*Available online a*t www.aexpbio.com

ISSN : 2348-1935

RESEARCH ARTICLE

Annals of Experimental Biology
2014, 2 (2):1-8

Effects of Flooding on Amassoma Flood Plain Phytoplankton Niger Delta, Nigeria

Akankali, J.A.[1], Abowei J.F.N[2] and CHARLES, E[2*]

[1]Department of Animal Science and Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, Nigeria
[2]Department of Biological Sciences, Faculty of Science, Niger Delta University,Wilberforce Island, Bayelsa State, Nigeria.

ABSTRACT

The Effects of Flood on Amassoma Flood Plain Sediments Niger Delta, Nigeria was studied for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with previous results obtained in the study area. A total of forty-three (43) phytoplankton species belonging to five (5) families were present both before and after flooding. These include: BACILLARIOPHYCEAE: Meloira granulate, Melosira varians, Melosira distance, Melosira pusila, Naviicula viridula, Nitzischia sigma, Cyclotella operculata, Cyclotella omata, Cosinodiscus lacustris, Cymbella lata, Fragilaria intermedia, Gyrosigma acuminatum, Pinnularia horealis, Amphora ovalis, Synedra ulna, Stephanodiscus asroea and Tabellaria fenestrrata; CHLOROPHYCEAE: Volvox aureus, Volvox globator, Coelastrum reticulate, Closterium intermedium, Closterium pervulum, Closterium gracile, Crusigenia puadrata, Crusigenia truncate, Netrium digitatus, Netrium intermedium, Gonatozygon aculeatum, Spirogyra sp, Spirotaenia condensate and Desmidium sp; CYNOPHYCEAE: Anabaena spiroides, Anabaena affinis, Anabaena arnoldii, Oscillartoria lacustris, Oscillartoria princeps, Raphidiopsis mediteranea, Rivularia sp and Lymbya limnetica; CHRYSOPHYCEAE: Dinobryon sertularia and XANTHOPHYCEAE: Trbonema minus and Tribonema viridis. Phytoplankton population also decreased drastically after the flooding though there was no significant variation between sampling stations.

Key words: Flooding effects, phytoplankton, Flood plain, Niger Delta, Nigeria

INTRODUCTION

Phytoplanktons are plants (microscopic), drifting at the mercy of water current [1]. They constitute the primary producers of aquatic ecosystems. They convert incident radiant energy of the sun to chemical energy in the presence of nutrients like phosphorous, nitrogen, iron, manganese, molybdenum and zinc. They are restricted to the aphetic zone where there is enough light for photosynthesis. The distribution, abundance and diversity reflect the physico-chemical conditions of aquatic ecosystem in general and its nutrient statue in particular [1]. In the aquatic ecosystem, the phytoplankton is the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell fish and finfish [2]. The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers [3]. Townsend *et al* (2000) reported that plankton communities serve as bases for food chain that supports the commercial fisheries [4]. Davies *et. al*; (2009) had also reported that phytoplankton communities are major producers of organic carbon in large rivers[3], a food source for planktonic consumers and may represent the primary oxygen source in lowgradient Rivers. Phytoplanktons are of great importance in bio-monitoring of pollution [3]. The distributions, abundance, species diversity, species composition of the phytoplankton are used to assess the biological integrity of the water body (Townsend *et al.* 2000). Phytoplankton also reflects the nutrient status of the environment. They do not have control over their movements thus they cannot escape pollution in the environment. Barnes (1980) reported that pollution affects the distribution, standing crop and chlorophyII concentration of phytoplankton [5].

Fertilization may not be the only reason for eutrophication or excessive growth of planktons in pond water surface. The growth of certain species of blue green algae such as *Microcystis*, *Anabaena*, *Tracheiomona* and the dinoflagellate, *Gymnodinium* form dense scums in surface waters. These are not in any way due to fertilization. Such growth can be the primary cause of fish kill in ponds. Dense growths of these algae absorb heat from the sunlight, causing a sharp rise in temperature of surface waters. This rise causes a shallow thermal stratification because light wind stiffed on only top waters. The heavy concentration of algae prevents the penetration of light for photosynthesis to depths below 1m. This causes anoxic condition in the deep areas, resulting in fish kills. The water becomes brown in colour with most of the plankton dead. No soluble phosphate is present in the top layer. The kills may have resulted from lack of oxygen and high concentration of free carbon dioxide.

Phytoplankton scum can be controlled by, avoiding excessive concentrations of phytoplankton scum especially *microcystis* on surface waters of fishponds. When such sums appear, dissolved oxygen should be measured daily to ensure that oxygen is present in depths below 1.3 meters.

Light penetration and distribution of dissolved oxygen in ponds can be facilitated with copper tetraoxosulphate (vi) in one or two applications, a week. The quantity of copper tetraoxosulphate (vi) ($CuSO_4$) in waters with 25ppm hardness is 800g/hectare surface area. The disadvantage is that, it adds to the total Biochemical oxygen demand BOD in the water. Nutrients may later recycle and cause heavy scum. Biological control using herbivores (plankton feeding fishes) appear more promising.

Floodplain or flood plain is an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. It includes the floodway, which consists of the stream channel and adjacent areas that actively carry flood flows downstream, and the flood fringe, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream which floods when the water level reaches flood stage. Flood plains are made by a meander eroding sideways as they travel downstream. When a river breaks its banks and floods, it leaves behind layers of alluvium (silt). These gradually build up to create the floor of the flood plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. These are accumulations of sand, gravel, loam, silt, and/or clay, and are often important aquifers, the water drawn from them being pre-filtered compared to the water in the river.

Geologically ancient floodplains are often represented in the landscape by fluvial terraces (Fig. 1). These are old floodplains that remain relatively high above the present floodplain and indicate former courses of a stream. Sections of the Missouri River floodplain taken by the United States Geological Survey show a great variety of material of varying coarseness, the stream bed having been scoured at one place and filled at another by currents and floods of varying swiftness, so that sometimes the deposits are of coarse gravel, sometimes of fine sand or of fine silt. It is probable that any section of such an alluvial plain would show deposits of a similar character.

The floodplain during its formation is marked by meandering or anastigmatic streams, ox-bow lakes and bayous, marshes or stagnant pools, and is occasionally completely covered with water. When the drainage system has ceased to act or is entirely diverted for any reason, the floodplain may become a level area of great fertility, similar in appearance to the floor of an old lake. The floodplain differs, however, because it is not altogether flat. It has a gentle slope down-stream, and often, for a distance, from the side towards the centre. Floodplains can support particularly rich ecosystems, both in quantity and diversity. Amassoma forests form an ecosystem associated with floodplains. They are a category of riparian zones or systems. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly; however the surge of new growth endures for some time. This makes floodplains particularly valuable for agriculture.

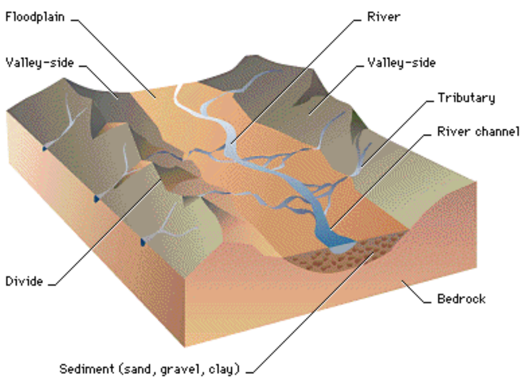


Fig 1 Anatomy of a Floodplain

The word "flood" comes from the Old English </wiki/Old_English_language> /flod/, a word common to Germanic languages (compare German /Flut/, Dutch /vloed/ from the same root as is seen in /flow, float/; also compare with Latin /fluctus/, /flumen/). Deluge myths are mythical stories of a great flood sent by a deity or deities to destroy civilization as an act of divine retribution, and are featured in the mythology of many cultures. Floods can also occur in rivers, when flow exceeds the capacity of the river channel, particularly at bends or meanders. Floods often cause damage to homes and businesses if they are placed in natural flood plains of rivers. While flood damage can be virtually eliminated by moving away from rivers and other bodies of water, since time out of mind, people have lived and worked by the water to seek sustenance and capitalize on the gains of cheap and easy travel and commerce by being near water. That humans continue to inhabit areas threatened by flood damage is evidence that the perceived value of living near the water exceeds the cost of repeated periodic flooding [6].

Floods (Plate 1) are also known to renew wetland areas which in turn host a wide range of flora and fauna. Preventing flood waters from entering such wetland areas will create imbalance to the natural state of things resulting in destruction of natural habitats and even extinction of various species of animals and plants. Floods play an important part in various ecosystems. Humans, therefore, should be careful when they try to prevent or control floods. Oftentimes, human intervention causes more harm than good [7]. Flooding of the rivers in the country is not uncommon; the September 2012 devastating flood which was clearly a natural disaster was a pointer to prior preparations being a proactive effort at mitigation of impacts of such disasters, but little information exits on how these flood events affect water and overbank sediment quality within the affected areas.

512 x 343.27KB jpeg
Source:Nayanet.com/news/source/1092p.html

768 x 510.95KB jpeg
Source:Nayanet.com/news/source/1092p.html

Plate1. Cases of flooding in Nigeria in Amassoma flood plain

Floods are caused by many factors: heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tides, tsunamis, or failure of dams, levees, retention ponds, or other structures that retain water. Flooding can be exacerbated by increased amounts of impervious surface or by other natural hazards such as wildfires, which reduce the supply of vegetation that can absorb rainfall. Periodic floods occur on many rivers, forming a surrounding region known as the flood plain. During times of rain, some of the water is retained in ponds or soil, some is absorbed by grass and vegetation, some evaporates, and the rest travels over the land as surface runoff. Floods occur when ponds, lakes, riverbeds, soil, and vegetation cannot absorb all the water. Water then runs off the land in quantities that cannot be carried within stream channels or retained in natural ponds, lakes, and man-made reservoirs. About 30 percent of all precipitation becomes runoff and that amount might be increased by water from other flood causing factors.

River flooding is often caused by heavy rain, sometimes increased by melting snow. A flood that rises rapidly, with little or no advance warning, is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area, or if the area was already saturated from previous precipitation. Even when rainfall is relatively light, the shorelines of lakes and bays can be flooded by severe winds that blow water into the shore areas. Coastal areas are also sometimes flooded by unusually high tides, such as spring tides, especially when compounded by high winds and storm surges. Tsunamis which are high, large waves, typically caused by undersea earthquakes, volcanic eruptions or massive explosions also cause flood.

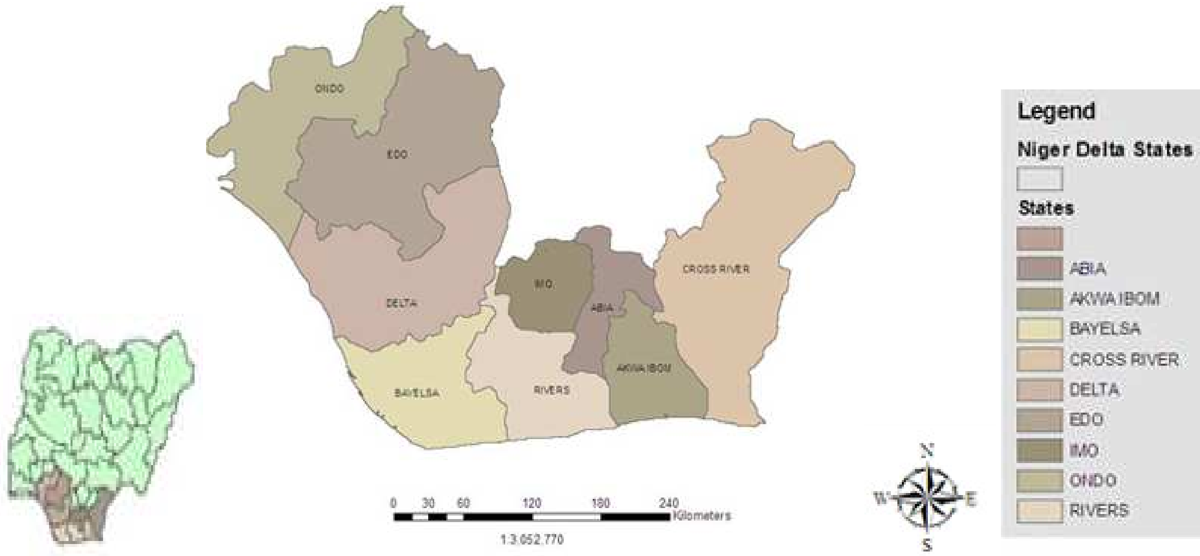
There are many disruptive effects of flooding on human settlements and economic activities. However, floods (in particular the more frequent/smaller floods) can also bring many benefits, such as recharging ground water, making soil more fertile and providing nutrients in which it is deficient. Flood waters provide much needed water resources in particular in arid and semi-arid regions where precipitation events can be very unevenly distributed throughout the year. Freshwater floods, particularly, play an important role in maintaining ecosystems in river corridors and are a key factor in maintaining floodplain biodiversity. Flooding adds a lot of nutrients to lakes and rivers which leads to improved fisheries for a few years; also because of the suitability of a floodplain for spawning (little predation and a lot of nutrients). Fish like the weather fish make use of floods to reach new habitats. Together with fish birds also profit from the boost in production caused by flooding. Periodic flooding was essential to the well-being of ancient communities along the Tigris-Euphrates Rivers, the Nile River, the Indus River, the Ganges and the Yellow River, among others. The viability for hydrological based renewable sources of energy is higher in flood prone regions.

MATERIALS AND METHODS

Study Area

The Niger Delta (Fig. 1) covers 20,000 km² within wetlands of 70,000 km² formed primarily by sediment deposition. Home to 20 million people and 40 different ethnic groups, this floodplain makes up 7.5% of Nigeria's total land mass. It is the largest wetland and maintains the third-largest drainage basin in Africa. The Delta's environment can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests [8]. This incredibly well-endowed ecosystem contains one of the highest concentrations of biodiversity on the planet, in addition to supporting abundant flora and fauna, arable terrain that can sustain a wide variety of crops, lumber or agricultural trees and more species of freshwater fish than any ecosystem in West Africa [9]. The region could experience a loss of 40% of its inhabitable terrain in the next thirty years as a result of extensive dam construction in the region. The carelessness of the oil industry has also precipitated this situation, which can perhaps be best encapsulated by a 1983 report issued by the NNPC, long before popular unrest surfaced. There has been the slow poisoning of the waters of this country and the destruction of vegetation and agricultural land by oil spills which occur during petroleum operations. But since the inception of the oil industry in Nigeria, more than twenty-five years ago, there has been no concerned and effective effort on the part of the government, let alone the oil operators, to control environmental problems associated with the industry [10]. It is estimated that:

- 1.5% of the country is at risk from direct flooding from the sea
- About 7% of the country is likely to flood at least once every 100 years from rivers
- 1.7m homes and 130,000 commercial properties, worth more than £200 billion, are at risk from river or coastal flooding in England
- Many more properties are also at risk from flash floods.



600 x 493 · 34 kB · jpeg
Source:http://www.gisdevlopment.net/application/health/overview/images/map-of-theniger-delta jpg.

Fig.1 Location of the Niger Delta

Sample collection

The study was carried out in Amassoma flood plain, in the Niger Delta of Nigeria for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with results obtained by Ezekiel, 2001[11] and Abowei, 2010 [12]. Four sampling stations were established along the length of the Amassoma River whenever, it was accessible by road. In each of the sampling stations, qualitative sampling of the surface waters was carried out by towing the net slowly behind a boat, at one to three knots for ten minutes. If all the water is filtered through the net (assuming no clogging of mesh by phytoplankton), the volume of water filtered can be calculated using the formula:

$$V = \pi r^2 L$$

Where, r = the radius of the hoop at the front of the net
L = the distance through which the net is hauled.

Hauls of this type are often used to assess the quantity of plankton in a given water column, but there are inaccuracies. The nets have been modified with fitted flow meters. These nets also collect the larger zooplanktons.

A quantitative method of sampling plankton populations is to centrifuge a small water sample and count the plankton in it. Although it is better to examine the plankton alive; examination is delayed for the preservation of the sample. Lugols iodine (10gm of iodine added to 20gk and increased to 200ml of H_2O plus 20g acetic acid) or ten percent neutral formalin is used as fixative. The preservative is added in the ratio of 1:100ml.

In a rough field method, developed for estimation of plankton, 50 liters of water are collected from different sections of the pond. These are filtered through an organdi or a muslin ring net with a 2.45cm diameter glass specimen tube tied to the lower narrow end of the net. Add a pinch of common salt to water in the tube. Detach the tube from the net. Within 15-20 minutes of post salt addition, the plankton settles at the bottom of the tube.

If the resultant sediment is from 6.4 to 8.5 mm of the tube, 50,000 to 75,000 spawn per ha can be stocked in the pond. The animal or plant nature of plankton is differentiated by, either a pace brownish (zooplankton) or greenish (phytoplankton) color. The plankton in the tube can be fixed in 2% formalin for detailed study. It can be concentrated into the Sedgwick – Rafter counting chamber. Carefully position the cover glass over the chamber without forming an air bubble. The glass diagonally across the chamber and slowly rotating the cover glass as the sample is introduced from the pipette.

Place the counting chamber beneath the microscope, select a random microscope field, identify and count planktons seen within the ocular micrometric grid using appropriate keys. Repeat this procedure at least ten times.

Calculation:
The Sedgwick Rafter counting chamber contains 1.00ml (50mm long, 20mm wide x 1mm deep).

$$\text{No of planktons per ml} = \frac{1000Tx}{AN}$$

Where,

T = Total number of plankton counted
X = concentrate volume (ml)
A = Area of grid in (mm)
N = Number of grids employed
1000 = Area of the counting chamber, n (mn^2).

In well managed ponds, with high nutrient concentrations; there is a dense algal growth. Such ponds have denser algae communities than unmanaged ponds and other natural waters [13].

RESULTS

Table 1 shows phytoplankton species present before and after flooding in the study area. A total of forty-three (43) phytoplankton species belonging to five (5) families were present both before and after flooding. These include: BACILLARIOPHYCEAE: *Meloira granulate, Melosira varians, Melosira distance, Melosira pusila, Naviicula viridula, Nitzischia sigma, Cyclotella operculata, Cyclotella omata, Cosinodiscus lacustris, Cymbella lata, Fragilaria intermedia, Gyrosigma acuminatum, Pinnularia horealis, Amphora ovalis, Synedra ulna, Stephanodiscus asroea* and *Tabellaria fenestrrata*; CHLOROPHYCEAE: *Volvox aureus, Volvox globator, Coelastrum reticulate, Closterium intermedium, Closterium pervulum, Closterium gracile, Crusigenia puadrata, Crusigenia truncate, Netrium digitatus, Netrium intermedium, Gonatozygon aculeatum, Spirogyra sp, Spirotaenia condensate* and *Desmidium sp;* CYNOPHYCEAE: *Anabaena spiroides, Anabaena affinis, Anabaena arnoldii, Oscillartoria lacustris, Oscillartoria princeps, Raphidiopsis mediteranea, Rivularia sp* and *Lymbya limnetica;* CHRYSOPHYCEAE: *Dinobryon sertularia* and XANTHOPHYCEAE: *Trbonema minus* and *Tribonema viridis*. Phytoplankton population also decreased drastically after the flooding though there was no significant variation between sampling stations.

DISCUSSION

Phytoplankton population also decreased drastically after the flooding though there was no significant variation between sampling stations. However Forty-three species belonging to 5 taxonomic groups were recorded in the study area. The phytoplankton composition was dominated by *Bacillariophceae* (diatoms) with 18 species (41.9%). *Chlorophyceae* had 14 species consisting of 32.6%. *Cyanophyceae* had 8 species consisting of 18.6%. The other were *Xanthophceae* (2 species) and *Chrysolpheae* (1 specie) consisting of 4.7 and 2.3%, respectively. This result is higher than the reports from some Niger Delta rivers. Yakubu *et a*l. (2000) recorded 17 species from Rivers River Nun[14]. Yakubu *et a*l. (2000) also observed 20 and 34 species from Orashi and Nkisa Rivers respectively [14] while Erondu and Chinda (1991) reported 27 species from New Calabar River [15]. However, the result of this study is lower than the reported 103 species from Imo River [16]. This result compared favourably with the reported 39 species in Lubara Creek [17] and 36 species of phytoplankton from the Lagos Lagoon [18].

Table 1 Phytoplankton Species Present in the study area

Phytoplankton species	Before flooding				After Flooding			
	Station 1	Station 2	Station 3	Mean	Station 1	Station 2	Station 3	Mean
BACILLARIOPHYCEAE								
Meloira granulata	49	74	122	82	12	-	18	10
Melosira varians	221	105	34	120	23	14	11	16
Melosira distance	332	435	217	261	12	07	23	14
Melosira pusila	311	276	233	273	16	8	2	9
Naviicula viridula	113	211	178	187	21	13	7	14
Nitzischia sigma	201	58	136	132	41	18	2	20
Cyclotella operculata	113	326	45	161	18	3	8	10
Cyclotella omata	171	44	69	95	7	3	9	10
Cosinodiscus lacustris	318	69	234	207	18	21	15	17
Cymbella lata	358	132	133	174	14	33	10	15
Fragilaria intermedia	221	231	23	158	3	12	7	10
Gyrosigma acuminatum	263	338	451	351	10	7	2	10
Pinnularia horealis	179	316	213	233	21	33	6	17
Amphora ovalis	180	143	32	118	11	16	3	10
Synedra ulna	58	111	56	75	5	21	13	13
Stephanodiscus asroea	47	98	42	63	-	2	1	1
Tabellaria fenestrrata	179	122	35	100	27	18	20	22
CHLOROPHYCEAE								
Volvox aureus	106	76	87	90	17	8	3	9
Volvox globator	174	56	66	99	6	12	15	11
Coelastrum reticulata	177	85	54	105	4	26	13	14
Closterium intermedium	150	121	36	102	14	-	10	8
Closterium pervulum	107	43	22	57	2	5	-	2
Closterium gracile	157	97	43	99	11	9	6	9
Crusigenia puadrata	123	56	22	67	3	16	11	10
Crusigenia truncata	23	111	89	74	8	-	11	6
Netrium digitatus	75	54	96	85	15	8	2	8
Netrium intermedium	105	37	121	96	12	18	5	13
Gonatozygon aculeatum	129	73	42	64	3	15	4	7
Spirogyra sp	78	36	77	88	11	9	11	11
Spirotaenia condensata	123	43						
Desmidium sp	146							
CYNOPHYCEAE								
Anabaena spiroides	-	4	55	18	4	-	-	1
Anabaena affinis	33	11	34	26	-	2	7	3
Anabaena arnoldii	111	43	-	51	3	6	6	5
Oscillartoria lacustris	27	22	-	16	9	10	8	9
Oscillartoria princeps	56	121	33	70	-	14	10	8
Raphidiopsis mediteranea	46	208	43	99	8	5	5	6
Rivularia sp	33	49	112	65	4	-	2	2
Lymbya limnetica	62	71	4	46	12	8	10	10
	43	27	21	30	1	-	3	1
CHRYSOPHYCEAE								
Dinobryon sertularia	45	-	3	16	-	-	8	3
XANTHOPHYCEAE								
Trbonema minus	65	2	-	22	13	1	1	5
Tribonema viridis	32	12	31	25	7	4	4	3

The result of this study, however, varies considerably from some other studies in Nigeria. Ogamba *et a*l. (2004) reported 143 species in Elechi creek [19]. Davies *et a*l. (2009) recorded 169 species in Elechi Creek [3] and Emmanuel and Onyema (2007) reported 82 species in Lagos Lagoon[2]. Furthermore, 19 Edogbolu and Aleleye-Wokoma (2007) reported 198 species from Ntawogba Creek, Port Harcourt [19]. Phytoplankton abundance is influenced by water temperature, velocity of current, availability of nutrient and light penetration into the water. Yakubu *et a*l. (1998) attributed influence of lotic environment to the difference of total number of species recorded in Nun River [20].

The dominance of Bacillariophyceae in this study is not an unusual occurrence. Many phytoplankton studies have reported the dominance of Bacillariophyceae in rivers and creeks of the Niger Delta and Nigeria [13], [18], [3], [16], [15, [3], [17]. Margalef (1963) had reported that species with the highest self-sustaining natural mechanisms of natural increase usually become dominant [21]. This may account with the widespread dominance of Bacillariophyceae in both fresh and brackish waters.

REFERENCES

[1] A Anene, Springfield Publishers**, 2003,** Pp 174 – 189.
[2] BE Emmanuel and IC Onyema. *Turkish Journal of Fisheries and Aquatic Sciences;* **2007,** 7: 105-113.
[3] OA Davies and JFN Abowei, *Eur. J. Sci. Res.,* **2009**, 26(3): 437-442.
[4] CR Townsend, J.D. Harper and M. Begon, Blackwell Science. **2000**, London, U.K.
[5] RSK Barnes, 1980: Cambridge University Press, London, U. K. **198**0, pp. 106.
[6] RL David, LP David and WE Kenneth, *Hydrobiologia*, **1981** 79: 187 – 194.
[7] IE Esu, Hordon Publishers (Nig.) Ltd., University of Ibadan, Nigeria. **1999**, 54pp.
[8] HE Welch, PEK Symons and DW Narver, *Environ. Can. Technical Report*, **1977**, No. 745.
[9] MT Thompson, Geological Survey Water-Supply Paper 1779-M. **1964**. Washington, D.C.: United States Government Printing Office.
[10] WG Powell, Applied Research Project.**2009**, Texas State University – San Marcos. http://ecommons.txstate.edu/arp/296/
[11]EN Ezekiel, University of Port Harcourt, Choba, **2001**, pp: 77.
[12] JFN Abowei, *Adv. J. Food Science Technology*, **2010**, 2 (1): 16 – 21.
[13] APHA, AWWA, WEF, Greenberg, A. E., Clesceri, L. S., and Eaton, A. D (eds) 18th Edition **1998**
[14] AF Yakubu, FD Sikoki, JFN Abowei and SA Hart, *Journal of Applied Sciences and Environmental Management*, **2000**.*Vol. 4(2) 41-46.*
[15] ES Erondu and AC Chindah, Nigeria Environ. Ecol., **1991**, 9(3): 561-570.
[16] N Zabbey, FD Sikoki and J Erondu., *African Journal of Aquatic Science* **2008,** 33(2): 241-248.
[17] JFN Abowei, CC Tawari and OA Davies, *Research Journal of Biological Sciences* **2008***, 3 (12): 1430-1436.*
[18] JA Nkwoji, IC Onyema and JK Igbo, *Science World Journal Vol.* **2010,** 5 (5): 7-14.
[19] EN Ogamba, AC Chinda, IKE Ekweozor and JN Onwuteaka., *Journal of Nigerian Environment Society (JNES)* ***2004***, Vol. 1 No. 2:121-130
[20] AF Yakubu, FD Sikoki and JPM Horsefall, *Journal of Applied Sciences and Environmental Management*, **1998**,*Vol. 1(1) 38-49.*
[21] R Margalef, University of Chicago Press **1963**, 111pp.