215       | 1064  |
| 99     | Sarirella 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     |
| 104    | Tabellaria binalis                     | -         | -         | -         | -         | -         | 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    |

-: 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. circiculata           | -         | 180       | 136       | 101       | 35        | 452   |
| 3      | A. sp.*                  | -         | 210       | 191       | 156       | 90        | 647   |
| 4      | A. spiroides             | 827       | 406       | 197       | 162       | 120       | 1712  |
| 5      | A. flas-azure            | 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. chlorinae             | -         | -         | 40        | 30        | 70        |
| 10     | Cochleochloris stagnina  | -         | -         | 190       | 155       | 89        | 434   |
| 11     | L. limicola              | 170       | 105       | 153       | 118       | 52        | 598   |
| 12     | L. major                 | 182       | 98        | 134       | 99        | 33        | 546   |
| 13     | Merismopedia sp*         | -         | -         | -         | -         | 30        | 30    |
| 14     | Microcystis aeruginosa   | 125       | 205       | 176       | 114       | 75        | 722   |
| 15     | M. flas-azure            | 100       | 176       | 187       | 152       | 86        | 701   |
| 16     | M. greggii               | 426       | 170       | 118       | 83        | 52        | 849   |
| 17     | M. palvea                | 502       | 190       | 173       | 138       | 72        | 1075  |
| 18     | Mougetgia sp.*           | -         | -         | 172       | 137       | 71        | 380   |
| 19     | Nodularia sp.*           | -         | 210       | 180       | 145       | 81        | 616   |
| 20     | Nostoc planctonicum      | -         | 160       | 138       | 103       | 67        | 468   |
| 21     | N. verrucosum            | 130       | 225       | 144       | 109       | 43        | 651   |
| 22     | Oscillatia lacustris     | 572       | 411       | 193       | 158       | 116       | 1450  |
| 23     | O. limosa                | 734       | 413       | 199       | 160       | 121       | 1627  |
| 24     | O. princeps              | 447       | 150       | 145       | 110       | 60        | 912   |
| 25     | O. rubescens             | 150       | 112       | 197       | 162       | 96        | 717   |
| 26     | O. tenus                 | 500       | 391       | 180       | 145       | 103       | 1319  |
| 27     | Phormidium mucicola      | 201       | 117       | 122       | 87        | 21        | 548   |
| 28     | P. sp.*                  | -         | 192       | 123       | 88        | 45        | 448   |
| 29     | P. tenue                 | 445       | 219       | 111       | 76        | 79        | 930   |
| 30     | P. valderiae             | -         | -         | -         | -         | 39        | 39    |
| 31     | Raphidiopsis curvata     | 122       | 140       | 120       | 85        | 88        | 555   |
| 32     | R. mediterranea          | -         | -         | 143       | 108       | 77        | 328   |
| 33     | Rivularia plancton       | 600       | 440       | 195       | 160       | 107       | 1502  |
| 34     | Spirulina lissnina       | 590       | 378       | 198       | 163       | 121       | 1450  |
| 35     | S. major                 | 156       | 130       | 150       | 115       | 87        | 638   |
| 36     | S. princeps              | 190       | 150       | 153       | 118       | 54        | 665   |
| 37     | S. subsulissina          | 425       | 147       | 148       | 113       | 37        | 870   |
| 38     | Tolyphothrix distorta    | 582       | 363       | 196       | 161       | 119       | 1421  |
| 39     | Trichodes lacastre       | 451       | 160       | 139       | 104       | 73        | 927   |

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

Total (counts mL\(^{-1}\)) 11419 7717 6018 4719 3036 32909

No. of species 27 32 37 38 40 40
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                       | 4.49      | 5.02      | 4.82      | 4.85      | 4.89      |
|                   | E                       | 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                       | 3.06      | 3.46      | 3.55      | 3.59      | 3.62      |
|                   | E                       | 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                       | 2.09      | 1.88      | 1.89      | 1.49      | 1.61      |
|                   | E                       | 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                       | 1.08      | 0.00      | 0.00      | 1.46      | 1.76      |
|                   | E                       | 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                       | 0.00      | 0.00      | 0.00      | 1.22      | 1.41      |
|                   | E                       | 0.00      | 0.00      | 0.00      | 0.88      | 0.55      |
|                   | D                       | 0.00      | 0.00      | 0.00      | 0.25      | 0.22      |

Table 8: 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 (Station 1).
- 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<sup>a</sup> | 30.03±0.04<sup>a</sup> | 29.70±0.01<sup>a</sup> | 29.00±0.01<sup>a</sup> | 29.30±0.02<sup>a</sup> |
| Transparency (m)  | 0.48±0.01<sup>a</sup> | 0.67±0.02<sup>a</sup> | 0.59±0.02<sup>a</sup> | 0.27±0.03<sup>a</sup> | 0.75±0.10<sup>a</sup> |
| Salinity (%)      | 20.50±0.83<sup>a</sup> | 18.50±1.60<sup>a</sup> | 1.27±1.22<sup>a</sup> | 7.36±0.10<sup>a</sup> | 22.73±1.83<sup>a</sup> |
| Chloride (mg L<sup>-1</sup>) | 69820.00±63.79<sup>b</sup> | 6059.00±0.50<sup>b</sup> | 4017.00±46.41<sup>e</sup> | 2832.00±20.62<sup>d</sup> | 8430.00±80.19<sup>b</sup> |
| Alkalinity (mg L<sup>-1</sup>) | 48.00±0.75<sup>c</sup> | 50.00±1.92<sup>c</sup> | 56.70±3.94<sup>d</sup> | 80.00±3.94<sup>c</sup> | 52.00±2.78<sup>c</sup> |
| Sulphate (mg L<sup>-1</sup>) | 1231.30±101.01<sup>b</sup> | 767.00±42.77<sup>b</sup> | 584.70±42.85<sup>e</sup> | 377.60±43.86<sup>d</sup> | 1147.20±90.26<sup>e</sup> |

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<sup>-1</sup> was recorded in station 4 and lowest 2.1 mg L<sup>-1</sup> in station 1. Nitrogen-nitrate ranged between 2.50 mg L<sup>-1</sup> station 1 and 2.63 mg L<sup>-1</sup> (station 3). The highest phosphate level 6.36 mg L<sup>-1</sup> was observed in station 1 and the lowest 3.75 mg L<sup>-1</sup> 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<sup>[1,2]</sup>. 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.<sup>[12]</sup>, 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<sup>[13]</sup> 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<sup>[14]</sup>. Dinoflagellates were the least abundant and this might be attributed to their inefficiency to compete for nutrients.<sup>[15,16]</sup>

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 algae 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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