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Impact of Crude Oil Exploitation on Plant Diversity Stock in Wetland Ecosystems in Bayelsa State, Nigeria

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Abstract | **Original Research Article**

This study investigated the impact of crude oil exploitation on plant diversity stock in wetland ecosystems in Bayelsa State, Nigeria. Three crude oil-impacted communities—Ayamasa, Ibelebiri, Ikarama, and Okumbiri—that have never experienced a crude oil spill served as a control in this study. To get the required data, four 50 x 10 m line transects were set up at each study site, 20 meters apart. From each of the 50 × 10 m plots, five 10 × 10 m subplots were additionally marked out (labelled A, B, C, D, and E). The data was processed using Paleontological Statistical Software (PAST). The findings showed that, in dry season samples, there were more trees in the control area than in crude oil-impacted areas (8<14<16<28); in wet season samples, the numbers were similar (8<14<19<28). Weak stem species were more prevalent in the sites of the crude oil spill particularly in the wet season. Plant species in the control group exhibit more diversity as measured by the Shannon-Weiner Index (3.695/3.987), whereas regions that have previously undergone cleanup efforts for crude oil spills showed signs of recovery with a comparatively diversity index (2.312-3.629) in both sample seasons. In total there was more plant abundance in the control compared to the crude-oil-impacted sites. The families of Poaceae and Asteraceae were dominant throughout the studied area in both the dry and wet seasons especially in the crude oil impacted locations. A total of 44 plant families and 86 plant species were found in the dry season while 56 families and 137 plant species in the rainy season. Results showed crude oil spills are detrimental to plant variety. As a result, precautions must be taken to prevent future spills, and stakeholders should approach crude oil spill remediation projects proactively rather than reactively.

Keywords: Crude Oil Exploitation, Plant Diversity, Wetland Ecosystems, Bayelsa State, Nigeria, Crude Oil Spills, Biodiversity Index, Poaceae, Asteraceae, Environmental Impact, Remediation.

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INTRODUCTION

Nigeria is one of the countries in Africa that is blessed with diverse, abundant natural resources, with the oil and gas sector contributing 65 percent of the country's tax revenue (Adegbola *et al*., 2023). Despite the huge revenue derived from the oil and gas sector in the country, the poor management of the sector has led to a series of environmental crises related to oil spills and gas flaring in oil-bearing communities of the Niger Delta. Nweze and Edame (2016) opined that all the phases of oil operations, from discovery to drilling to transportation, lead to the extinction of flora diversity in the Niger Delta. The extinction or degradation of flora diversity has become endemic because crude oil (petroleum) hydrocarbons are one of the common groups of persistent organic pollutants in the environment of the Niger Delta today. However, plants may respond differently to the presence of crude oil because of the mutagenic and carcinogenic properties it possesses (Skrypnik *et al.*, 2021).

It is imperative to note that plant species have different varying tolerance capacities for toxicity. However, the concentration levels of low-boiling compounds, unsaturated compounds, aromatics, and acids to a large extent determine the toxic impacts on plants (Odiyi *et al.*, 2020). When oil spills occur, the pollutant penetrates into the plant; the oil may travel in the intercellular spaces and possibly also in the vascular system. Cell membranes are damaged by penetration of hydrocarbon molecules, leading to leakage of cell contents, and oil may enter the cells. Oils reduce transpiration rate, probably by blocking stomata and intercellular spaces (Odukoya *et al.*, 2019). These penetrations into the plant system destabilize the plant's metabolism. In a study by Tanee and Albert (2015) on the long-term effects of crude oil spills on plant composition at Kwawa, Ogoni, it was reported that crude oil spills reduce plant growth, affect photosynthetic processes, increase oxidation stress, and alter nutrient uptake mechanisms, among others.

On account of these, Obi-Iyeke (2022) recognized and subsequently submitted that plant species react differently to disturbances and alterations in their environment; hence, the knowledge of species diversity is helpful for ascertaining the impact of biotic disturbances, the rate of succession, and environmental stability. In view of this, the aim of this study is to investigate the effects of crude oil spills on plant diversity in the wetland ecosystems in Bayelsa State, Nigeria.

MATERIALS AND METHODS

Study Area

The study area includes the following communities: Ayamasa in Ekeremor LGA, Ibelebiri in Ogbia LGA, Ikarama in Yenagoa LGA, and Okumbiri in Sagbama LGA. Bayelsa State, located in the south-south part of Nigeria, is situated in 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 (Alexande *et al*., 2017). It has a total area of 21,100 square kilometers (Kadafa, 2012). It is geographically positioned on latitude 04^0 15^1 North, 05^0 23^1 South, and longitude 05^0 22^1 West and 06^0 45^1 East (Figure 1). According to the Niger Delta Development Commission (Esara *et al.*, 2024), the region's main ecological zones are the lowland rainforest zone, the derived savannah zone in the north, the freshwater swamp forest zone, the mangrove forest and coastal vegetation zone, and others.

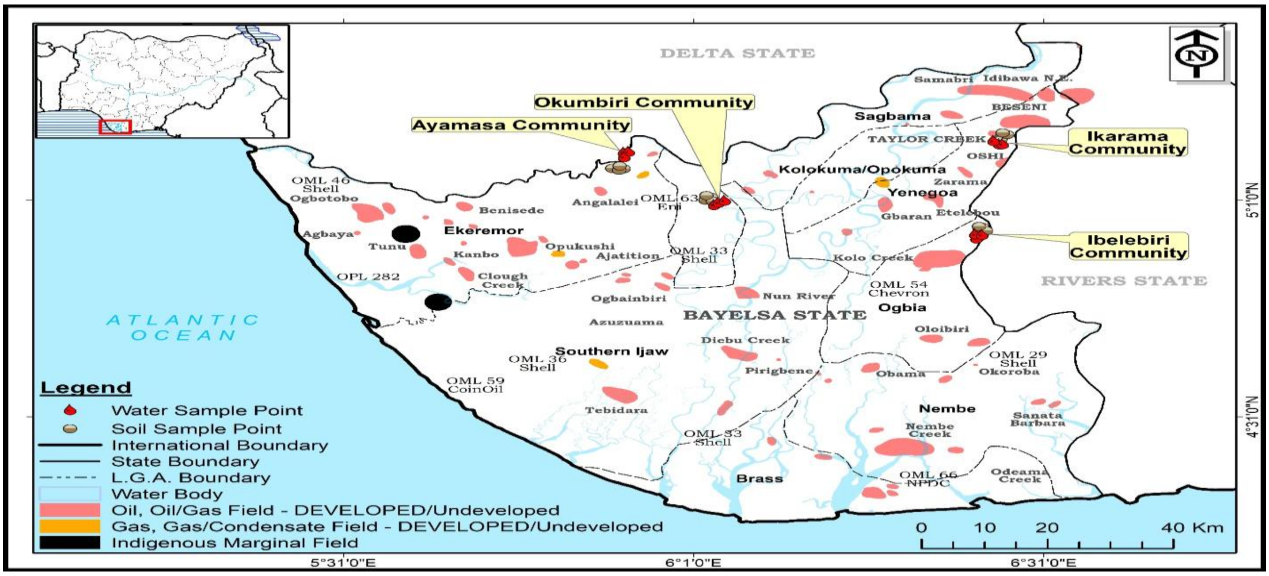

Figure 1: Sample Areas and Oil and Gas Fields in Bayelsa State
Source: Modified from Nigeria-Sao Tome Joint Development Zone Map, 2025

The region is completely below sea level and is home to an intricate network of wetlands made up of mangroves and swiftly moving rivers (Esara *et al*., 2024). 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 (Nweze & Edame, 2016). The average yearly rainfall in the state ranges between 2000 and 2800 mm, while it occasionally exceeds 2900 mm (Bello & Nwaeke, 2023). Rainfall often starts in February and lasts until November, with July and September frequently being the wettest months.

Sample Design and Data Collection

The stratified random sample approach was applied in this investigation. Four sites were specifically chosen, one from each of the state's senatorial districts. The locations include the Okumbiri community, which serves as the control; the Ibelebiri community in Bayelsa East; the Ikarama community in Bayelsa Central; and the Ayamasa community in Bayelsa West district.

Data on the flora species were gathered at each research location using four line transects measuring 50 meters by 10 meters (50 x 10 m) and 20 meters apart. From each of the 50 x 10 m plots, five 10 × 10 m subplots were also plotted out, and they were designated as A, B, C, D, and E. All tree species, shrubs, and herbs in the designated line transects and subplots were identified and counted with the help of botanists using identification guides by Nyananyo (2006).

Estimation of Flora Species

Species Density: This represents the total number of distinctive plant species present in a particular location. It is an estimate of the amount of vegetation in a transect that indicates how strong the ecosystem is (Obi-Iyeke 2022). It helps by offering a guide on the overall number of species, their composition, and their abundance in the environment of polluted oil fields and the control. According to Obi-Iyeke (2022), vegetation changes brought on by anthropogenic disturbances like oil pollution, climate change, or any other human-induced environmental impact can be identified using density. We used the formula below to estimate flora species density in this study:

Density = Total number of individual species/Total area of the transects studied

Species Abundance: This is the total number of individuals of each species in the community per unit area. It is calculated as:

Abundance = Total number of individuals of each species in all transects / Total number of transects in which the species occurs.

Percentage Frequency*:* This is a measure of how often a species occurs in a sample. It was calculated using the formula thus:

Number of transects in which species occurred / Total number of transects studied * 100.

Species Diversity: The species diversity index ('H') was computed using the Shannon Wiener index (1949). The formula for the estimation of the Shannon Wiener index (H) is:

$$H = -\sum_{i=1}^{S_{obs}} p_i \log_e p$$

Where:

H=Shannon diversity index

S= the total number of species in the habitat

Pi= proportion S (species in the family) made up of the ith species

Ln= natural logarithm.

Species evenness (E): This was calculated by adopting Shannon's equitability (EH) thus:

EH = H/ log(S).

METHODS OF DATA ANALYSIS

The Paleontological Statistics software program developed by Hammer *et al*. (2001) was used to analyze the terrestrial plant diversity indices used in this investigation.

RESULTS

The flora community structures of the sampled locations throughout the dry and wet seasons are shown in Tables 1 and 2, respectively. According to the tables, Okumbiri (the control site) maintains the highest count of trees and shrubs in both dry and wet seasons, with 28 trees and 13 shrubs in the wet season. Whereas, Ayamasa, Ibelebiri, and Ikarama which have documented history of crude oil pollution show significantly fewer trees, especially Ibelebiri, which consistently records only 8 trees in both seasons, indicating severe impact from oil pollution. In Ayamasa, herbs/sedges increased drastically from 6 (dry season) to 12 (wet season), possibly due to seasonal moisture favoring weak-stem species. Ibelebiri shows a sharp rise in herbs/sedges from 5 to 28 in the wet season, suggesting that weak-stem species are benefiting from reduced competition with woody vegetation. Okumbiri retains a stable herb/sedge population, reinforcing its role as a control. Oil-impacted areas have very low fern presence in the dry season (Ibelebiri records 0 ferns), but Ayamasa and Okumbiri show notable increases in wet season fern populations (Ayamasa rising to 3, and Okumbiri jumping to 15). This may indicate that some fern species are more resilient to crude oil contamination or that the wet season offers better growing conditions.

Table 1: Forest Community Structure for Dry Season

Index	**Ayamasa**	**Ibelebiri**	**Ikarama**	**Okumbiri (Control)**
Trees	16	8	14	28
Shrubs	10	6	11	13
Herbs / Sedges	6	5	4	6
Climbers /Lianas	6	2	4	6
Ferns	1	0	1	3
Ratio of Woody to weak-stem species	2.55	2.00	2.78	3.67

Source: Analysis by Author (2024)**.** *Woody species = Trees, Shrub and Woody climbers. Weak-stem species = herbs, sedges, weak-stem climbers and ferns

Table 2: Forest Community Structure for Wet Season

Index	Ayamasa	Ibelebiri	Ikarama	Okumbiri (Control)
Trees	19	8	14	28
Shrubs	13	6	14	13
Herbs / Sedges	12	28	14	6
Climbers / Lianas	8	6	6	6
Ferns	3	0	1	15
Ratio of Woody to weak-stem species	1.57	0.41	1.33	1.83

Source: Analysis by Author (2024). *Woody species = Trees, Shrub and Woody climbers. Weak-stem species = herbs, sedges, weak-stem climbers and ferns

According to Tables 1 and 2, Okumbiri the unpolluted control location shows the highest woody species dominance in both seasons (3.67 in the dry season, 1.83 in the wet season). Ayamasa and Ikarama display declining woody species dominance in the wet season (Ayamasa's ratio dropping from 2.55 to 1.57, Ikarama from 2.78 to 1.33), meaning weak-stem species outcompete woody species as moisture increases. Ibelebiri records an extremely low ratio in the wet season (0.41), showing that weak-stem species have overtaken woody species due to environmental stress. In this study, oil-polluted locations show suppressed woody species presence, with Ibelebiri facing the greatest impact (lowest tree/shrub numbers and weakest woody species ratio). According to earlier research, the low number of trees in areas affected by crude oil spills is caused by lower regeneration, tree mortality, and vegetation structure change (Obi-Iyeke, 2022). Furthermore, oil spills have been known to cause defoliation, limb loss, and ultimately the collapse of large trees (Skrypnik *et al.*, 2021). This could be the path taken in the event of crude oil spills in the areas examined, which would account for the limited stands seen in this investigation.

Terrestrial Flora Diversity

Tables 3 and 4 show the diversity of terrestrial flora observed throughout the dry and wet seasons. In the dry season, Ayamasa, Ibelebiri, and Ikarama, which have documented histories of crude oil pollution, recorded lower species richness (39, 21, and 34, respectively) compared to Okumbiri (56) in the control location. While in the wet season campaign, Ayamasa had a species richness of 55, Ibelebiri had 48, and Ikarama had 49, still lagging behind the control location, Okumbiri, with 68 species. This implies that certain plant species are unable to flourish due to pollution, which probably lowers species richness. Regarding the plant family diversity during the dry and wet season, Tables 2a and 2b show that Ayamasa had 28, Ibelebiri 16, and Ikarama 24, compared to Okumbiri's 44. However, in the wet season the numbers improve (33, 23, 31) but remain lower than 41 families in the control. This further demonstrates how pollution diminishes family diversity, which probably has an impact on the structure of plant communities. In the dry season, the individual/abundance count in Ayamasa, Ibelebiri, and Ikarama is 678, 382, and 551, compared to 738 at Okumbiri, the control site. While wet season values are 917, 788, and 882 compared to 1211 in Okumbiri.

Additionally, for the dry season campaign, crude oil-impacted locations have Shannon-Wiener Index values ranging from 2.312 to 3.103, while Okumbiri, which has no documented history of crude oil leaks, had 3.695. Whereas wet season values range between 2.813 and 3.279 for polluted locations, the control site had 3.894. This highlights how pollution lowers species diversity, perhaps as a result of stresses that impact plant survival. Simpson's Index (1-D): Okumbiri, the control site, had values closer to 1 (0.969 dry, 0.979 wet), showing strong biodiversity, while Ayamasa, Iblebiri, and Ikarama, polluted sites, recorded lower values, suggesting species decline. The Margalef Index (dry season) shows polluted sites have lower index values (3.364, 5.228) compared to 8.328 in Okumbiri. Equitability Index (Dry Season): Polluted sites show lower species distribution (0.759, 0.701) compared to 0.918 at the control site. These suggest that pollution reduces species richness and fair distribution, making ecosystems less resilient.

The fact that rainy season samples exhibited more species diversity than dry season samples can be confirmed by closely examining the tables. This proves that in addition to human-caused influences, climate variables like air temperature and rainfall may have an impact on the quality-of-life forms. The findings in this study are consistent with a prior study by Obi-Iyeke (2022), in which the Shannon-Wiener index likewise demonstrated that the vegetation in the control site was more varied and diversified than the vegetation in locations affected by crude oil.

Table 3: Terrestrial Flora Diversity Index in the dry season

Index	Ayamasa	Ibelebiri	Ikarama	Okumbiri (Control)
Taxa_S	39	21	34	56
Families	28	16	24	32
Individuals/ Abundance (n)	788	382	551	738
Density (m^{-2})	0.394	0.191	0.276	0.369
Dominance _D	0.062	0.150	0.165	0.031
Simpson _1-D	0.938	0.850	0.835	0.969
Shannon _H	3.103	2.312	2.473	3.695
Evenness _e^H/S	0.571	0.481	0.349	0.719
Equitability _J	0.847	0.760	0.701	0.918
Margalef	5.698	3.364	5.228	8.328

Source: Field survey by the authors (2024)

Sampled area (a) = 2(5m) × 4(50m) = 10m×200m = 2,000m^2 Density = n/a

Table 4: Terrestrial Flora Diversity Index in the wet season

Index	Ayamasa	Ibelebiri	Ikarama	Okumbiri (Control)
Taxas_S	55	48	49	68
Family	33	23	31	41
Individuals/abundance (n)	1536	3077	1746	1083
Density (m-2)	0.768	1.539	0.873	0.543
Dominance _D	0.049	0.050	0.094	0.025
Simpson _1-D	0.951	0.950	0.906	0.975
Shannon _H	3.279	3.316	2.813	3.894
Evenness _e^H/S	0.658	0.574	0.340	0.722
Equitability _J	0.808	0.857	0.723	0.923
Margalef	7.770	5.852	6.430	9.589

Source: Field survey by the authors (2024)

Sampled area (a) = 2(5m) × 4(50m) = 10m×200m = 2,000m^2 Density = n/a

Table 5: Plant species identified across the four sampled locations in the dry season.

S/N	Family	Name of Species	Life Form	AY	IB	IK	OK (Cont)	RF(%)
1	**Anacardiaceae**	*Lannea nigritana*	Tree	0	0	4	0	0.66
		Spondias mombin	Tree	0	7	8	3	1.99
2	**Annonaceae**	*Cleistopholis patens*	Tree	5	0	3	13	1.99
3	**Apocyanaceae**	*Alstonia boonei*	Tree	5	0	0	7	1.32
		Alstonia macrophylla	Tree	2	0	0	0	0.66
		Funtumia elastica	Tree	1	0	0	7	1.32
		Saba senegalensis	Climber	0	0	0	6	0.66
4	**Arecaceae**	*Calamus deerratus*	Climber	0	0	0	20	0.66
		Elaeis guineensis	Tree	0	0	14	20	1.32
		Raphia hookeri	Tree	3	0	0	0	0.66
5	**Asclepiadaceae**	*Gongronema latifolium*	Climber	10	0	2	0	1.32
6	**Aspleniaceae**	*Asplenium nidus*	Fern	0	0	0	11	0.66
7	**Asteraceae**	*Aspilia africana*	Herb	72	67	0	13	1.99
		Chromolaena odorata	Herb	34	104	0	0	1.32
8	Caesalpinioideae	*Albizia adianthifolia*	Tree	0	0	0	2	0.66
		Anthonotha	Tree	0	0	4	2	1.32

		macrophylla						
9	**Cannabaceae**	*Trema orientale*	Shrub	0	7	0	0	0.66
10	**Clusiaceae**	*Allanblackia gabonensis*	Tree	0	0	0	11	0.66
		Harungana madagascariensis	Tree	12	5	0	7	1.99
		Symphonia globulifera	Tree	3	0	5	15	1.99
11	**Combretaceae**	*Combretum racemosum*	Climber	26	0	0	39	1.32
		Combretum tomentosum	Climber	24	0	0	0	0.66
12	**Costaceae**	*Costus afer*	Herb	28	10	0	13	1.99
13	**Cyperaceae**	*Cyperus* sp.	Sedges	47	0	0	0	0.66
14	**Davalliaceae**	*Nephrolepis biserrata*	Fern	24	0	19	39	1.99
15	**Detarioideae**	*Hymenaea courbaril*	Shrub	2	0	0	0	0.66
16	**Dillieniaceae**	*Tetracera alnifolia*	Climber	3	0	5	28	1.99
17	**Ebernaceae**	*Diospyros crassiflora*	Tree	0	0	0	5	0.66
18	**Euphorbiaceae**	*Alchornea cordifolia*	Shrub	52	25	34	48	2.65
		Alchornea latifolia	Shrub	0	0	9	0	0.66
		Macaranga barteri	Tree	0	0	0	18	0.66
		Ricinodendron heudelotii	Tree	0	1	0	0	0.66
		Uapaca heudelotii	Tree	0	0	0	7	0.66
19	**Lauraceae**	*Cinnamomum cassia*	Tree	0	0	0	7	0.66
20	**Lecythidaceae**	*Napoleonaea imperialis*	Shrub	0	0	4	17	1.32
21	**Longanaceae**	*Anthocleista djalonensis*	Tree	6	0	0	0	0.66
		Anthocleista procera	Tree	0	0	4	3	1.32
22	**Malvaceae**	*Ceiba pentandra*	Tree	0	0	0	4	0.66
		Glyphaea brevis	Shrub	0	0	0	3	0.66
		Grewia flavescens	Shrub	8	0	0	0	0.66
		Sterculia tragacantha	Tree	0	0	0	18	0.66
		Triplochiton scleroxylon	Tree	0	0	0	4	0.66
		Triumfetta rhomboidei	Shrub	8	13	0	0	1.32
23	**Marantaceae**	*Marantochloa congensis*	Herb	0	0	0	22	0.66
		Marantochloa purpurea	Herb	0	0	7	26	1.32
24	**Melastomataceae**	*Melastoma malabathricum*	Shrub	24	0	0	0	0.66
25	Meliaceae	*Carapa procera*	Tree	5	0	0	23	1.32
26	Menispermaceae	*Anamirta Cocculus*	Shrub	0	0	5	0	0.66
27	**Mimosoideae**	*Mimosa pigra*	Herb	0	0	144	0	1.32
28	**Moraceae**	*Ficus exasperata*	Tree	0	9	0	0	0.66
		Ficus polita	Tree	0	2	0	0	0.66
		Ficus sur	Tree	12	9	12	0	1.99
29	**Myrtaceae**	*Psidium guajava*	Tree	0	0	2	0	0.66
30	**Onagraceae**	*Ludwigia decurrens*	Herb	42	69	0	0	1.32
31	**Papilionoideae**	*Baphia nitida*	Shrub	12	0	0	12	1.32
		Dalbergia horrida	Shrub	0	0	4	1	1.32
		Millettia aboensis	Tree	0	6	9	10	1.99
		Philenoptera cyanescens	Shrub	42	0	0	0	0.66
		Pterocarpus	Tree	0	0	2	0	0.66

		santalinoides						
32	**Passifloraceae**	*Smeathmannia pubescens*	Shrub	0	0	8	37	1.32
33	**Phyllanthaceae**	*Bridelia micrantha*	Tree	11	0	0	6	1.32
		Margaritaria discoidea	Tree	0	0	0	2	0.66
		Spondianthus preussii	Tree	5	0	0	21	1.32
34	**Poaceae**	*Coix lachrymal*	Herb	61	21	29	10	2.65
		Echinochloa crus-pavonis	Herb	0	0	161	0	0.66
35	**Polypodiaceae**	*Platycerium staghorn*	Fern	0	0	0	10	0.66
36	**Rubiacea**	*Brenania brieyi*	Tree	0	0	2	0	0.66
		Mitragyna ledermannii	Tree	6	0	0	0	0.66
		Mussaenda polita	Shrub	3	2	4	12	2.65
		Oxyanthus speciosus	Shrub	0	0	3	0	0.66
		Oxyanthus unilocularis	Shrub	0	0	0	3	0.66
		Pauridiantha floribunda	Shrub	16	5	6	8	2.65
		Pausinystalia macroceras	Shrub	0	0	0	6	0.66
		Psychotria nervosa	Shrub	0	0	9	2	1.32
		Tabernaemontana pachysiphon	Shrub	0	0	0	1	0.66
		Villaria odorata	Shrub	6	0	7	17	1.99
37	**Sapindaceae**	*Allophylus africanus*	Tree	0	0	7	5	1.32
		Paullinia pinnata	Climber	24	6	7	34	2.65
38	**Sapotaceae**	*Pouteria campechiana*	Tree	5	0	0	6	1.32
39	**Smilacaceae**	*Smilax anceps*	Climber	23	7	7	41	2.65
40	**Solanaceae**	*Solanum torvum*	Shrub	0	5	0	0	0.66
41	**Sterculiaceae**	*Cola laurifolia*	Tree	0	0	1	0	0.66
42	**Strelitziaceae**	*Strelitzia reginae*	Herb	0	0	0	13	0.66
43	Urticaceae	*Musanga cecropioides*	Tree	4	2	0	7	1.99
		Myrianthus arboreus	Tree	0	0	0	7	0.66
44	**Verbanaceae**	*Vitex doniana*	Tree	2	0	0	6	1.32
Total	**Families (44)**	**Plant Species (86)**		**678**	**382**	**551**	**738**	100.00

Table 6: Plant species identified across the four sampled locations d the wet season.

S/N	Family	Name of Species	Life Form	AY	IB	IK	OK (Cont)	RF (%)
1	**Anacardiaceae**	*Lannea nigritana*	Tree	0	0	4	0	0.46
		Spondias mombin	Tree	0	7	8	3	1.39
2	**Annonaceae**	*Cleistopholis patens*	Tree	2	0	3	13	1.39
3	**Apocynaceae**	*Alstonia boonei*	Tree	2	0	0	7	0.93
		Alstonia macrophylla	Tree	1	0	0	0	0.46
		Funtumia elastica	Tree	1	0	0	7	0.93
		Saba senegalensis	Climber	0	0	0	6	0.46
		Angadenia berteroi	Herb	0	8	0	0	0.46
		Rauvolfia vomitoria	Shrub	0	0	4	0	0.46
4	**Arecaceae**	*Calamus deerratus*	Climber	0	0	0	20	0.46
		Elaeis guineensis	Tree	0	0	14	20	0.93
		Raphia hookeri	Tree	2	0	0	0	0.46
5	**Asclepiadaceae**	*Gongronema latifolium*	Climber	10	0	2	0	0.93
6	**Aspleniaceae**	*Asplenium nidus*	Fern	0	0	0	11	0.46

7	**Asteraceae**	*Ageratum conyzoides*	Herb	0	33	0	0	0.46
		Aspilia Africana	Herb	42	23	50	13	1.85
		Chromolaena odorata	Herb	34	16	0	0	0.93
		Conyza sumatrensis	Herb	0	17	0	0	0.46
		Crassocephalum crepidioides	Herb	0	10	0	0	0.46
		Cyanthillium cinereum	Herb	0	27	0	0	0.46
		Emilia sonchifolia	Herb	0	0	38	0	0.46
8	Caesalpinioideae	Albizia adianthifolia	Tree	0	0	0	2	0.46
		Anthonotha macrophylla	Tree	0	0	4	2	0.93
9	**Cannabaceae**	*Trema orientale*	Shrub	0	7	0	0	0.46
10	**Clusiaceae**	Allanblackia gabonensis	Tree	0	0	0	11	0.46
		Harungana madagascariensis	Tree	5	5	0	7	1.39
		Symphonia globulifera	Tree	3	0	5	15	1.39
11	**Colchicaceae**	*Gloriosa superba*	Liana	0	0	11	0	0.46
12	**Combretaceae**	Combretum racemosum	Climber	10	0	0	19	0.93
		Combretum tomentosum	Climber	13	0	0	0	0.46
13	**Convolvulaceae**	*Ipomea involucrata*	Liana	35	14	0	0	0.93
		Ipomoea indica	Liana	0	16	0	0	0.46
		Ipomea ratan	Liana	0	0	30	0	0.46
14	**Costaceae**	Costus afer	Herb	28	10	0	13	1.39
15	**Cucurbitaceae**	*Sicyos angulatus*	Liana	9	0	0	0	0.46
16	**Cyatheaceae**	*Sphaeropteris cooperi*	Fern	0	0	0	15	0.46
17	**Cyperaceae**	*Cyperus haspan*	Herb	0	22	59	0	0.93
		Cyperus sp.	Sedges	71	0	0	0	0.46
		Scleria depressa	Herb	0	15	0	0	0.46
18	**Davalliaceae**	*Nephrolepis biserrata*	Fern	84	0	19	39	1.39
19	**Detarioideae**	*Hymenaea courbaril*	Shrub	3	0	0	0	0.46
20	**Dillieniaceae**	*Tetracera alnifolia*	Climber	3	0	5	28	1.39
21	**Dryopteridaceae**	*Ctenitis* sp	Fern	0	0	0	37	0.46
22	**Ebernaceae**	*Diospyros crassiflora*	Tree	0	0	0	5	0.46
23	**Euphobiaceae**	*Spondianthus preussii*	Shrub	5	0	3	21	1.39
		Alchornea cordifolia	Shrub	42	15	34	48	1.85
		Alchornea latifolia	Shrub	0	0	9	0	0.46
		Croton hirtus	Herb	0	9	0	0	0.46
		Macaranga barteri	Tree	4	0	0	18	0.93
		Ricinodendron heudelotii	Tree	0	1	0	0	0.46
		Uapaca heudelotii	Tree	2	0	0	7	0.93
24	**Fabaceae**	*Dioclea reflexa*	Liana	0	11	0	0	0.46
		Sindora wallichii	Shrub	3	0	0	0	0.46
25	**Irvingiaceae**	*Klainedoxa gabonensis*	Tree	1	0	0	0	0.46
26	**Lamiaceae**	*Coleus monostachyus*	Herb	0	16	0	0	0.46
27	**Lauraceae**	Cinnamomum cassia	Tree	0	0	0	7	0.46
28	**Lecythidaceae**	*Napoleonaea imperialis*	Shrub	0	0	14	17	0.93
29	**Longanaceae**	Anthocleista djalonensis	Tree	2	0	0	0	0.46
		Anthocleista procera	Tree	0	0	4	3	0.93
30	**Lygodiaceae**	*Lygodium microphyllum*	Fern	13	0	0	16	0.93
		Lygodium smithianum	Fern	19	0	0	38	0.93
31	**Malvaceae**	*Ceiba pentandra*	Tree	0	0	0	4	0.46
		Glyphaea brevis	Shrub	0	0	0	3	0.46
		Grewia flavescens	Shrub	8	0	0	0	0.46
		Sterculia tragacantha	Tree	0	0	0	18	0.46
		Triplochiton scleroxylon	Tree	0	0	0	4	0.46

		Triumfetta rhomboidei	Shrub	8	19	0	0	0.93
		Urena lobata	Herb	0	27	56	0	0.93
32	**Marantaceae**	*Marantochloa congensis*	Herb	0	0	0	42	0.46
		Marantochloa purpurea	Herb	0	11	7	36	1.39
33	**Melastomataceae**	*Melastoma malabathricum*	Shrub	5	0	0	0	0.46
34	Meliaceae	Carapa procera	Tree	2	0	0	23	0.93
35	Menispermaceae	*Anamirta Cocculus*	Shrub	0	0	5	0	0.46
36	**Mimosoideae**	*Mimosa pigra*	Herb	0	0	68	0	0.46
37	**Moraceae**	Ficus exasperata	Tree	0	9	0	0	0.46
		Ficus polita	Tree	0	2	0	0	0.46
		Ficus sur	Tree	12	9	12	0	1.39
38	**Myrtaceae**	*Psidium guajava*	Tree	0	0	2	0	0.46
39	**Onagraceae**	*Ludwigia decurrens*	Herb	62	20	51	0	1.39
40	**Papilionoideae**	*Baphia nitida*	Shrub	4	0	0	32	0.93
		Dalbergia horrida	Shrub	6	0	4	1	1.39
		Millettia aboensis	Tree	0	6	9	10	1.39
		Philenoptera cyanescens	Shrub	18	0	0	0	0.46
		Pterocarpus santalinoides	Tree	0	0	2	0	0.46
41	**Passifloraceae**	*Smeathmannia pubescens*	Shrub	0	0	8	37	0.93
42	**Phyllanthaceae**	*Bridelia micrantha*	Shrub	6	0	3	26	1.39
		Margaritaria discoidea	Tree	0	0	0	2	0.46
		Phylanthus amarus	Herb	58	17	27	0	1.39
43	**Poaceae**	*Cenchrus purpureus*	Herb	0	0	36	0	0.46
		Coix lachrymal	Herb	51	21	29	10	1.85
		Dactylis glomerata	Herb	0	24	0	0	0.46
		Dichanthelium clandestinum	Herb	19	0	0	0	0.46
		Digitaria ciliaris	Herb	0	42	0	0	0.46
		Digitaria horizontalis	Heb	0	24	0	0	0.46
		Digitaria ischaemum	Herb	0	39	0	0	0.46
		Digitaria radicosa	Herb	0	26	0	0	0.46
		Digitaria sanguinalis	Herb	0	34	0	0	0.46
		Echinochloa colona	Herb	25	29	0	0	0.93
		Echinochloa crus-galli	Herb	32	43	0	0	0.93
		Echinochloa crus-pavonis	Herb	0	0	21	0	0.46
		Leersia oryzoides	Herb	0	36	40	0	0.93
		Megathyrsus maximus	Herb	0	0	77	0	0.46
		Paspalum notatum	Herb	41	0	0	0	0.46
		Pleuropogon californicus	Herb	0	32	0	0	0.46
		Sacciolepis Africana		0	0	42	0	0.46
		Sorghum halepense	Herb	0	4	0	0	0.46
44	**Polypodiaceae**	*Drynaria laurentii*	Fern	0	0	0	17	0.46
		Phlebodium aureum	Fern	0	0	0	15	0.46
		Platycerium coronarium	Fern	0	0	0	11	0.46
		Platycerium staghorn	Fern	0	0	0	10	0.46
45	**Pteridaceae**	*Adiantum caudatum*	Fern	0	0	0	12	0.46
		Pteris atrovirens	Fern	0	0	0	19	0.46
46	**Rubiacea**	*Brenania brieyi*	Tree	0	0	2	0	0.46
		Mitragyna ledermannii	Tree	3	0	0	0	0.46
		Mussaenda polita	Shrub	2	2	4	22	1.85
		Nauclea diderrichii	Tree	3	0	0	0	0.46
		Oxyanthus speciosus	Shrub	0	0	3	0	0.46
		Oxyanthus unilocularis	Shrub	0	0	0	23	0.46

		Pauridiantha floribunda	Shrub	10	5	16	18	1.85
		Pausinystalia macroceras	Shrub	0	0	0	26	0.46
		Psychotria nervosa	Shrub	0	0	9	22	0.93
		Spermacoce ocymifolia	Herb	58	0	0	0	0.46
		Tabernaemontana pachysiphon	Shrub	0	0	0	19	0.46
		Villaria odorata	Shrub	6	0	7	17	0.00
47	**Sapindaceae**	*Allophylus africanus*	Tree	0	0	7	25	0.93
		Paullinia pinnata	Climber	14	6	7	24	1.85
48	**Sapotaceae**	*Pouteria campechiana*	Tree	3	0	0	26	0.93
49	**Smilacaceae**	*Smilax anceps*	Climber	8	7	7	31	1.85
50	**Solanaceae**	*Solanum torvum*	Shrub	0	5	0	0	0.46
51	**Sterculiaceae**	*Cola laurifolia*	Tree	0	0	1	0	0.46
52	**Strelitziaceae**	*Strelitzia reginae*	Herb	0	0	0	13	0.46
53	**Tectariaceae**	*Tectaria fernandensis*	Fern	0	0	0	37	0.46
54	Urticaceae	Musanga cecropioides	Tree	2	2	0	7	0.93
		Myrianthus arboreus	Tree	0	0	0	7	0.46
55	**Verbanaceae**	Vitex doniana	Tree	2	0	0	6	0.93
56	**Vitaceae**	*Cissus glaucophylla*	Liana	0	0	0	40	0.46
		Cissus verticillate	Liana	0	5	0	48	0.93
Total	**Families (56)**	**Plant Species (137)**		**917**	**788**	**882**	**1211**	**100.00**

DISCUSSION

The floristic component and comparative analysis of the four sampled locations show that 86 plant species belonging to 44 families were identified and counted during the dry season, while 137 plants from 56 families were enumerated during the wet season (Tables 5 and 6). The Poaceae family recorded the highest counts in Ibelebiri (1484 in wet, 21 in dry), Ikarama (1153 in wet, 190 in dry), and Ayamasa (477 in wet, 61 in dry), compared to Okumbiri, the control location (10 in wet, 10 in dry). This implies that *Poaceae* plays a part in stabilization and recovery by thriving in damaged soils. Following is the *Asteraceae* family surging in the wet season (626 in Ibelebiri, 156 in Ayamasa) but was already high in the dry season (171 in Ibelebiri, 106 in Ayamasa). This suggests that it may be a pollution-resistant family. In a related study, Obi-Iyeke (2022) also recorded the prevalence of *Poaceae* in sites affected by crude oil in the Niger Delta. Poaceae families accounted for 52% of all families in the area under study, according to Obi-Iyeke. This study also aligns with studies conducted by Prasad and Feitas (2003) and Edema *et al.* (2009) that also provide more insight into these. Additionally, they noted that *Poaceae* had a heavy metal tolerance.

Furthermore, in this study, the *Euphorbiaceae* family was found in all locations, with its highest count in Okumbiri (94). *Papilionoideae* family was present across all sites but strongest in Okumbiri. *Rubiaceae* family was found in all locations, though its numbers are highest in Ayamasa (142). *Cyperaceae* (Sedge Family) shows a high presence in Ibelebiri (107), Ikarama (59), and Ayamasa (101) but is absent in Okumbiri. *Polypodiaceae* (ferns) was found exclusively in Okumbiri in both seasons (73 wet, 10 dry). *Strelitziaceae, Cyatheaceae, Dryopteridaceae, Passifloraceae, Aspleniaceae,* and *Lauraceae* were completely absent in polluted areas but were recorded in Okumbiri, the control site. In this study, pollution drastically affects plant diversity. Sensitive families are nearly absent in polluted locations, reinforcing the long-term environmental impact of oil spills. This study's findings are consistent with those of Feepee *et al*. (2023) in River State, Nigeria. According to Feepee *et al*., the control group had an average of 106 plants per hectare, but the areas that had previously seen a crude oil spill had an average of 21 plants per hectare and 8 plants per hectare. Additionally, Feepee *et al*. found that the control study site had an average of four plant species per unit area, whereas the polluted remediated sites had an average of one plant species per unit area, and the polluted un-remediated sites had an average of half a species per unit area.

Additionally, crude oil leaks always cause a gradual loss of pigments produced by photosynthesis (chlorosis), which manifests as a shift in leaf color from green to light green to yellow prior to defoliation and improved litter fall start. Particularly during the dry season, when drought and water scarcity cause vegetation structure restoration to proceed slowly, leaf and stem surface exposure from oil coating can cause vegetation stems to transition from ash-brown to dark brown (Imoobe & Iroro, 2009).

However, the post-impact effect of the crude oil pollution in the research area can be explained by the differences in the composition of individual plant species seen among study sites. The results showed that the numbers of individual species' plants varied significantly between the control study sites and the crude oil post-impacted sites. Similarly, this result was consistent with the findings of Nwokocha and Diene (2010) and Serrano *et al*. (2018), who report that petroleum hydrocarbon pollution has been shown to have detrimental effects on plants and the ecosystem; these effects are typically noticeable in changes to the physical and chemical characteristics of soil, which in turn affect plant growth.

CONCLUSION AND POLICY RECOMMENDATIONS

The study examined how Bayelsa State's flora diversity was impacted by crude oil spills. The study's findings, which followed a tried-and-true methodology, demonstrated that the flora species in the control group has richer flora, greater biodiversity stability, and better resilience, while polluted areas struggle to sustain diverse plant life. Also, Ecological health indicators (Shannon, Simpson and Margalef Indices) were significant lower in crude oil contaminated locations confirm that pollution negatively impacts biodiversity. Furthermore, stand features were higher in the control group, but sites with effective remedial exercises demonstrated rapid recovery in week stem species particularly in the wet season. Overall, the loss or degradation of mangrove forests as a result of crude oil exploration and exploitation affects not only the Niger Delta's flora diversity but also the ability of more than 70% of the rural population, who depend on agriculture for their livelihood, particularly piscatorial subsistence. Thus, the ongoing devastation of the intertidal coastal ecosystem, which serves as a haven for a wide variety of species, will also have an effect on the inhabitants' quality of life. In order to prevent future spills, oil corporations and the government at all levels must adopt preventative measures and approach crude oil spill cleanup projects proactively rather than reactively.

REFERENCES

Adegbola, O.O., Fakile, S.A., Eluyela, D.F., Onabote, A.A., John, O.N., & Ifeanyichukwu, S. (2023). Impact of Oil and Non-oil Tax Revenue on Economic Growth in Nigeria. *International Journal of Energy Economics and Policy*, 13(2), 545-552

Alexander, I.A., Dada, A.S., & Oluwasegun, F.O. (2017). Extension Implications of Skill Gaps among Cassava farmers in the Niger Delta Region of Nigeria. *Journal of Agricultural Extension*, *21*(2).

Bello, A. & Nwaeke, T. (2023). Impacts of Oil Exploration (Oil and Gas Conflicts; Niger Delta as a Case Study). *Journal of Geoscience and Environment Protection*, 11, 189-200.

Edema, N. E., Obadoni, B. O., Erheni, H. and Osakwuni, U. E. (2009) Eco-phytochemical Eco-Phytochemical Studies of Plants in a Crude Oil Polluted Terrestrial Habitat Located at Iwhrekan, Ughelli North Local Government Area of Delta State. Nature and Science 7 (9), 49-52.

Esara, U. V., Asuquo, M. E., Udoh, A. J. (2024). Oil and militancy in Nigeria's Niger Delta. *Journal of Advanced Research and Multidisciplinary Studies*, 4(3), 77-89. DOI: 10.52589/JARMS-F6LTPPUZ

Feepee, E.F; Eludoyin, O.S., & Deekor, T.N (2023). Assessment of plant species diversity, density and abundance of crude oil post impacted communities in Gokana LGA of Rivers State, Nigeria. Journal of Science and Technology Research & Development 2, (2); 45-60.

Imoobe, T. & Tanshi, I. (2009). Ecological restoration of oil spill sites in the Niger delta, Nigeria. J. Sustain. Dev. in Africa, 11(2): 45-65.

Kadafa AA (2012) Oil exploration and spillage in the Niger Delta of Nigeria. *Civ Environ Res.*, 2(3):38 –51

Nweze, P.N. & Edame, C.E. (2016). An empirical investigation of oil revenue and economic growth in Nigeria. *European Scientific Journal*, 12(25), 271 – 294.

Nkwocha, E.E., and P.O., Diene, (2010). Effect of Oil pollution on local plants species and food crops. Society of Education, India, 1, 189-198.

Nyananyo, B.L. (2006). *Plants from the Niger Delta*. Published by Onyoma Research Publication

Patra, D.K., Acharya, S., Pradhan, C.,Patra. H.K (2021). Poaceae plants as potential phytoremediators of heavy metals and eco-restoration in contaminated mining sites. *Environmental Technology and Innovation*, 21:101293.

Obi-Iyeke, G.E. (2022). Effect of crude oil spillage on plant species and diversity. *Journal of Biodiversity and Environmental Sciences*, 20(5), 29-40.

Odiyi, B.O., Giwa, G.O., Abiya, S.E., & Babatunde, O.S. (2020). Effects of crude oil pollution on the morphology, growth and heavy metal content of maize (Zea mays Linn.). *J. Environ. Manag.*, 24, 119–125

Odukoya, J., lambert, R. & Skrabani, R. (2019). Understanding the impacts of crude oil and its induced abiotic stresses on agrifood production: A review. *Horticulturae*, 5, 47;

Prasad, M.N.V. and Feitas H. (2003). Metal hyperaccumulation in plants-Biodiversity prospecting for phytoremediation technology. Electron J. Biotechnol, 2003; 6(3).

Sarada, P.M., & Okosodo, E.F. (2024). Assessment of avifauna and flora diversity in degraded mangrove ecosystems on Eagle Island, Niger-Delta Rivers State, Nigeria. *Int J Oceanogr Aquac* 8:000297.

Serrano, R., Lastra, M. & López, J. (2018). Other Environmental Health Issues: Oil Spill. 10.1016/B978-0-12-409548-9.11156-X.

Skrypnik, L., Maslennikov, P., Novikova, A., & Kozhikin, M. (2021). Effect of crude oil on growth, oxidative stress and response of anti-oxidative system of Two Rye (Secale cereale L.) Varieties. *Plants*; 10, 157. https://doi.org/10.3390/plants10010157

Tanee, F.B.G & Albert, E. (2015). Reconnaissance assessment of long-term effects of crude oil spill on soil chemical properties and plant composition at Kwawa, Ogoni, Nigeria. *Journal of Environmental Science and Technology*, 8, 320-329.