SSR Journal of Multidisciplinary (SSRJM)

Volume 2, Issue 3, 2025 Homepage: https://ssrpublisher.com/ssrjm/
Email: office.ssrpublisher@gmail.com

OPEN ACCESS

ISSN: 3049-1304

Ecological Assessment of Phytoplankton Diversity in Crude Oil-Impacted Aquatic Ecosystems in Bayelsa State, Nigeria

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Received: *19.05.2025* | ***Accepted:*** *26.06.2025* | ***Published:*** *28.06.2025*

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DOI: *10.5281/zenodo.15764069*

Abstract **Original Research Article**

This study assessed the diversity of phytoplankton in selected crude oil-impacted aquatic ecosystems in Bayelsa State, Nigeria. With petroleum exploration being a foundation of the region's economy, oil pollution has severely affected aquatic life, including phytoplankton—the primary producers in aquatic food webs. Phytoplankton samples were collected during both dry and wet seasons from four water bodies: River Niger (Ayamasa and Okumbiri axes), Taylor Creek (Ikarama axis), and Kolo Creek (Ibelebiri axis) all from the three geographical districts of Bayelsa State. Diversity was analyzed using standard indices such as Simpson, Shannon-Wiener, and Margalef. Results showed significantly higher phytoplankton diversity and abundance during the dry season, particularly at Ayamasa, compared to the wet season. Chlorophyta and Bacillariophyta were the most abundant phyla, with Bacillariophyta showing a high tolerance to pollution. The presence of pollution-indicator species like *Euglena sanguinea* and *Anabaena spiroides* in impacted areas suggests ongoing environmental stress. Overall, crude oil pollution influenced phytoplankton community structure, with seasonal variations highlighting the dynamic nature of these aquatic ecosystems. The findings highlight the value of phytoplankton as bioindicators for monitoring water quality and ecological health in oil-impacted regions.

Keywords: Phytoplankton Diversity, Crude Oil Pollution, Aquatic Ecosystems, Bioindicators, Seasonal Variation, Water Quality Monitoring.

Citation: Kotingo, E. K., Ogamba, E. N. & Oyedeji, A. A. (2025). Ecological Assessment of Phytoplankton Diversity in Crude Oil-Impacted Aquatic Ecosystems in Bayelsa State, Nigeria. *SSR Journal of Multidisciplinary (SSRJM)*, *2*(3), 114-123.

INTRODUCTION

Petroleum production has been a cornerstone of Nigeria's economy since the discovery of crude oil in Oloibiri, Bayelsa State, in 1958. Today, the sector contributes approximately 80% of government budgetary revenue and 95% of foreign exchange earnings (Global Edge, 2023). However, the environmental costs of oil exploration and production have grown increasingly severe, particularly in the Niger Delta. Between 2019 and 2021 alone, over 43,000 barrels of oil were spilled in 881 recorded incidents across Nigeria, exacerbating ecological degradation in oil-producing states such as Bayelsa (Bello & Nweaka, 2023).

One of the most affected components of aquatic ecosystems in these regions is phytoplankton—microscopic photosynthetic organisms that form the base of the aquatic food web and play a key role in carbon cycling, oxygen production, and nutrient regulation (Wilson & Hayek, 2019). Phytoplankton are particularly vulnerable to pollution because of their high surface-area-to-volume ratio and passive mobility in the water column (Ikpeme *et al.*, 2013). Crude oil and its derivatives, including polycyclic aromatic hydrocarbons (PAHs), can impair photosynthesis, inhibit cell division, and alter community structures (Ozhan *et al*., 2014). This sensitivity makes phytoplankton excellent bioindicators for tracking environmental change and assessing water quality (Taş *et al*., 2010).

Numerous studies have documented how oil pollution decreases phytoplankton diversity while increasing the prevalence of pollution-tolerant taxa, particularly Bacillariophyta and Euglenophyta (Chris & Amaewhule, 2022; Grami *et al*., 2024). Seasonal factors such as rainfall, temperature, and nutrient influx also influence phytoplankton composition, complicating the detection of oil-related impacts (Effiong *et al*., 2018). This calls for location-specific, seasonally aware studies to inform targeted environmental management strategies.

Given the increasing frequency and severity of oil spills in Bayelsa and the vital role phytoplankton play in ecological stability, this study aims to assess the diversity and distribution of phytoplankton in selected oil-impacted water bodies. By examining both dry and wet season

variations, the research evaluates not only the biological effects of oil contamination but also the phytoplankton community's potential as an early-warning system for ecological disturbance.

Study Area

The study areas are River Niger (Ayamasa Community Axis) Ekeremor Local Government Area, Kolo Creek (Ibelebiri Community Axis) Yenagoa Local Government Area, Taylor Creek (Ikarama Community Axis) Yenagoa Local Government Area, and River Niger (Okumbiri Community Axis) Sagbama Local Government Area, all situated in Bayelsa State, the core of the Niger Delta. The waters of the Atlantic Ocean dominate its southern and western borders, and it shares a border with Rivers State to the east and Delta to the north (Alexander, 2017). It has a total area of 21,100 square kilometers (Kadafa, 2012). It is geographically positioned at latitude 040 151 North, 050 231 South, and longitude 050 221 West and 060 451 East (Figure 1.1). It is mostly composed of tropical rainforests. The Niger Delta Development Commission (NDDC, 2006) states that the major ecological zones in the area include the mangrove forest and coastal vegetation zone, the freshwater swamp forest zone, the lowland rainforest zone, and the derived savannah zone in the north.

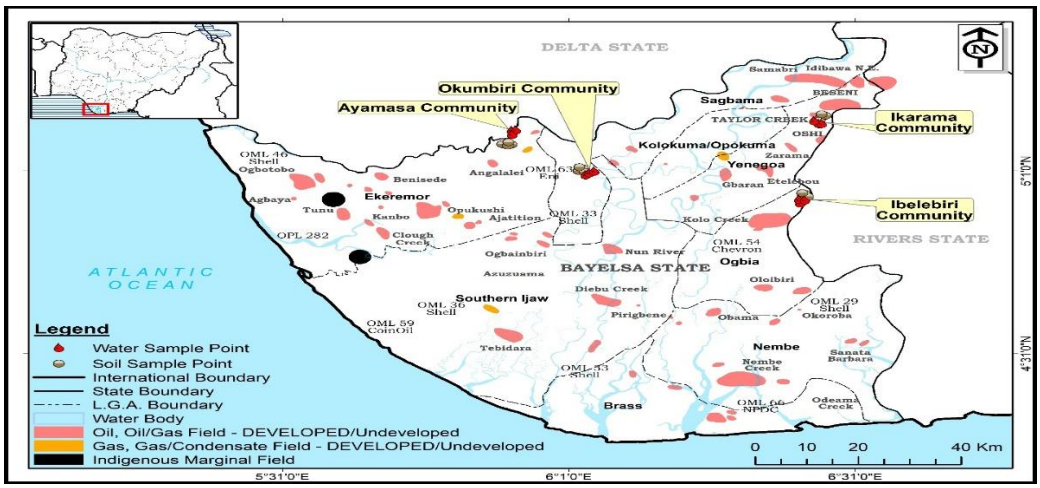

Figure 1.1: Map Showing Sample Areas and Oil and Gas Fields in Bayelsa State
Source: Modified from the Nigeria-Sao Tome Joint Development Zone Map, 2025.

Among the many creeks and rivers in the south that flow into the Atlantic Ocean are significant ones such as San Bartholomew, Brass, Nun, Ramos, Santa Barbara, St. Nicholas, Sangana, Fishtown, Ikebiri Creek, Middleton, Digatoro Creek, Pennington, and Dobo (NDDC, 2006). Rainfall often starts in February and lasts until November, with July and September frequently being the wettest months. Typically, the dry season lasts from early December until February. Surface air temperatures are normally high and rather stable all year round.

Study Design

Four waterbodies were purposefully selected following a survey of Bayelsa State's three geopolitical districts. The waterbodies are the River Niger (Ayamasa Axis) in Bayelsa West, Taylor Creek (Ibelebiri Axis) in Bayelsa Central, and Kolo Creek (Ibelebiri Axis) in Bayelsa East. While the River Niger (Okumbiri Axis) served as the reference site due to no recorded pollution history. The other water bodies have documented histories of crude oil leaks in the region.

Phytoplankton Data Collection

Phytoplankton samples were collected from the four study locations using a conical plankton net measuring 0.5 m in diameter and 2 m in length. The net had a mesh size of 30 to 70 nm. According to the APHA's defined protocol (APHA, 2005), a little bottle with a capacity of roughly 30 cm^3 was fastened to the narrow end of the plankton net. Care was subsequently taken when the water samples were scooped and then poured into a bottle with a capacity of 100 cm^3.. The plankton net was washed with distilled water before deployment at the new sample collecting station in order to prevent contamination. According to APHA (1998), the concentrated phytoplankton samples were stored with 5% formalin before being moved to the laboratory in a refrigerated box. The concentrated samples were shaken to homogenize them after being diluted with distilled water in the laboratory until a 50 mL concentration was reached.

Phytoplankton Counting and Analysis

Prior to adequately decanting the supernatant to a volume of 50 ml, plankton samples were placed in the testing facility for 24 hours to settle by gravity. Using a Pasteur pipette, 1 ml of the stock sample was extracted and put into a Sedgwick Rafter counting chamber. In order to facilitate counting, the plankton is allowed to settle into a single layer on the slide for two to fifteen minutes after it has been filled (Nannette, 2012). A computer was connected to a DC2 camera via a USB cord, and the camera was connected to the light microscope's eyepiece. Subsequently, exposure is adjusted and the microscope's

screen is optimized. Botes (2003), Edmondson (1959), Phyllis *et al*. (1970), and Nannette (2012) identification guides were utilized.

METHODS OF DATA ANALYSIS

Diversity indices, including species richness, Shannon-Wiener (H), Simpson's diversity (1-D), evenness, equitability (J), and Margalef's index, were calculated using Paleontological Statistics (PAST) software (Hammer *et al.*, 2001). Microsoft Excel 2019 was used for chart generation.

RESULTS

In the dry season, species richness was highest in the River Niger, Ayamasa axis (42 species), followed by the River Niger, Okumbiri axis (20), Kolo Creek, Ibelebiri axis (18), and Taylor Creek, Ikarama axis (9). However, in the wet season, species counts declined across all locations: Ayamasa (8), Ibelebiri (10), Okumbiri (6), and Ikarama (2). The polluted site at Ayamasa exhibited high diversity during the dry season, but its dramatic reduction in the wet season highlights a potential impact of pollution under varying environmental conditions.

The total phytoplankton individual counts decreased from dry to wet seasons, particularly in crude oil-impacted water bodies (Figures 1 and 2). In the dry season, Ayamasa (52 individuals) and Ibelebiri (30) showed elevated abundance relative to Okumbiri (28), yet this abundance sharply dropped during the wet season. Dominance was highest in Ikarama (polluted site) during the wet season (D = 0.680), indicating reduced evenness, while Okumbiri consistently demonstrated more balanced species representation.

Simpson and Shannon indices were consistently higher at Okumbiri, especially during the wet season, signifying a stable and diverse ecosystem (Table 2). In contrast, polluted sites like Ikarama recorded lower Shannon indices in the wet season (H = 0.500), further indicating biodiversity stress. Table 1 depicts that Ayamasa had the highest Shannon index (H = 3.648) during the dry season despite its pollution status, possibly due to opportunistic species thriving temporarily.

Evenness and equitability indices in the control site (Okumbiri) remained relatively high across seasons, underscoring ecological stability. Among the polluted sites, Ayamasa showed strong evenness in the dry season but a decline during the wet. Ikarama presented the lowest equitability in the wet season (J = 0.722), suggesting dominance by a few resilient species.

In the dry season, Bacillariophyta and Chlorophyta dominated polluted locations, especially in Ayamasa and Ibelebiri (Table 3). The Dynophyta phylum exhibited complete dominance at its polluted site (D = 1), with only one species recorded. Okumbiri displayed a more even distribution among phyla, aligning with its role as a control. While in the wet season, Bacillariophyta again led in diversity and abundance, particularly in the control site. Chrysophyta was found only in polluted waters and had a dominance value of 1, indicating an imbalanced composition. Taxonomic evenness was generally lower in polluted sites, reflecting environmental stress responses.

Table 1: Phytoplankton Diversity Index Per Sampled Community Water Bodies in Dry Season

Index	**Ayamasa (River Niger)**	**Ibelebiri (Kolo Creek)**	**Ikarama (Taylor Creek)**	**Okumbiri (River Niger)**
Species	42	18	9	20
Divisions	5	3	4	4
Individuals/Abundance (n)	52	30	11	28
Dominance _D	0.030	0.078	0.140	0.063
Simpson _I-D	0.970	0.922	0.860	0.936
Shannon _H	3.648	2.728	2.098	2.887
Evenness _e^H/S	0.914	0.850	0.906	0.897
Equitability _J	0.976	0.944	0.955	0.963
Margalef	10.38	4.998	3.336	5.702

Source: Analysis by Author (2024)

Table 2: Phytoplankton Diversity Index Per Sampled Community Water Bodies in Wet Season

Index	**Ayamasa (River Niger)**	**Ibelebiri (Kolo Creek)**	**Ikarama (Taylor Creek)**	**Okumbiri (River Niger)**
Species	8	10	2	6
Divisions	2	4	2	3
Individuals / Abundance (n)	20	39	5	9
Dominance _D	0.15	0.120	0.680	0.210
Simpson _1-D	0.85	0.879	0.32	0.790
Shannon _H	1.973	2.19	0.500	1.677
Evenness _e^H/S	0.899	0.893	0.825	0.892
Equitability _J	0.949	0.951	0.722	0.936
Margalef	2.337	2.457	0.621	2.276

Source: Analysis by Author (2024).

Table 3: Diversity Index Per Phytoplankton Phyla in Dry Season

Index	Chloro Phyta	Cyano phyta	Bacillario phyta	Xantho phyta	Dyno phyta	Eugleno phyta
Species	26	11	29	3	1	5
Individuals / Abundance (n)	42	14	46	5	1	13
Dominance _D	0.076	0.102	0.054	0.36	1	0.254
Simpson _1-D	0.924	0.898	0.946	0.640	0	0.746
Shannon _H	2.978	2.342	3.178	1.055	0	1.479
Evenness _e^H/S	0.756	0.946	0.828	0.957	1	0.878
Equitability _J	0.914	0.977	0.944	0.960	-	0.919
Margalef	6.689	3.789	7.313	1.243	0	1.559

Source: Analysis by Author (2024).

Table 4: Diversity Index Per Phytoplankton Phyla in Wet Season

Index	Chlorophyta	Cyanophyta	Bacillario phyta	Chrysophyta	Euglenophyta
Species	4	3	7	1	3
Individuals/Abundance (n)	19	8	30	3	13
Dominance_D	0.280	0.406	0.162	1	0.385
Simpson_H	0.720	0.594	0.838	0	0.615
Shannon_H	1.316	0.974	1.878	0	1.012
Evenness_e^H/S	0.932	0.883	0.934	1	0.917
Equitability_J	0.949	0.887	0.965	-	0.921
Margalef	1.019	0.962	1.764	0	0.780

Source: Analysis by Author (2024)

Table 5: Dry Season Distributions of Phytoplankton Species

S/N	Station/Taxa	Ayamasa (River Niger)	Ibelebiri (Kolo Creek)	Ikarama (Taylor Creek)	Okumbiri (River Niger)	Total
A	**Chlorophyta**					
1	*Mougeotia indica*	4	0	3	2	9
2	*Ulothrix moniliformis*	1	0	0	0	1
3	*Closterium gracile*	1	0	0	0	1
4	*Ankistrodesmus facatus*	1	0	0	1	2
5	*Cloterium juncidum*	2	0	0	0	2
6	*Onychonema leave*	1	0	0	0	1
7	*Desmidium baileyi*	1	0	0	0	1
8	*Microspra spp.*	1	0	0	0	1
9	*Ophiocytium parvulum*	1	0	0	0	1
10	*Spirulina major*	1	0	0	0	1
11	*Oedogonium spp.*	1	0	0	0	1
12	*Closteium strigosum*	1	0	0	0	1
13	*Eastrum denticulatum*	1	0	0	0	1
14	*Closterium lineatum*	1	0	0	0	1
15	*Hylotheca undulate*	1	0	0	0	1
16	*Euastrum ansatum*	1	0	0	0	1
17	*Closteriopsis longissimi*	1	0	0	2	3
18	*Pleurotaniu coronatum*	0	0	0	1	1
19	Oedogonium capillare	0	1	0	1	2
20	Zygnema czurdae	0	3	0	0	3
21	*Draparnaldea spp.*	0	0	1	0	1
22	*Spirogyra condensensata (Conjugate stage)*	0	0	1	0	1
23	*Cladophora crispate*	0	1	0	0	1
24	*Pleurotaenium coronatum*	0	2	0	0	2
25	*Ankistrodesmus falcatus*	0	1	0	0	1
26	*Oocystis spp.*	0	1	0	0	1

B	**Cyanophyta**					
27	*Lyngbya limnetica Lemn**	1	0	0	0	2
28	*Spirulina subtilissima*	1	0	0	1	2
29	*Spirulna major**	1	0	0	0	1
30	*Aphanizomenon flos-aqueal (L)*	1	0	0	0	1
31	*Phormiaium valderiae (Delp)*	0	0	0	1	1
32	*Microcystis pulverea*	0	0	0	1	1
33	*Lyngbya major*	0	0	0	2	2
34	*Nostc planctanicum*	0	0	0	1	1
35	*Phormialum valderiae*	0	0	0	1	1
36	*Anabaena spiroides*	0	0	0	0	0
37	*Phormidium mucicol*	0	0	1	2	3
C	**Bacillariophyta**					
38	*Nitzschia sigma*	1	0	0	1	2
39	*Guinardia delicatula*	3	0	0	0	3
40	*Cyclotella stelligera*	1	0	0	0	1
41	*Surirella robusta var. splendida*	1	0	0	0	1
42	*Melosira italic*	1	0	0	0	1
43	*Melosira undulata**	2	0	0	0	2
44	*Epithemia zebra*	1	0	0	0	1
45	*Fragilaria intermedia*	2	0	0	0	2
46	*Melosira cf. spaerica*	1	0	0	0	1
47	*Epithemia argus*	1	0	0	0	1
48	*Thalassiosira anguste-lineata**	1	0	0	1	2
49	*Nitzchia kiitzingiana*	1	0	0	0	1
50	*Melosira islandica*	1	0	0	0	1
51	*Melosira granulate var.**	2	0	1	0	3
52	*Melosira granulate (Ehr)**	2	0	0	0	2
53	*Melosira listans*	1	0	0	0	1
54	*Synedra ulna var. biceps*	1	0	0	1	2
55	*Cymbella ventricose*	0	0	0	5	5
56	*Tebellria fenestrate*	0	0	0	1	1
57	*Navicula spp.*	0	0	0	2	2
58	*Psedo-nitzschia qustralis*	0	0	1	0	1
59	*Psedo-nitzschia pungen*	0	0	1	0	1
60	*Melosira pusilla*	0	1	1	0	2
61	*Synedra acus*	0	2	0	0	2
62	*Cymbella ventricosa Kutz.*	0	1	0	0	1
63	*Fragilaria construens (Ehr)*	0	1	0	0	1
64	*Pinnularia braunii*	0	1	0	0	1
65	*Pinnularia spp.*	0	1	0	0	1
66	*Chaetocero contrictus*	0	1	0	0	1
D	**Xanthophyta**					
67	*Tribonema viride Pasch*	1	0	0	0	1
68	*Vaucheria litorea*	1	0	1	0	2
69	*Ophiocytium parvulum*	1	0	0	1	2
E	**Dynophyta**					
70	*Protopridinium pentagonum*	1	0	0	0	1
F	**Euglenophyta**					
71	*Euglena clavate*	0	1	0	0	1
72	*Euglena sanuinea**	0	5	0	0	5
73	*Euglena caudate**	0	2	0	0	2
74	*Euglena spp.**	0	3	0	0	3
75	*Euglena wangi*	0	2	0	0	2
	Total	**52**	**30**	**11**	**28**	**121**

Note: Phytoplankton species asterisked are the pollution indicator species

Table 6: Wet Season Distributions of Phytoplankton Species

S/N	Taxa / Station	Ayamasa (River Niger)	Ibelebiri (Kolo Creek)	Ikarama (Taylor Creek)	Okumbiri (River Niger)	Total
A	**Bacillariophyta**					
1	*Pseudo-nitzschia pungen*	0	4	0	2	6
2	*Melosira cf. spearica**	0	4	0	0	4
3	*Melosira granulata var angustissima**	4	1	1	0	6
4	*Guinardia delicatula**	3	0	0	0	3
5	*Thalassiosira anguste-linata**	2	0	0	0	2
6	*Nitzschia sigma*	1	0	0	4	5
7	*Melosira granulata (Her)**	4	0	0	0	4
B	**Chlorophyta**					
8	*Closterium gracile Breb*	0	6	0	0	6
9	*Mougeotia indica*	0	0	4	1	5
10	*Oedogonium spp*	0	2	0	0	2
11	*Zygnema crurdea*	0	6	0	0	6
C	**Euglenophyta**					
12	*Colacium cyclopicola*	0	2	0	0	2
13	*Euglena sanguinea**	0	6	0	0	6
14	*Euglena spp.**	0	5	0	0	5
D	**Chrysophyta**					
15	*Mallomenat asaroides Perty*	0	3	0	0	3
E	**Cyanophyta**					
16	*Lyngbya limnetica Lemm**	3	0	0	1	4
17	*Anabaena spiroides**	2	0	0	1	3
18	*Spirulina major**	1	0	0	0	1
Total		**20**	**39**	**5**	**9**	**73**

Note: Phytoplankton species asterisked are the pollution indicator species

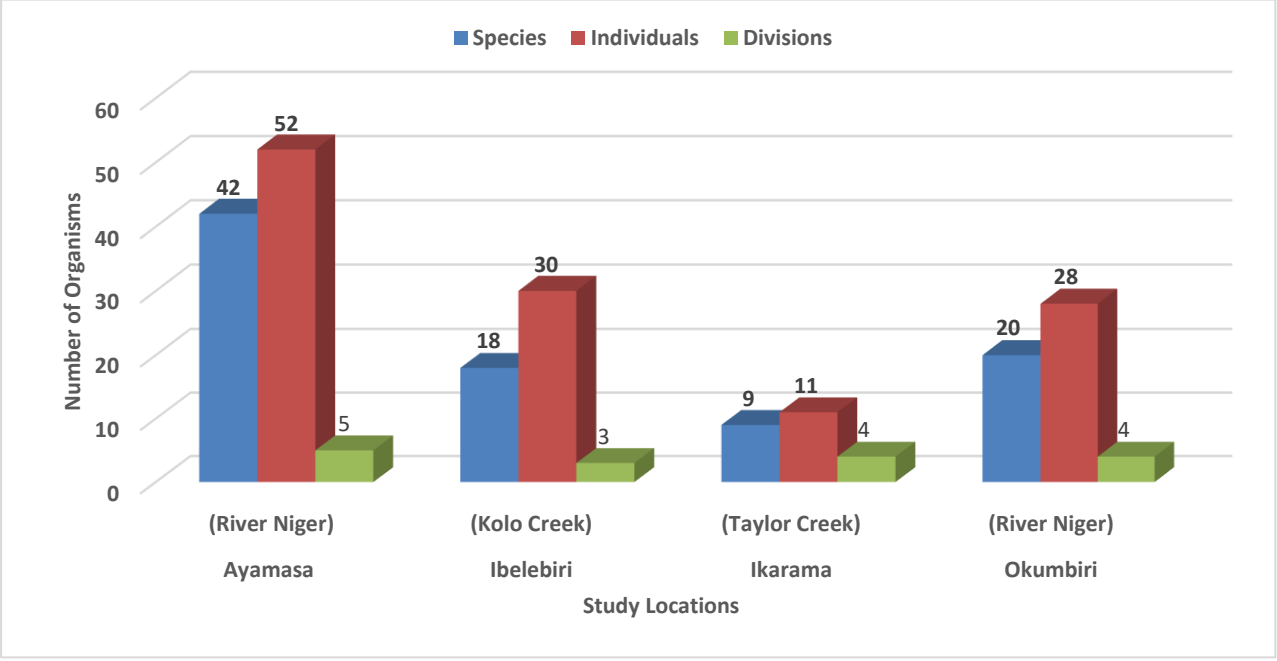

Figure 1: Dry Season Phytoplankton Distribution Per Sampled Water Bodies

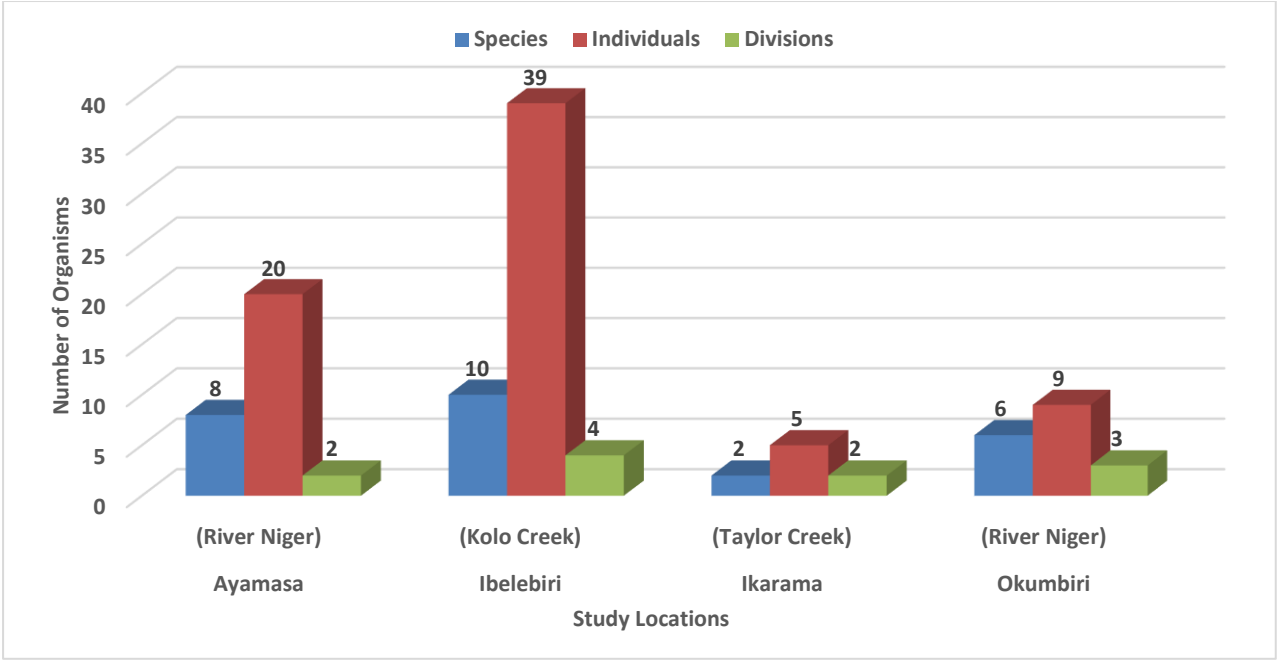

Figure 2: Wet Season Phytoplankton Distribution Per Sampled Water Bodies

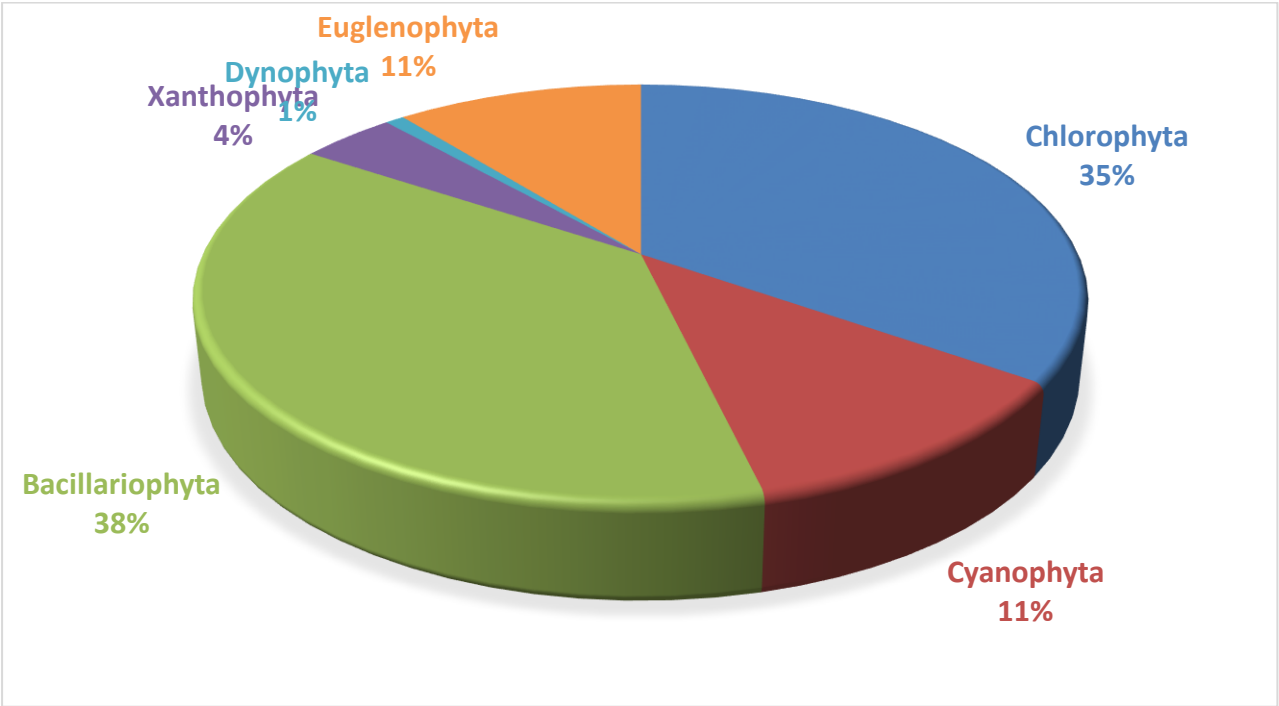

Figure 3: Abundance of Phytoplankton Percentage distributions per Phyla in the Dry Season

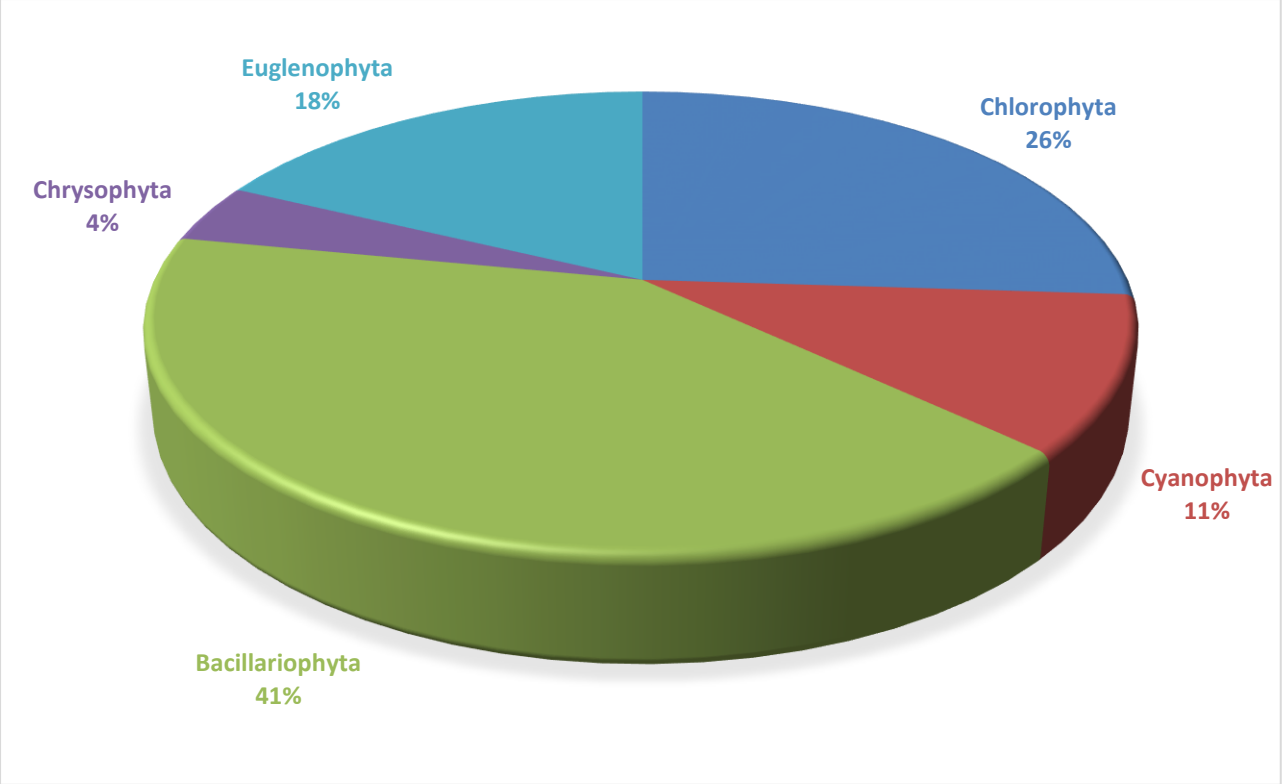

Figure 4: Abundance of Phytoplankton Percentage distributions per Phyla in the Wet Season

DISCUSSIONS

Microalgae have a crucial role in the ecosystem, particularly in the aquatic domain. These essential ecological species contribute to the diet of marine life and, more significantly, are crucial in reducing the effects of regional and global climate change. However, a number of human actions, including the spilling of crude oil, have put the amount and quality of phytoplankton in jeopardy. It is sufficient to say that numerous environmental components are frequently adversely affected when oil spills occur throughout any stage of its production and no remediation method is carried out (Chukwuka *et al*., 2018).

In this study, the distribution of phytoplankton in the three investigated water waterbodies and the control location varied significantly over the dry and rainy seasons. Tables 5 and 6 provide a taxonomic list of the phytoplankton species that were found in the research area during the dry and rainy seasons. There is a sharp decline in the diversity of microalgae between the phytoplankton data gathered during the rainy and dry seasons. In particular, the distribution of the samples taken during the dry season was more diverse than that of the samples taken during the wet season (Figures 1 and 2). This finding supports a previous study conducted in the Niger Delta region that found that higher phytoplankton abundance was seen during the dry season (Effiong *et al.*, 2018). The aforementioned study attributed this to a potential decrease in freshwater inflow from rivers, which raises salinity and nutrient availability and results in an increase in phytoplankton.

Furthermore, the results of a previous study by Chris and Amaewhule (2022) that found that environmental factors such as high temperature, low pH, transparency, and dissolved oxygen were directly responsible for enhanced species availability are also supported by this result. Additionally, the study argued that photosynthesis is enhanced by the high temperatures during the dry months. Additionally, low pH allows the primary producers to access nutrients like phosphate and nitrate, whereas high nutritional status (phosphate, nitrate, and sulfate) promotes the growth of phytoplankton.

Unexpectedly, Ayamasa's phytoplankton's Simpson and Shannon diversity indexes (0.970 and 3.648) were higher than those of the reference community, Okumbiri (0.936 and 2.887). While only 28 individuals from 20 species and 4 divisions were documented during the dry season in the control, 52 individuals from 42 species and 5 divisions were seen in Ayamasa (Figure 1). However, the control area (Okumbiri) has more phytoplankton than Ibelebiri and Ikarama, which have both previously recorded oil spills. Although values were higher during the dry season than the wet one, this was comparable to the situation in the Saint Bartholomew River, where species richness and Shannon-Weiner diversity show notable regional variability (Ibim & Chris, 2019). The greater stability of the environmental elements during this season, particularly sunlight, which results in a more stable/increasing temperature, may be the cause of the increased diversity (Longphuirt *et al.*, 2020).

Additionally, the effects of pollution on aquatic communities are frequently reflected in species diversity indexes. The greater diversity of phytoplankton species in Ayamasa is reflected in the higher species diversity found in this study, as shown by the Shannon-Wiener and Evenness indexes. Therefore, the lower biotic index values indicate that there is less species diversity during the wet

season. Overall, the sampled areas showed a low variety index (Tables 1 and 2). The homogeneity and stability of the environment's chemical and physical characteristics are most likely the cause of such minimal variance (Longphuirt *et al.*, 2020).

In this study, Chlorophyta (green algae) was dominant during the dry season at Ayamasa, with 17 species recorded, suggesting possible organic enrichment. In contrast, the wet season showed a significant decline across the River Niger, Kolo Creek, and Taylor Creek—areas known for a history of crude oil leaks. This decline may be attributed to reduced water clarity caused by runoff, which hampers photosynthesis (Ajibade & Okonofua, 2023; Cao *et al*., 2013).

Bacillariophyta (diatoms) dominated in both seasons (Figures 3 and 4), indicating a tolerance to pollution. Polluted sites featured multiple species such as *Melosira* spp., *Guinardia delicatula*, and *Thalassiosira angusteli-nata*, which are typical indicators of organic pollution (Ajibade & Okonofua, 2023).

Cyanophyta (blue-green algae) appeared predominantly at polluted sites, with increases in *Lyngbya limnetica*, *Anabaena spiroides*, and *Spirulina major*. These species are often associated with eutrophic or polluted waters, reflecting high nutrient levels (Ajibade & Okonofua, 2023).

Euglenophyta (euglenoids) were especially dominant in the Kolo Creek area (Ibelebiri axis) across both seasons, with a notable increase in *Euglena sanguinea*. Euglenoids thrive in environments with poor water quality and elevated organic matter, reinforcing the indication of pollution (Ajibade & Okonofua, 2023). Similarly, Chris and Amaewhule (2022) reported reduced species richness and higher dominance of pollution-tolerant genera such as *Euglena* and *Anabaena* in the Isaka-Bundu waterway in Rivers State. This supports our observation of *Euglena sanguinea* and *Anabaena spiroides* thriving in oil-affected sites like Kolo Creek and the River Niger (Ayamasa axis). Furthermore, locations with a history of crude oil spills—such as the River Niger (Ayamasa axis), Kolo Creek (Ibelebiri axis), and Taylor Creek (Ikarama axis)—consistently exhibit higher phytoplankton species compared to the control site at River Niger (Okumbiri axis). This observation suggests nutrient enrichment, likely driven by pollutants that support excessive algal growth (Ajibade & Okonofua, 2023; Skorobogatova *et al*., 2019). In contrast, the control site at Okumbiri has fewer taxa, indicating a more stable and balanced ecosystem with minimal organic disturbance affecting phytoplankton dynamics.

CONCLUSION

This study highlights the substantial impact of crude oil pollution on phytoplankton diversity within aquatic ecosystems in Bayelsa State. Phytoplankton abundance and species richness were consistently higher during the dry season, reflecting favorable environmental stability and nutrient availability. The dominance of tolerant groups such as Bacillariophyta and Euglenophyta in oil-impacted locations highlights the ecological stress induced by hydrocarbon pollutants. Interestingly, sites like the Ayamasa axis of the River Niger recorded higher diversity indices than the control site, likely due to nutrient enrichment from pollution sources, a double-edged effect where contamination may temporarily fuel algal growth while undermining long-term ecosystem integrity.

Moreover, the presence of indicator taxa such as *Anabaena* spp. and *Euglena sanguinea* points to worsening eutrophic conditions, signaling the early stages of ecosystem imbalance. If left unaddressed, these disruptions could cascade through the food web, affecting zooplankton, fish, and ultimately the livelihoods of local communities. Additionally, the compounding pressure of climate change—through altered rainfall patterns and rising temperatures—may amplify these vulnerabilities by modifying the timing and composition of phytoplankton blooms.

Ultimately, this study affirms the value of phytoplankton as responsive bioindicators of environmental degradation and calls for an integrated, ecosystem-based approach to watershed management that addresses pollution, habitat restoration, and sustainable resource use. Protecting phytoplankton diversity is not only critical for ecosystem health but also for preserving the ecological services and economic stability that local communities depend on.

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