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# Natural Regeneration; 4 Years after the Ekiugbo Oil Spill, at Ughelli, Delta State, Nigeria: Implication for Phytoremediation Potential

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**Abstract**
This study assessed the floristic composition, structural classification and phytosociology of life form regeneration, mode of regeneration and demographic status of regeneration in vegetation forest, 4 years after pollution impact. It was aimed at evaluating the phytoremediation potential of some hydrocarbon tolerant macrophytes (HTM). Conventional ecological approach involving stratified simple random design method and phytosociological indices were used. Result has classified the study site flora as low land secondary mosaic vegetation with heterogenous continuum in spatial and closed horizontal structural arrangement. Phytosociological dynamics of 51 herbaceous and 12 shrubby life forms of 63 representative species under 21 families and 49 genera of angiosperms recorded changes. Four prevalently dominant families very abundant with highest species diversity richness and three families in abundance were recorded. Shrubby recruit was lower than Herbaceous recruits with the Herbaceous sedge (HS) recording highest recruits among regenerating life forms (HS>HG>HH>HCl). The herbaceous life form had Chamaephytes 33(64.71%) and Hemicryptophytes 18(35.29%). The shrubby life form recorded 2(11.11%) Nanophanerophytes and Mesophanerophytes respectively and 8(66.67%) Microphanerophytes. The herbaceous life form mode of regeneration had 28 recruits with multiplier mode, and 23 recruits with single mode of regeneration. Four recruits exhibited multiplier mode and eight with single mode of regeneration across shrubby life form. Demographic status of regeneration revealed greater seedling than sapling density devoid of adult tree recruits, thus implies “successful and new regeneration”
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## 1. INTRODUCTION

Primary vegetation forests in parts of Niger Delta, especially those of the Ughelli North in Delta State are fast disappearing due to diverse anthropogenic impacts. The consequences of which (as exemplified in the 2015 oil spill at Ughelli due to pipeline integrity failure), and other sources of natural perturbation have resulted to degradation of natural habitats of many plant species in the area (Figs 1a, b, c). As a result the demographic status of susceptible species of the primary stands is simultanousely replaced by secondary species vegetations. This challenge can be adequately addressed via concerted efforts toward understanding the diversity and natural dynamics of plant species regeneration, population change and replacement overtime.

Prior to the installation of networks of crude oil pipeline Right of Ways (ROWs), the adjoining lands of Ekiugbo were green and forested. Agricultural activity was the main occupation in the area. Today the scenario is different due to the impact of oil on the land. (Figs. 1a, b, c) Operating companies in the area often carry out physical clean-up of spill on the land, though without any form of replanting to restore the environment to apparently natural status. Four years after, the impacted site at succession of natural regeneration had recruits of diverse life forms. Earlier studies of tropical tree regeneration have focused mainly on seedlings, which are more abundant and crucial components of tree population dynamics than other life stages (Tripathi and Khan, 1992; Scholl and Taylor, 2006). Changes in the competitive abilities of seedlings for regeneration based on shifting opportunities depend on floristic and structural changes of vegetation component. Plant species through various mode of regeneration status such as coppicing, seedling, rhizome and sapling with few resilient species exhibiting multiplier mode of regeneration in post-remediated hydrocarbon polluted site has been recorded (Edwin-Wosu and Edu, 2013).

Phytosociology is the study of plant communities and a conceptual model which describes vegetation of an area. It is beyond plant species sampling and assessing their contaminant concentration. Several studies have shown that phytosociological indices can provide insight into plant species regeneration status, which plays a key role in enhancing their sustainable management, utilization, conservation and valuation of recruits of seedling, sapling,and coppice (Mwavu and Witkowski, 2008, 2009b; Tesfaye *et al*., 2010; John *et al*., 2013, Edwin-Wosu and Edu, 2013).

Phytosociology and natural regeneration provide quantitative and qualitative models and useful application in phytoremediation technology as well as in ecological monitoring and restoration. Combination of plant species communities growing in polluted soils can be successfully enumerated through phytosociological analyses of potential recovery of polluted site.

Across the interval of time-lag adaptation of species to hydrocarbon pollution exposure there is often changes in demographic (growth, survival and reproduction) status of hydrocarbon vulnerable and resilient species. Such species across phases of phytoremediation protocol and mechanisms for organic and / or inorganic pollution have been categorized into three levels of remediation potential, viz: Hydrocarbon Tolerant Macrophyte (HTM); Suspected Phytoremediation Macrophyte (SPM) and Demonstrated Phytoremediation Macrophyte (DPM) or Hydrocarbon Utilizing Macrophyte (HUM). (Edwin-Wosu, 2011).

Some plant species via natural regeneration have suitable potential noted for phytoremediation of contaminated or polluted sites (Robson *et al*. 2003, 2004; Gaskin and Bentham 2010; Leonid *et al.*, 2018). However, there is still paucity of information on plant species natural regeneration in parts of Niger Delta hydrocarbon impacted sites in both remediated and non-remediated sites. The motivation for this study has arisen a hypothesis such as: can natural regeneration be imminent source for species with remediation potential? This therefore informed the need to evaluate the demographic status of plant species natural regeneration for remediation potential in parts of Niger Delta. This present study was aimed at assessing the HTM and SPM with the objective of evaluating the mode and status of regenerating recruits in parts of Niger Delta area of study.

## 2.0. MATERIALS AND METHODS

### 2.1. Description of the Study Area, Location and Site

The study area is Ughelli Local Council, among the 25 Local Government Areas in Delta State, South-South Nigeria. Precisely the study location - Ughelli North Local Government Area with its' situate between Lat. 5°00'N to 6°30'N and Long.5°00'E to 6°45'E (Fig 2) is one of the hydrocarbon hub in the Niger Delta. The soil condition of the study location is a sandy-loam in texture and rich in nutrients composition of organic and inorganic (particularly industrial clay) components. The location is generally low-lying with heterogeneous vegetation interspersed with the mangrove swamp and the rainforest, secondary and mosaic in nature with successive diverse life form due to disturbance of oil prospecting exploration in the area. The area is characterized by mean annual rainfall (2768.8mm) and mean annual temperature (32.8°C) (Efe, 2010). The study location is comprised of 15 communities / towns including the study site- **Ekiugbo**.

The study site – Ekiugbo a secondary vegetation low land habitat with its geographical location situated at Lat. 5°30'0"N and Long. 6°0'0"E (Fig.2).The study site is an agrarian community and with the rich forestry is also known for their traditional ethno-botanical utilization of plant species. The secondary forest vegetation system is associated with network of crude oil pipeline Right of Ways (ROWs) (Figs 3a, b). The soil is sandy-silt and clay in nature. Though originally a climax vegetation of various strata based on Key Informant Interview (KII) (Edwin-Wosu and Anaele, 2018), the effect of human activities such as farming far and near residential areas as well as encroachment to ROWs by the local inhabitants and the impact of post-spill (due to pipeline integrity failure in 2015) has left the study location with some form of irregular vegetation features in heterogeneity (Figs.4a,b,c).The vegetation can therefore be categorized as a low land secondary mosaic forest in a similar assertion by Hopkin (1968). However, it is yet described as rainforest vegetation corroborating the views of SAF (1954) and Edwin-Wosu and Edu, (2013)

### 2.2. Vegetation Assessment

2.2.1. *Sampling methods and procedures*

An integrated sampling approach involving the stratified random design (Mueller-Dombois and Ellenberg, 1974), and geospatial tools [GPS, Remote Sensing (RS) and Geographic Information System (ESRI'S ARCMAP version 10.4)] was adopted. This was implemented along specific transect of four sub-sampling units (10 x 5m) of transect direction of the sampled plot (40 x 20 meters) to determine phytosociologically the regeneration status of the post – oil impacted site. The sampled plot coordinates and geospatial distribution of the regenerating recruits were taken using a handheld GPS (BHnav300 model). The coordinates were transferred to Microsoft Excel and then imported into ESRI'S ARCMAP software (version 10.4) in which the geo-referenced map showing the satellite imagery of the regenerating species was produced.

2.2.2. *Regeneration Assessment*

A stratified random design (Mueller Dombois and Ellenberg, 1974) was adopted in which a systematic survey of recruits and identification of plant sample were carried out in a representative sampled plot (40x20m) along the right of way in early wet season. Based on similarity in the trend condition of species composition of study site, a representative transect of four sub-sampling units (10x5m) in the sampled plot was laid out for regeneration study. Representative plant species identification was done directly in the field as much as possible and authenticated using relevant reference books such as Burkill, 1985, 1994, 1995, 1997, 2000; Ivens *et al*. (1972); Keay (1989) and Floras such as Hutchinson and Dalziel, 1954, 1958, 1963, 1968 & 1972; Joyce and Stanfield (1974); Joyce (1989). All the natural recruits across demographic regeneration status were recorded based on Sukumar *et al*. (1992) method of density gradient criteria for vegetation monitoring. Density was calculated by counted plants of different species in each sub-sampling unit for qualitative and quantitative demographic assessment of naturally regenerating recruits. Regenerating status was considered "good" when seedling density > sapling/coppicing density > adult tree density, "fair" when seedling density > sapling /coppicing density = adult density, "poor", when the species survived in only the sapling/ coppicing stage but not in the seedling stage, "none", for species with no sapling / coppicing or seedling stages but present as adult trees, and "new" when adults of a species were absent but sapling / coppicing and/or seedling stage(s) were present (Sukumar *et al*., 1992)

2.2.3. *Data analysis*

Data analysis of the regenerating recruits was based on standard phytosociological indices involving: frequency of distribution, abundance, and density of the representative recruits of the study site (Supriya and Yadava, 2006; Shukla, 2009 amd Chikkahuchaiah *et al*., 2016); diversity index in richness among species (Shannon-Wiener,1963); The degree of evenness or equitability (Pielou, 1969); species in semi-quantitative scale (Pryor, 1981); relative density, relative abundance and relative frequency (Misra, 1968); Importance Value Index (IVI) (Shukla and Chandel, 1980); distribution patterns with the "Rule of Thumb" designated as; Regular (< 0.03), Random (0.03 - 0.05) and Contiguous (> 0.05) distribution (Curtis and Cottam, 1956) and Life form spectrum (Raunkiaer, 1934).

## 3.0. RESULT

### 3.1. Floristic composition, structure and classification

The result of floristic classification, structure and composition of the new regeneration has shown that the area was characterized by a progressive succession impact and consequently a classified trend of low land secondary mosaic vegetation with heterogenous continuum in spatial and closed horizontal structural arrangement (Figs. 5a,b).The heterogeneity was a complex of various herbaceous and shrubby life forms in various diversity and abundance with representative recruits exemplified in Table 1. There was variation in the rank of species frequency in different subunit transect of the sampled plot. A total representative of 63 species of herbaceous and shrubby life forms under 21 families and 49 genera of angiosperms was recorded (Table 1).

Diverse prevalence of family dominance was noted among seven families (Poaceae, Euphorbiaceae, Rubiaceae, Cyperaceae, Commelinaceae, Fabaceae and Convolvulaceae) of regenerating recruits. Four families (Poaceae, Euphorbiaceae, Cyperaceae, and Fabaceae) with the highest species richness in diversity were very abundant; Poaceae with 31.92% dominance had 15 diverse species, Cyperaceae (29.79%) 14 species and Euphorbiaceae (10.64%) 5 species while the least species richness (4) was noted with the Fabaceae (8.51%) among the very abundant family (Table 1).

### 3.2. Phytosociology of habit based life form recruits

Phytosociological assessment of the regenerating species recorded variation in ecological indices in relative percentages among the herbaceous (51) and shrubby (12) life forms of the representative recruits (Table 2). Result has revealed one species (*Acroceras zizanioides*) with the highest frequency (100%) of occurrence and seven individual species of least frequency (25%) class among the herbaceous grass (HG) recruits. The herbaceous herb (HH) life form has recorded three species (*C. lanata, N. canescens* and *P. ambigua*) with highest frequency (100%) of occurrence and five species of least (25%) frequency among the regenerating recruits. The herbaceous sedge (HS) has four species (*C. haspan, C. difformis, H. heteromorphum* and *P. lanceolatus*) with highest (75%) frequency class and six species of least (25%) frequency among the regenerating recruits. The herbaceous climbers (HCl) with highest frequency (75%) were (*P.phaseoloides* and *C. mucunoides*) and four species of least (25%) frequency distribution. Generally in all bounding coordinates the frequency distribution of herbaceous recruits has indicated a variation in trend of distribution in the order of *HH > HG > HS > HCl* with percentage frequency ratio (31.37: 29.41: 27.45: 11.77).

Three species (*M. barteri, T. cordifolia* and *A. cordifolia*) with the highest frequency (100%) class and five species of least frequency (25%) class among shrubby recruits were recorded. On the whole the herbaceous recruits recorded a greater percent frequency (2,500) than shrubby recruit (675).

The highest density (1,000$m^2$ = 4.22%) of regenerating recruits was noted in two herbaceous grass (HG) species (*A. zizanioides* and *P. indica*) and the least density (75$m^2$ = 0.32 %) with *L. caerulescens*. The herbaceous herb (HH) recruits with the highest density (1125$m^2$ = 4.75%) was *Cynotis lanata* and least density 75$m^2$ (0.32%) was *Conyza sumatrensis*. Herbaceous sedge (HS) (*F. littoralis*) was noted for highest density of 1000$m^2$ (4.22%) with *M. longibracteatus* and *M. alternifolius* of least density (125$m^2$ = 0.53%) respectively.

Herbaceous climber (HCl) of highest density (875$m^2$ = 3.69%) and least density (75$m^2$ = 0.32%) was recorded by *Calopogonium mucunoides* and *Ipomoea involucrata* recruits respectively. Generally, in all bounding coordinates the herbaceous recruits showed variation in the trend of density $m^2$ of individuals in the orders of *HS>HG>HH>HCl* with percentage density ratio (31.91: 29.91: 29.43: 8.75).

One recruit (*Triumfetta cordifolia*) was noted for highest density ($525m^2$ = 2.22%) and one recruits (*Rauvolfia vomitoria*) had least density ($50m^2$ = 0.21%) among the shrubby recruits respectively. On the whole herbaceous recruits had a density of $21{,}152m^2$ and shrubby recruit ($2{,}650m^2$).

A highest abundance of 22.00 (4.38%) and least abundance of 3.00 (0.60%) was recorded with the HG recruit (*Ischaemum rogosum* and *Leptochloa caerulescens*) respectively. The HH recruits recorded highest abundance (15 = 2.99%) with *Spigellia anthelmia* and least abundance (2.50 = 0.50%) with *Palisota ambigua*. The HS had *K. pumila* with highest abundance (28.00 = 5.57%) and least abundance (5.00 = 1.00%) with *M. longibracteatus* and *M. alternifoluis* respectively. The HCl recruit showed highest abundance (11.67 = 2.32%) with *C. mucunoides* and least abundance (3.00 = 0.60%) with *Ipomoea involucrata*. Generally, the herbaceous recruits has recorded varying trend of abundance in the order *HS>HG>HH>HCl* with percentage ratio (35.93: 30.92: 24.84: 8.31). A shrubby recruit (*Melastomastrum capitatum*) with highest (15.00 = 2.99 %) abundance and two species (*Macaranga barteri* and *Rauvolfia vomitoria*) (2.00 = 0.10 %) were respectively noted. An overall abundance (449.52) of herbaceous recruit and shrubby recruit (52.92) were noted.

The importance value index (IVI) was highest (9.36%) and least (2.01%) in two HG recruits (*A. zizanioides* and *S. barbata*) respectively. The HH recruits highest (10.14%) IVI in *C. lanata* and least (1.71%) in *C. sumatrensis*; HS recruits highest (9.77%) in *F. littoralis* and least (2.32%) in *M. longibracteatus* and *M. alternifolius* respectively; and HCl recruit highest (8.37%) IVI in *C. mucuniodes* and least (1.71%) in *I. Involucrata* were recorded. The overall trend of herbaceous IVI in the order *HS>HG>HH>HCl* with percentage ratio (31.95: 29.71: 28.43: 9.90) was noted. The shrubby recruits recorded a highest IVI (6.41%) in *T. cordifolia* and least (1.71%) in *Aeschynomene indica*, *V. africana* and *U. lobata* respectively. In overall, the herbaceous recruit IVI (253.77%) and shrub recruit IVI (42.99%) were noted.

The Shannon-Weinner species diversity richness and evenness noted *A. zizanioides* for highest richness (1.53); evenness (0.84) and least richness (0.03); evenness (0.02) for *B. deflexa* and *S. megaphylla* respectively among HG recruits. *Cynotis lanata* with highest richness (1.77); evenness (0.98) was noted alongside least richness (0.03); evenness (0.02) for *E. alba* and *C. hirtus* respectively among the HH recruits. The HS recruits had *F. littoralis* with highest richness (1.64); evenness (0.91) and least richness (0.09); evenness (0.05) for *M. longibractaetus* and *M. alternifoluis* respectively. The HCl recruit with highest richness (1.23); evenness (0.68) was in *Calopogonium mucunoides* and least richness (0.0.06); evenness (0.08) with *Ipomoea asarifolia*. The general trend of herbaceous richness and evenness was in the order *HS>HG>HH>HCl* with percentage richness ratio (35.61:30.51:24.65:9.23) and evenness ratio of 35.57:30.53:24.69:9.20 respectively. The shrubby recruit recorded highest richness (0.69) and evenness (0.38%) with *T. cordifolia* and least richness (0.001) and evenness (0.0001) with *M. subulalus*. On the overall the herbaceous recruit had higher richness (24.71) and evenness (13.69) than shrubby recruits with 2.86 richness and evenness (1.59).

The pattern of distribution among the regeneration recruits has recorded 0.88 as highest distribution in contiguous pattern with *I. rogosum* and least distribution (0.08) with *S. megaphylla* among HG recruit. The HH recruit had a highest (0.60) distribution in contiguous pattern with *S. anthelmia* and least (0.04) distribution in random pattern with *N. canescens*. The HS recruit highest (1.12) contiguous distribution was in *K. pumila* and least (0.08) in *H. heteromorphum*, HCl recruit highest (0.32) in *I. asarifolia* and least (0.07) in *P. phaseoloides*. The general trend of herbaceous distribution pattern was in the order *HS>HG>HH>HCl* with relative ratio of 38.22: 32.07: 21.54: 8.18 respectively. The shrubby recruits had a highest (0.60) distribution in contiguous pattern with *Melastomastrum capitatum* and least (0.02) in regular pattern with *Macaranga barteri*. On the overall the herbaceous recruits had higher distribution (12.35) pattern than shrubby recruits with 1.43.

### 3.3. Life form regeneration based on environmental adaptation

A total of 51 recruits of herbaceous life form under ecological resilience revealed diverse environmental adaptiveness of life form with 33 (64.71%) Chamaephytes and 18 (35.29%) Hemi-cryptophytes recorded at the post-polluted site (Table 3). Across the diverse environmental adapted life form, 11(21.57%) HG was Chamaephytes, HH (11= 21.57%) Chamaephytes, HS (10 = 19.61%) Chamaephytes and HCl (1 = 1.96%) Chamaephytes. Similarly, HG had 4 (7.84%) Hemi-cryptophytes, HH 5(9.80%) Hemi-cryptophytes, HS 4(7.84%) Hemi-cryptophytes and HCl 5 (9.80%) Hemi-cryptophytes recorded. The 12 shrubby life form had 2(11.11%) Nano-phanerophytes, and Mesophanerophytes respectively with 8(66.67%) Microphanerophytes recorded.

### 3.4. Degree mode of regeneration

The mode of regeneration across the recruits has revealed various levels or degree (single or multiplier) across the life form regeneration status (Table 3). The HG has five levels of regeneration across 15 recruits; 10 recruits exhibiting multiplier mode and five with single mode of regeneration with their relative percentage composition across individual HG life from (Table 4). The HH showed six mode of regeneration across 16 recruits; seven recruits exhibiting multiplier mode and nine of single mode with their relative percentage composition across individual HH life forms. While the HS had four degree mode of regeneration across 14 recruits; eight exhibiting multiplier mode and six exhibiting single mode of regeneration, HCl had two levels of regeneration across six recruits; three exhibiting multiplier and three single mode of regeneration respectively with their relative percentage across individual HCl life forms respectively. The shrubby life form has four levels of regeneration across 12 recruits; 4 recruits exhibiting multiplier mode and eight with single mode of regeneration with their relative percentage across individual shrubby life form.

### 3.5. Demographic Regeneration Status

The demographic status of regenerating species was maximal at the post polluted land scape of the study site having a total of 63 recruits' composition of 49 (77.78%) seedling and 14 (22.22%) sapling status across the herbaceous and shrubby recruits (Table 3). Two seedlings (*A. zizanioides* and *P. indica*) with maximum density (1000m$^2$) respectively of the total density (6,327m$^2$) of the 15 HG seedlings (Table 3). The HH with 12 recruits had one seedling (*Cynotis lanata*) with maximum density (1125m$^2$) of the total density (4,800m$^2$) of the recruits. The HS (14) recruits had one seedling (*Fimbristylis littoralis*) with maximum density (1000m$^2$) of the total density (6750m$^2$). The HCl recruits had recorded one seedling (*Pueraria phaseoloides*) with maximum density (500m$^2$) of the total density (1850m$^2$). The shrubby (Sh) recruits had one seedling (*Desmodium tortusium*) with maximum density (250m$^2$) of the total density (325m$^2$). Within the seedling status, the HS had the highest seedling density and HCl least density in the order of *HS>HG> HH> HCl*. Across the HH and Sh recruits one sapling recruit (*Palisota hirsuta*) had maximum density (550m2) of the total density (1425m$^2$) while Sh sapling recruit had *Triumfetta cordifolia* with maximum density (525m$^2$) of the total density (2325m$^2$). Within the sapling status Sh had greater sapling density than HH sapling density (*Sh>HH*). Generally the regenerating recruits of the life forms had greater seedling density (20, 052m$^2$) than sapling density (3,750m$^2$).

## 4. DISCUSSION

Floristic composition, structure and classification are an important aspect of phytosociological analysis in ecological study. Similar to assertion by Mohammed and Al-Amin (2007); Edwin-Wosu and Edu, (2013), the nature of vegetation in a pristine and / or disturbed condition such as that observed in Ekiugbo can largely depend on the ecological characteristic of site, phytosociology, life form based on habit / environmental adaptation, mode and status of regenerating recruits under local environmental conditions. The virginity of the floristic composition and structure of Ekiugbo vegetation system under hydrocarbon exploration was characterized by retrogressive succession impact. Habitat alteration due to anthropogenic activities is among the major risk of ecosystem degradation (Edwin-Wosu and Edu, 2013; Jayakumar and Nair, 2013). This has resulted to a low land secondary mosaic vegetation of the study site with heterogenous continuum in horizontal structural arrangement due to the impact of post oil spill phenomenon, floristic succession, and demographic regeneration across adaptation and growth survival of the recruits. This corroborates Edwin-Wosu and Edu, (2013) who reported the assessment of regeneration status of species in a post-remediated crude oil impacted site in Akwa-Ibom State.

These have caused changes in the vegetation complex of herbaceous and shrubby life forms in various abundance and diversity of species, genera and families. Spatial heterogeneity of diversity due to some underlying pattern or process such as environmental heterogeneity and biotic/abiotic coupling process have been reported (Pringle, 1990). The diverse prevalence of family dominance in their order percentage composition and species richness was revealed among the regenerating member recruits of the Poaceae, Cyperaceae, Euphorbiaceae, Fabaceae, Rubiaceae, Commelinaceae and Convolvulaceae. Report of dominant families of regeneration in a crude oil impacted site in Akwa-Ibom State has also been documented (Edwin-Wosu and Edu, 2013).

Phytosociology deals with plant assemblages or communities of vegetation stands. It places vegetation units into a hierarchical system based on varying degrees of floristic similarity. In the present study variation in the phytosociological indices among habit based herbaceous and shrubby life forms have been revealed. Such variation can be homogenous or heterogenous in distribution.

Frequency distribution and density of plant species influences the structural composition of tropical vegetation. In the present study greater numbers of recruits were in frequency class 0-25% and least number in frequency class 75 – 100%. The frequency distribution of these recruits implies that most of them had low frequency as would be expected in tropical species abundance distribution. This corroborates Jayakumar and Nair (2013) on studying species diversity and tree regeneration pattern. In such variation the HH among the order (*HH>HG>HS>HCl*) of life form had the highest frequency across the regenerating recruits of the post-polluted site. Variation in species composition is mostly due to microenvironmental abiotic changes (Shameem *et al*., 2011), however, spatial variation of the herbaceous recruits might be due to the nature anthropogenic disturbances such as the oil spill incident, yet had higher frequency than the shrubby recruits. This corroborates Sultana *et al*. (2014); Bere and Mangadze, (2014); Chikkahuchaiah *et al.* (2016); and Edwin-Wosu and Anaele, (2018) who has evaluated the impact of anthropogenic disturbance on species composition in diverse ecological analyses.

The highest abundance of recruit among the life form was revealed in HG (*I. rogosum*), HH (*S. anthelmia*), HS (*K. pumila*), HCl (*C. mucunoides*) and Sh (*M. capitatum*) respectively. The greater abundance of the herbaceous lower vascular species among the life forms is an indication of a secondary vegetation structure heterogenous in nature as a result of regeneration process with few species that were present as shrub. The HS exhibited the highest density, IVI, diversity richness in the order *HS> HG>HH> HCl* among the regenerating recruits. Besides the herbaceous recruits was higher than shrubby recruits. This variation might be the result of anthropogenic influence already observed in course of oil pollution phenomenon across time-lag intervals of adaptation. Variation in plant species density of regenerating recruits in light of post impacted disturbances have been documented (Sharma 2012; Dangwal *et al*., 2012; Varun *et al*., 2017).

Importance Value Index is an important phytosociological index that reveals ecological significance of species in a given ecosystem (Worku *et al*., 2012; Edwin-Wosu and Edu, 2013; Edwin-Wosu and Anaele, 2018). *Acroceras zizanioides, Cynotis lanata, Fimbristylis littoralis, Calopogonium mucuniodes* and *Triumfetta cordifolia* regeneration at the post impacted site can be considered the most ecologically important herbaceous and shrubby recruits with IVI values of more than five contributed by their high value of frequency, abundance and density. Among such ecologically important species *C. lanata* was noted for highest IVI.

Species diversity is one of the major criteria in recognizing the importance of an area for conservation, hence an index associated with some level of variations in terms of richness and evenness (Edwin-Wosu and Edu, 2013). Species diversity could be low due to disturbance but an increased interval between disturbances also increases diversity (Kalacska *et al*., 2004), and also can allow community succession to progress beyond a typical stage, causing changes in plant community structure (Richardson and Thuiller, 2007; Edwin-Wosu and Anaele, 2018).A greater contiguous distribution pattern among the regenerating species of herbaceous and shrubby life forms occurred. However, a least random and least regular pattern of distribution within HG and Sh recruits where respectively reported. Contiguous distribution pattern in natural vegetation is the prevalent pattern in nature unlike random and regular distribution found in very uniform environment (Verma *et al*., 1999; Edwin-Wosu and Edu, 2013).The discrepancies in the phytosociological indices could also be attributed to other environmental factors including forest management or soil conditions or other environmental complexes as reported by Tuomisto (2010), but are not measured in this present study. Also can be the effect of the heterogeneity observed in the structural composition and classification of the low land secondary mosaic vegetation of the post impacted site. There was increase in the herbaceous status of habit based life form with a total representative of 51 recruits. The increase within the study site is an indication of a primary regenerative succession which seems to be progressive toward a climax vegetation of habit based shrubby life form.

Environmental pollution especially of hydrocarbon nature often possess direct or indirect threat to biodiversity even at the instance of some form of resilience and adaptation by some flora in readiness for regeneration. Regeneration is critical phase of forest management, hence the desired species composition and stocking after disturbance is maintained (Duchok *et al*., 2005). The regeneration of life form based on environmental adaptiveness has revealed variation in the post-pollution landscape of the study site. While the Chamaephyte had the highest percentage in establishment and composition, Hemi-cryptophytes was least in its percentage establishment and composition among the habit based herbaceous life form. Similarly, within the habit-based shrubby life form were highest percentage composition of Microphanerophytes and least percentage composition of Nanophanerohyte and Mesophanerophytes. The presence of this demographic variation in the colonized and established succession stages is an indication that the study location was at one time under human disturbance such as the crude oil spillage. This corroborates similar observation by Kalacska *et al.* (2004); Edwin-Wosu and Edu, (2013).

The existence of species in the community largely depends also on its mode of regenerating recruits under varied local environmental conditions. Upon such condition open canopy (Khan *et al*., 1987; Srinivas 1992; Edwin-Wosu and Edu, 2013) might favour vegetation establishment through increased solar radiation incident on the forest floor. Many species at the study site which supposedly under natural habit were not present as trees. New species were found regenerating and were absent as adults. Greater number of recruits among the herbaceous life form exhibited multiplier capability through coppicing, seedling, Rhizome, and Tuber in their mode of regeneration, while few exhibited single mode of regeneration and vice versa for the shrubby life form.

Consequently the mode of regeneration as observed following resilience and adaptiveness across the post-pollution landscape had two major demographic (seedling and sapling) status of regeneration established among the habit based life form regenerating recruits. This could be based on local environmental condition in which open canopy often favour and influences demographic status of vegetation through increased solar radiation on forest floor as earlier reported (Edwin-Wosu and Edu, 2013). There was variation among the seedling of herbaceous recruits with the HS having greater seedling density while the shrubby recruits had higher sapling density. Between the two demographic statuses, the seedling status was greater in density than the sapling status. Though the area was oil impacted, after 4-years the establishing recruits was approximately similar to natural forest of Ekiugbo in Ughelli, Delta State. Complete absence of adult tree density and presence of seedling and sapling densities is indication of a "successful and new regeneration" (Fig. 5) (Sukumar *et al.,* 1992).

The dominance of some families under a natural regeneration phenomenon of hydrocarbon impacted site in course of their resilience, adaptation, growth survival as reported in this present study can be a source of species selection for natural remediation potential via human effort. The ecological significance based on the IVI of some families in the present study had indicated such species as *A. zizanioides, C. lanata*, *Fimbristylis littoralis, C. mucunioides* and *T.cordifolia* as HTM and SPM with remediation potential under natural regeneration. Several report have documented array of plant species by natural regeneration under these prevalent family (Poaceae, Fabaceae, Cyperaceae, and Asteraceae) with the potential to tolerate as well as facilitate the phytoremediation of petroleum hydrocarbon contaminated or polluted soil under field and / or laboratory condition (Robson *et al*. 2004; Robson *et al*. 2003; Gaskin and Bentham 2010; Sunday and Aboh, 2012; Leonid *et al*., 2018).

The frequency, abundance, density, and species diversity considered as indices of success in reforestation (Saxena *et al*., 1984) suggest that it is possible to re-establish a complete forest cover for the degraded deforested Ekiugbo site by natural regeneration. The recorded indices are considered quite adequate for complete recruiting for biodiversity conservation. Therefore by proper protection of the recruiting regeneration, the study location can become a natural forest again that can be categorized as low land secondary mosaic vegetation in a similar assertion by Edwin-Wosu (2011).

## CONCLUSION

The phytosociology of life form and demographic status of regeneration recruits of the 4 years after pollution impact has been assessed with the aim of evaluating the phytoremediation potential of some hydrocarbon tolerant macrophytes (HTM) and suspected phytoremediation macrophytes (SPM). The heterogeneity of the low land secondary mosaic vegetation in spatial and closed horizontal continuum structural arrangement is an indication of changes in phytosociological dynamics of vegetation array of the herbaceous and shrubby life forms of representative species under families and genera of angiosperms recorded. Shrubby recruits were lower than Herbaceous recruits with the Herbaceous sedge (HS) having the highest recruits among regenerating life forms (*HS>HG>HH>HCl*). Based on environmental resilience and adaptiveness Chamaephytes and Hemicryptophytes were observed across herbaceous life forms and Nanophanerophytes, Mesophanerophytes and Microphanerophytes were observed across shrubby life form. Also the herbaceous life form had greater multiplier mode than single mode of regeneration and vice versa for the shrubby life form. Demographic status of regeneration revealed a successful and new regeneration due to greater seedling density than sapling density devoid of adult tree recruits. The ecological significance based on the IVI has indicated some species of families (Poaceae, Commelinaceae, Cyperaceae, Fabaceae and Asteraceae) as HTM and SPM with remediation potential to facilitate the phytoremediation of hydrocarbon polluted soil habitat under natural regeneration.

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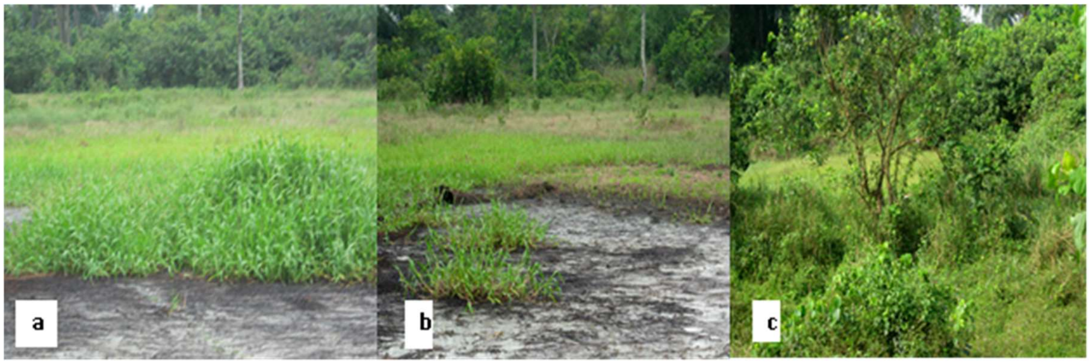



**Figs.1a,b, c: Parts of the oil spilled post impacted adjoining vegetation of the ROW and habitat regeneration at Ekiugbo study location**

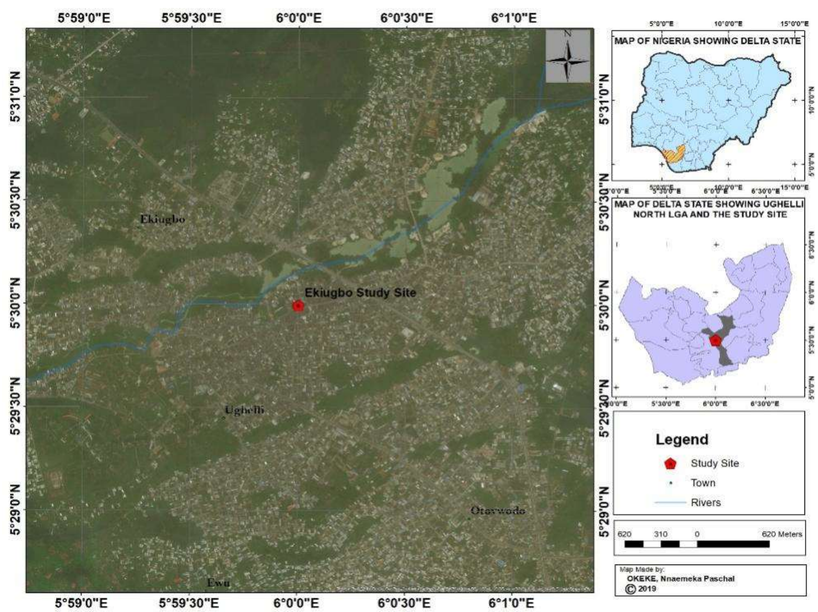


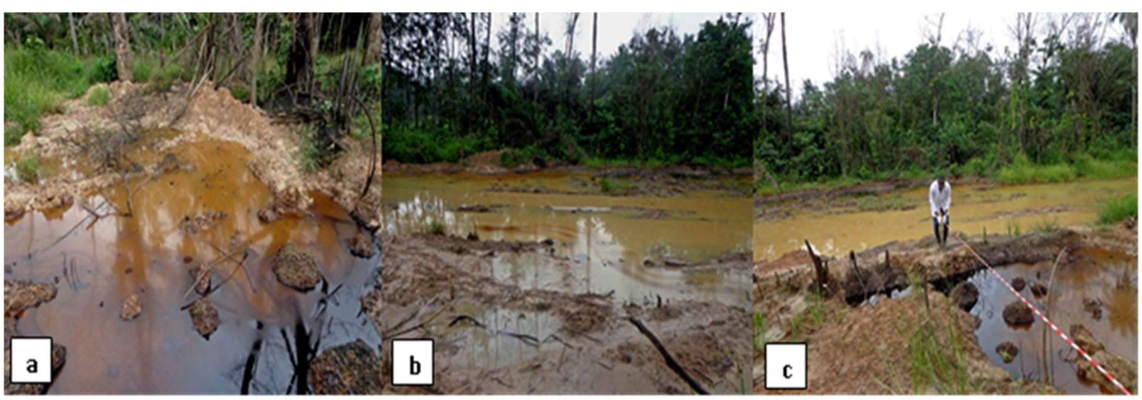

**Fig. 2: Indicating Satellite Imagery of Ughelli North study area and Ekiugbo sampled site**

**Figs.5a, b: Parts of the New Regeneration in 2019, 4 years after Ekiugbo oil spill along the Right Of Way**

**b. Parts of the regeneration sampled plot with representative sub-sampled transect unit for regeneration assessment.**


**Figs. 3a, b: Parts of the Right of Way (ROW) associated with adjoining secondary vegetation of the study location**




**Figs. 4a, b, c: Part of the 2015 Oil spilled impacted Site at Ekiugbo ROW Study Location with irregular vegetation structure**

**Table 1: Qualitative and Quantitative Phytosociological Representative of Hydrocarbon Tolerant Species; 4 years after the Ekiugbo oil spill, at Ughelli, Delta State, Niger Delta, Nigeria.**

| S/N | Species | FAMILY | Common name | %F | Dm² | A | %RF | %RD | %RA | IVI | RIVI | SdH' | SdE | A/F | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Ischaemum rogosum* Salisb. | Poaceae | Saramilla grass | 25 | 550 | 22.00 | 0.79 | 2.32 | 4.38 | 7.49 | 2.48 | 0.98 | 0.54 | 0.88 | + |
| 2 | *Panicum maximum* Jacq. | Poaceae | Guinea grass | 50 | 350 | 7.00 | 1.57 | 1.48 | 1.39 | 4.44 | 1.47 | 0.25 | 0.14 | 0.14 | ++ |
| 3 | *Leersia hexandra* Sw. | Poaceae | Swamp rice grass | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 4 | *Acroceras zizanioides* (Kunth) Dandy | Poaceae | Oat grass | 100 | 1000 | 10.00 | 3.15 | 4.22 | 1.99 | 9.36 | 3.10 | 1.52 | 0.84 | 0.10 | ++++ |
| 5 | *Leptochloa caerulescens* Steud. | Poaceae | Grass | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 6 | *Panicum laxum* Sw. | Poaceae | Panic grass | 50 | 550 | 10.00 | 1.57 | 2.11 | 1.99 | 5.67 | 1.88 | 0.52 | 0.29 | 0.20 | ++ |
| 7 | *Brachiaria deflexa* (Schumach.) C.E.Hubb. ex Robyns | Poaceae | Annual brachiaria | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.22 | 1.07 | 0.03 | 0.02 | 0.32 | + |
| 8 | *Brachiaria lata* (Schumach.) C.E.Hubb. | Poaceae | Grass | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 9 | *Paspalum scrobiculatum* Linn. | Poaceae | Ditch millet | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 10 | *Perotis indica* (Linn.) O. Kuntze | Poaceae | Grass | 75 | 1000 | 13.33 | 2.36 | 4.22 | 2.65 | 9.23 | 3.06 | 1.49 | 0.83 | 0.18 | +++ |
| 11 | *Setaria barbata* (Lam.) kunth | Poaceae | Bristly fox tail grass | 25 | 100 | 4.00 | 0.79 | 0.42 | 0.80 | 2.01 | 0.67 | 0.12 | 0.07 | 0.16 | + |
| 12 | *Setaria megaphylla* (Steud.) T.Dur. & Schinz | Poaceae | Big-leaf bristle grass | 50 | 200 | 4.00 | 1.57 | 0.84 | 0.80 | 3.21 | 1.06 | 0.03 | 0.02 | 0.08 | ++ |
| 13 | *Oplismenus burmannii* (Retz.) P. Beauv | Poaceae | Burmann's basket grass | 75 | 875 | 11.67 | 2.36 | 3.69 | 2.32 | 8.37 | 2.77 | 1.23 | 0.68 | 0.16 | +++ |
| 14 | *Andropogon repens* Steud. | Poaceae | Grass | 50 | 327 | 6.50 | 1.57 | 1.37 | 1.29 | 4.23 | 1.40 | 0.20 | 0.11 | 0.13 | ++ |
| 15 | *Andropogon tectorum* Schum & Thonn | Poaceae | Giant blue stem | 50 | 225 | 4.50 | 1.57 | 0.95 | 0.90 | 3.42 | 1.13 | 0.06 | 0.03 | 0.09 | ++ |
| | **SUBTOTAL** | | | **675** | **6327** | **139** | **21.25** | **26.47** | **27.68** | **75.40** | **24.97** | **7.54** | **4.18** | **3.96** | |
| 16 | *Macaranga barteri* Mull-Arg | Euphorbiaceae | NA | 100 | 200 | 2.00 | 3.15 | 0.84 | 0.40 | 4.39 | 1.45 | 0.23 | 0.13 | 0.02 | ++++ |
| 17 | *Alchornea laxiflora* (Benth) Pax &K. Hoffm | Euphorbiaceae | Christmas bush | 75 | 175 | 2.33 | 2.36 | 0.74 | 0.46 | 3.56 | 1.18 | 0.08 | 0.04 | 0.03 | +++ |
| 18 | *Alchornea cordifolia* (Schum & Thonn) Mull-Arg | Euphorbiaceae | Christmas bush | 100 | 300 | 3.00 | 3.15 | 1.27 | 0.60 | 5.02 | 1.66 | 0.37 | 0.21 | 0.03 | ++++ |
| 19 | *Croton hirtus* L'Her. | Euphorbiaceae | Hairy cotton | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.22 | 1.07 | 0.03 | 0.02 | 0.32 | + |
| 20 | *Mallotus subulatus* Mull-Arg | Euphorbiaceae | Kamala plant | 50 | 175 | 3.50 | 1.57 | 0.74 | 0.70 | 3.01 | 1.00 | 0.00 | 0.00 | 0.07 | ++ |
| | **SUBTOTAL** | | | **350** | **1050** | **18.83** | **11.02** | **3.58** | **3.75** | **19.13** | **6.36** | **0.63** | **0.40** | **0.47** | |
| 21 | *Sphenoclea zeylanica* Gaertn. | Sphenocleaceae | Wedge wort | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| | **SUBTOTAL** | | | **25** | **125** | **5.00** | **0.79** | **0.53** | **1.00** | **2.32** | **0.77** | **0.09** | **0.05** | **0.20** | |
| 22 | *Oldenlandia corymbosa* Linn | Rubiaceae | Flat-top mille graines | 75 | 500 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.92 | 0.54 | 0.30 | 0.09 | +++ |
| 23 | *Pentodon pentandrus* (Schumach. & Thonn.) Vatke | Rubiaceae | NA | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 24 | *Diodia sarmentosa* Sw. | Rubiaceae | Tropical button weed | 50 | 450 | 9.00 | 1.57 | 1.90 | 1.79 | 5.26 | 1.74 | 0.42 | 0.23 | 0.18 | ++ |
| | **SUBTOTAL** | | | **150** | **1075** | **20.67** | **4.72** | **4.54** | **4.12** | **13.38** | **4.43** | **1.05** | **0.58** | **0.47** | |
| 25 | *Melastomastrum capitatum* (Vahl) A. & R. Fern | Melastomataceae | NA | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| | **SUBTOTAL** | | | **25** | **375** | **15.00** | **0.79** | **1.58** | **2.99** | **5.36** | **1.77** | **0.44** | **0.24** | **0.60** | |
| 26 | *Triumfetta cordifolia* A. Rich. | Tiliaceae | Cord-Leaf bur back | 100 | 525 | 5.25 | 3.15 | 2.22 | 1.04 | 6.41 | 2.12 | 0.69 | 0.38 | 0.05 | ++++ |
| | **SUBTOTAL** | | | **100** | **525** | **5.25** | **3.15** | **2.22** | **1.04** | **6.41** | **2.12** | **0.69** | **0.38** | **0.05** | |
| 27 | *Cyperus iria* Linn. | Cyperaceae | Rice field flat Sedge | 25 | 550 | 22.00 | 0.79 | 2.32 | 4.38 | 7.49 | 2.48 | 0.98 | 0.54 | 0.88 | + |
| 28 | *Cyperus haspan* Linn | Cyperaceae | Haspan flat Sedge | 75 | 725 | 9.67 | 2.36 | 3.06 | 1.92 | 7.34 | 2.43 | 0.94 | 0.52 | 0.13 | +++ |
| 29 | *Cyperus difformis* Linn. | Cyperaceae | Umbrella Sedge | 75 | 650 | 8.67 | 2.36 | 2.74 | 1.73 | 6.83 | 2.26 | 0.80 | 0.44 | 0.12 | +++ |
| 30 | *Fimbristylis littoralis* Gaudich | Cyperaceae | Fimbry Sedge | 50 | 1000 | 20.00 | 1.57 | 4.22 | 3.98 | 9.77 | 2.23 | 1.64 | 0.91 | 0.40 | ++ |
| 31 | *Kyllinga pumila* Michx. | Cyperaceae | Low spike Sedge | 25 | 700 | 28.00 | 0.79 | 2.95 | 5.57 | 9.31 | 3.08 | 1.50 | 0.83 | 1.12 | + |
| 32 | *Kyllinga squamulata* Thonn. ex Vahl. | Cyperaceae | Asian spike Sedge | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| 33 | *Mariscus longibracteatus* Cherm. | Cyperaceae | Sedge | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 34 | *Cyperus rotundus* Linn. | Cyperaceae | Purple nut sedge | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 35 | *Mariscus alternifolius* Vahl | Cyperaceae | Sedge | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 36 | *Hypolytrum heteromorphum* Nelmes | Cyperaceae | Forest sedge | 75 | 450 | 6.00 | 2.36 | 1.90 | 1.19 | 5.45 | 1.80 | 0.46 | 0.26 | 0.08 | +++ |
| 37 | *Rhynchosporra corymbosa* (Linn.) Britton | Cyperaceae | Sedge | 25 | 250 | 10.00 | 0.79 | 1.05 | 1.99 | 3.83 | 1.27 | 0.13 | 0.07 | 0.40 | + |
| 38 | *Pycerus lanceolatus* (Poir.) C.B.Clarke | Cyperaceae | Sedge | 75 | 575 | 7.67 | 2.36 | 2.43 | 1.53 | 6.32 | 2.09 | 0.67 | 0.37 | 0.10 | +++ |
| 39 | *Scleria naumanniana* Boeck. | Cyperaceae | Bush knife Sedge | 50 | 300 | 6.00 | 1.57 | 1.27 | 1.19 | 4.03 | 1.33 | 0.16 | 0.09 | 0.12 | ++ |
| 40 | *Kyllinga erecta* Schumach. | Cyperaceae | Sedge | 50 | 550 | 11.00 | 1.57 | 2.32 | 2.19 | 6.08 | 2.01 | 0.61 | 0.34 | 0.22 | ++ |
| | **SUBTOTAL** | | | **650** | **6750** | **161.51** | **20.46** | **28.48** | **32.15** | **81.09** | **25.83** | **8.80** | **4.87** | **4.72** | |
| 41 | *Palisota ambigua* (P. Beauv) C. Bil. | Commelinaceae | NA | 100 | 250 | 2.50 | 3.15 | 1.05 | 0.50 | 4.70 | 1.56 | 0.30 | 0.17 | 0.03 | ++++ |
| 42 | *Palisota hirsuta* (Thunb.) K.Schum. | Commelinaceae | NA | 75 | 550 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.15 | 0.07 | 0.04 | 0.09 | +++ |
| 43 | *Cynotis lanata* Benth | Commelinaceae | Cynotis | 100 | 1125 | 11.25 | 3.15 | 4.75 | 2.24 | 10.14 | 3.36 | 1.77 | 0.98 | 0.11 | ++++ |
| | **SUBTOTAL** | | | **175** | **1925** | **20.42** | **8.66** | **7.91** | **4.07** | **20.64** | **6.07** | **2.14** | **1.19** | **0.23** | |
| 44 | *Eclipta alba* (Linn) Hassk | Asteraceae | False daisy | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.21 | 1.06 | 0.03 | 0.02 | 0.32 | + |
| 45 | *Conyza sumatrensis* (Retz.) Walker | Asteraceae | Flea bane | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| | **SUBTOTAL** | | | **50** | **275** | **11.00** | **1.58** | **1.16** | **2.19** | **4.49** | **1.63** | **0.17** | **0.10** | **0.44** | |
| 46 | *Costus lucanusianus J.* Braun & K. Schum. | Costaceae | Wild ginger lily | 50 | 250 | 5.00 | 1.57 | 1.05 | 1.00 | 3.62 | 1.20 | 0.10 | 0.06 | 0.10 | ++ |
| | **SUBTOTAL** | | | **50** | **250** | **5.00** | **1.57** | **1.05** | **1.00** | **3.62** | **1.20** | **0.10** | **0.06** | **0.10** | |
| 47 | *Hydrolea palustris* (Aubl.) Rausch | Hydrophyllaceae | NA | 75 | 375 | 5.00 | 2.36 | 1.58 | 1.00 | 4.94 | 1.64 | 0.35 | 0.19 | 0.07 | +++ |
| | **SUBTOTAL** | | | **75** | **375** | **5.00** | **2.36** | **1.58** | **1.00** | **4.94** | **1.64** | **0.35** | **0.19** | **0.07** | |

| S/N | Species | FAMILY | Common name | %F | Dm² | A | %RF | %RD | %RA | IVI | RIVI | SdH' | SdE | A/F | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | *Aeschynomene indica* Linn. | Fabaceae | Curly indigo | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 49 | *Pueraria phaseoloides* (Roxb.) Benth. | Fabaceae | Tropical kudzu | 75 | 500 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.92 | 0.54 | 0.30 | 0.09 | +++ |
| 50 | *Desmodium tortuosum* (Sw)DC | Fabaceae | Florida begger weed | 75 | 250 | 3.33 | 2.36 | 1.05 | 0.66 | 4.07 | 1.35 | 0.18 | 0.10 | 0.04 | +++ |
| 51 | *Calopogonuim mucunoides* Desv | Fabaceae | Calopo weed | 75 | 875 | 11.67 | 2.36 | 3.69 | 2.32 | 8.37 | 2.77 | 1.23 | 0.68 | 0.16 | +++ |
| | **SUBTOTAL** | | | **250** | **1700** | **24.67** | **7.87** | **7.17** | **4.91** | **19.95** | **6.61** | **2.09** | **1.16** | **0.41** | |
| 52 | *Cnestis ferruginea* DC | Connaraceae | NA | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| | **SUBTOTAL** | | | **50** | **375** | **7.50** | **1.57** | **1.58** | **1.49** | **4.64** | **1.54** | **0.29** | **0.16** | **0.15** | |
| 53 | *Rauvolfia vomitoria* Afzel | Apocynaceae | Swizzle stick | 25 | 50 | 2.00 | 0.79 | 0.21 | 0.40 | 1.40 | 0.46 | 0.16 | 0.09 | 0.08 | + |
| 54 | *Voacanga africana* Stapf | Apocynaceae | False rubber | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| | **SUBTOTAL** | | | **50** | **125** | **5.00** | **1.58** | **0.53** | **1.00** | **3.11** | **1.03** | **0.30** | **0.17** | **0.20** | |
| 55 | *Marantochloa leucantha* (K.Schum) Milne-Rich | Marantaceae | Yoruba soft cane | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| | **SUBTOTAL** | | | **50** | **375** | **7.50** | **1.57** | **1.58** | **1.49** | **4.64** | **1.54** | **0.29** | **0.16** | **0.15** | |
| 56 | *Ipomoea asarifolia* (Desr) Roem & Schult. | Convolvulaceae | Ginger leaf morning glory | 25 | 150 | 6.00 | 0.79 | 0.63 | 1.19 | 2.61 | 0.86 | 0.06 | 0.03 | 0.24 | + |
| 57 | *Ipomoea involucrata* P. Beauv. | Convolvulaceae | Morning glory | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 58 | *Ipomoea triloba* Linn. | Convolvulaceae | Morning glory | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 4.32 | 1.43 | 0.22 | 0.12 | 0.20 | + |
| | **SUBTOTAL** | | | **75** | **350** | **14** | **2.37** | **1.48** | **2.79** | **8.64** | **2.86** | **0.42** | **0.23** | **0.56** | |
| 59 | *Crinum jagus* (Thomps) Dandy | Amaryllidaceae | Forest crinum | 50 | 300 | 6.00 | 1.57 | 1.27 | 1.19 | 4.03 | 1.33 | 0.16 | 0.09 | 0.12 | ++ |
| | **SUBTOTAL** | | | **50** | **300** | **6.00** | **1.57** | **1.27** | **1.19** | **4.03** | **1.33** | **0.16** | **0.09** | **0.12** | |
| 60 | *Spigellia anthelmia* Linn | Longaniaceae | Worm plant | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| | **SUBTOTAL** | | | **25** | **375** | **15.00** | **0.79** | **1.58** | **2.99** | **5.36** | **1.77** | **0.44** | **0.24** | **0.60** | |
| 61 | *Urena lobata* Linn. | Malvaceae | Hibiscus bur | 25 | 75 | 25 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| | **SUBTOTAL** | | | **25** | **75** | **25** | **0.79** | **0.32** | **0.60** | **1.71** | **0.57** | **0.14** | **0.08** | **0.12** | |
| 62 | *Ludwigia decurrens* (DC.) Walter | Onagraceae | Water prime rose | 75 | 700 | 9.33 | 2.36 | 2.95 | 1.86 | 7.17 | 2.37 | 0.89 | 0.49 | 0.12 | +++ |
| | **SUBTOTAL** | | | **75** | **700** | **9.33** | **2.36** | **2.95** | **1.86** | **7.17** | **2.37** | **0.89** | **0.49** | **0.12** | |
| 63 | *Nelsonia canescens* (Lam) Spreng | Acanthaceae | Blue pussy leaf | 100 | 375 | 3.75 | 3.15 | 1.58 | 0.75 | 5.48 | 1.81 | 0.47 | 0.26 | 0.04 | ++++ |
| | **SUBTOTAL** | | | **100** | **375** | **3.75** | **3.15** | **1.58** | **0.75** | **5.48** | **1.81** | **0.47** | **0.26** | **0.04** | |
| | **TOTAL** | | | **3175** | **23700** | **502.43** | **101.96** | **99.99** | **100.06** | **302.01** | **99.22** | **27.57** | **15.28** | **13.78** | |

**Note: %F= Percentage frequency. D = Density (number of individual m²). A = Abundance. %RF = Relative frequency. %RD = Relative density. %RA = Relative abundance. IVI = Importance Value Index. SdH'= Species diversity richness. SdE = Species diversity evenness. A/F = Ratio A: F distribution pattern** with the "*thumb of rule*" designated as follows: *Regular (<0.03), random (0.03 – 0.05),* and *contiguous (>0.05)* distribution. **+ (1-25) Very scarce, ++ (26-59) Scarce, +++ (60-79) Abundant, ++++> (100-α) Very abundant, NA- Not available, %F- Percentage frequency.**

**Table 2: Phytosociological Representative of Recruit Life form (based on habit) of Hydrocarbon Tolerant Species; 4 years after the Ekiugbo oil spill, at Ughelli, Delta State, Niger Delta, Nigeria.**

| S/N | Species | FAMILY | Life Form | %F | Dm² | A | %RF | %RD | %RA | IVI | RIVI | SdH' | SdE | A/F | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Ischaemum rogosum* Salisb. | Poaceae | HG | 25 | 550 | 22.00 | 0.79 | 2.32 | 4.38 | 7.49 | 2.48 | 0.98 | 0.54 | 0.88 | + |
| 2 | *Panicum maximum* Jacq. | Poaceae | HG | 50 | 350 | 7.00 | 1.57 | 1.48 | 1.39 | 4.44 | 1.47 | 0.25 | 0.14 | 0.14 | ++ |
| 3 | *Leersia hexandra* Sw. | Poaceae | HG | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 4 | *Acroceras zizanioides* (Kunth) Dandy | Poaceae | HG | 100 | 1000 | 10.00 | 3.15 | 4.22 | 1.99 | 9.36 | 3.10 | 1.52 | 0.84 | 0.10 | ++++ |
| 5 | *Leptochloa caerulescens* Steud. | Poaceae | HG | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 6 | *Panicum laxum* Sw. | Poaceae | HG | 50 | 550 | 10.00 | 1.57 | 2.11 | 1.99 | 5.67 | 1.88 | 0.52 | 0.29 | 0.20 | ++ |
| 7 | *Brachiaria deflexa* (Schumach.) C.E.Hubb. ex Robyns | Poaceae | HG | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.22 | 1.07 | 0.03 | 0.02 | 0.32 | + |
| 8 | *Brachiaria lata* (Schumach.) C.E.Hubb. | Poaceae | HG | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 9 | *Paspalum scrobiculatum* Linn. | Poaceae | HG | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 10 | *Perotis indica* (Linn.) O. Kuntze | Poaceae | HG | 75 | 1000 | 13.33 | 2.36 | 4.22 | 2.65 | 9.23 | 3.06 | 1.49 | 0.83 | 0.18 | +++ |
| 11 | *Setaria barbata* (Lam.) kunth | Poaceae | HG | 25 | 100 | 4.00 | 0.79 | 0.42 | 0.80 | 2.01 | 0.67 | 0.12 | 0.07 | 0.16 | + |
| 12 | *Setaria megaphylla* (Steud.) T.Dur. & Schinz | Poaceae | HG | 50 | 200 | 4.00 | 1.57 | 0.84 | 0.80 | 3.21 | 1.06 | 0.03 | 0.02 | 0.08 | ++ |
| 13 | *Oplismenus burmannii* (Retz.) P. Beauv | Poaceae | HG | 75 | 875 | 11.67 | 2.36 | 3.69 | 2.32 | 8.37 | 2.77 | 1.23 | 0.68 | 0.16 | +++ |
| 14 | *Andropogon repens* Steud. | Poaceae | HG | 50 | 327 | 6.50 | 1.57 | 1.37 | 1.29 | 4.23 | 1.40 | 0.20 | 0.11 | 0.13 | ++ |
| 15 | *Andropogon tectorum* Schum & Thonn | Poaceae | HG | 50 | 225 | 4.50 | 1.57 | 0.95 | 0.90 | 3.42 | 1.13 | 0.06 | 0.03 | 0.09 | ++ |
| 16 | *Sphenoclea zeylanica* Gaertn. | Sphenocleaceae | HH | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 17 | *Oldenlandia corymbosa* Linn | Rubiaceae | HH | 75 | 500 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.92 | 0.54 | 0.30 | 0.09 | +++ |
| 18 | *Palisota ambigua* (P. Beauv) C. Bil. | Commelinaceae | HH | 100 | 250 | 2.50 | 3.15 | 1.05 | 0.50 | 4.70 | 1.56 | 0.30 | 0.17 | 0.03 | ++++ |
| 19 | *Eclipta alba* (Linn) Hassk | Asteraceae | HH | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.21 | 1.06 | 0.03 | 0.02 | 0.32 | + |
| 20 | *Palisota hirsuta* (Thunb.) K.Schum. | Commelinaceae | HH | 75 | 550 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.15 | 0.07 | 0.04 | 0.09 | +++ |
| 21 | *Costus lucanusianus* J. Braun & K. Schum. | Costaceae | HH | 50 | 250 | 5.00 | 1.57 | 1.05 | 1.00 | 3.62 | 1.20 | 0.10 | 0.06 | 0.10 | ++ |
| 22 | *Hydrolea palustris* (Aubl.) Rausch | Hydrophyllaceae | HH | 75 | 375 | 5.00 | 2.36 | 1.58 | 1.00 | 4.94 | 1.64 | 0.35 | 0.19 | 0.07 | +++ |
| 23 | *Marantochloa leucantha* (K.Schum) Milne-Rich | Marantaceae | HH | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| 24 | *Conyza sumatrensis* (Retz.) Walker | Asteraceae | HH | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 25 | *Croton hirtus* L'Her. | Euphorbiaceae | HH | 25 | 200 | 8.00 | 0.79 | 0.84 | 1.59 | 3.22 | 1.07 | 0.03 | 0.02 | 0.32 | + |
| 26 | *Crinum jagus* (Thomps) Dandy | Amaryllidaceae | HH | 50 | 300 | 6.00 | 1.57 | 1.27 | 1.19 | 4.03 | 1.33 | 0.16 | 0.09 | 0.12 | ++ |
| 27 | *Spigellia anthelmia* Linn | Longaniaceae | HH | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 28 | *Diodia sarmentosa* Sw. | Rubiaceae | HH | 50 | 450 | 9.00 | 1.57 | 1.90 | 1.79 | 5.26 | 1.74 | 0.42 | 0.23 | 0.18 | ++ |
| 29 | *Ludwigia decurrens* (DC.) Walter | Onagraceae | HH | 75 | 700 | 9.33 | 2.36 | 2.95 | 1.86 | 7.17 | 2.37 | 0.89 | 0.49 | 0.12 | +++ |
| 30 | *Cynotis lanata* Benth | Commelinaceae | HH | 100 | 1125 | 11.25 | 3.15 | 4.75 | 2.24 | 10.14 | 3.36 | 1.77 | 0.98 | 0.11 | ++++ |
| 31 | *Nelsonia canescens* (Lam) Spreng | Acanthaceae | HH | 100 | 375 | 3.75 | 3.15 | 1.58 | 0.75 | 5.48 | 1.81 | 0.47 | 0.26 | 0.04 | ++++ |
| 32 | *Cyperus iria* Linn. | Cyperaceae | HS | 25 | 550 | 22.00 | 0.79 | 2.32 | 4.38 | 7.49 | 2.48 | 0.98 | 0.54 | 0.88 | + |
| 33 | *Cyperus haspan* Linn | Cyperaceae | HS | 75 | 725 | 9.67 | 2.36 | 3.06 | 1.92 | 7.34 | 2.43 | 0.94 | 0.52 | 0.13 | +++ |
| 34 | *Cyperus difformis* Linn. | Cyperaceae | HS | 75 | 650 | 8.67 | 2.36 | 2.74 | 1.73 | 6.83 | 2.26 | 0.80 | 0.44 | 0.12 | +++ |
| 35 | *Fimbristylis littoralis* Gaudich | Cyperaceae | HS | 50 | 1000 | 20.00 | 1.57 | 4.22 | 3.98 | 9.77 | 2.23 | 1.64 | 0.91 | 0.40 | ++ |
| 36 | *Kyllinga pumila* Michx. | Cyperaceae | HS | 25 | 700 | 28.00 | 0.79 | 2.95 | 5.57 | 9.31 | 3.08 | 1.50 | 0.83 | 1.12 | + |
| 37 | *Kyllinga squamulata* Thonn. ex Vahl. | Cyperaceae | HS | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| 38 | *Mariscus longibracteatus* Cherm. | Cyperaceae | HS | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 39 | *Cyperus rotundus* Linn. | Cyperaceae | HS | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 40 | *Mariscus alternifolius* Vahl | Cyperaceae | HS | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 41 | *Hypolytrum heteromorphum* Nelmes | Cyperaceae | HS | 75 | 450 | 6.00 | 2.36 | 1.90 | 1.19 | 5.45 | 1.80 | 0.46 | 0.26 | 0.08 | +++ |
| 42 | *Rhynchosporra corymbosa* (Linn.) | Cyperaceae | HS | 25 | 250 | 10.00 | 0.79 | 1.05 | 1.99 | 3.83 | 1.27 | 0.13 | 0.07 | 0.40 | + |

| S/N | Species | FAMILY | Life Form | %F | $Dm^2$ | A | %RF | %RD | %RA | IVI | RIVI | SdH' | SdE | A/F | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Britton | | | | | | | | | | | | | | |
| 43 | *Pycerus lanceolatus* (Poir.) C.B.Clarke | Cyperaceae | HS | 75 | 575 | 7.67 | 2.36 | 2.43 | 1.53 | 6.32 | 2.09 | 0.67 | 0.37 | 0.10 | +++ |
| 44 | *Scleria naumanniana* Boeck. | Cyperaceae | HS | 50 | 300 | 6.00 | 1.57 | 1.27 | 1.19 | 4.03 | 1.33 | 0.16 | 0.09 | 0.12 | ++ |
| 45 | *Kyllinga erecta* Schumach. | Cyperaceae | HS | 50 | 550 | 11.00 | 1.57 | 2.32 | 2.19 | 6.08 | 2.01 | 0.61 | 0.34 | 0.22 | ++ |
| 46 | *Pentodon pentandrus* (Schumach. & Thonn.) Vatke | Rubiaceae | HCl | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 2.32 | 0.77 | 0.09 | 0.05 | 0.20 | + |
| 47 | *Ipomoea asarifolia* (Desr)Roem & Schult. | Convolvulaceae | HCl | 25 | 150 | 6.00 | 0.79 | 0.63 | 1.19 | 2.61 | 0.86 | 0.06 | 0.03 | 0.24 | + |
| 48 | *Ipomoea involucrata* P. Beauv. | Convolvulaceae | HCl | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 49 | *Pueraria phaseoloides* (Roxb.) Benth. | Fabaceae | HCl | 75 | 500 | 6.67 | 2.36 | 2.11 | 1.33 | 5.80 | 1.92 | 0.54 | 0.30 | 0.09 | +++ |
| 50 | *Ipomoea triloba* Linn. | Convolvulaceae | HCl | 25 | 125 | 5.00 | 0.79 | 0.53 | 1.00 | 4.32 | 1.43 | 0.22 | 0.12 | 0.20 | + |
| 51 | *Calopogonuim mucunoides* Desv | Fabaceae | HCl | 75 | 875 | 11.67 | 2.36 | 3.69 | 2.32 | 8.37 | 2.77 | 1.23 | 0.68 | 0.16 | +++ |
| 52 | *Macaranga barteri* Mull-Arg | Euphorbiaceae | SH | 100 | 200 | 2.00 | 3.15 | 0.84 | 0.40 | 4.39 | 1.45 | 0.23 | 0.13 | 0.02 | ++++ |
| 53 | *Melastomastrum capitatum* (Vahl) A. & R. Fern | Melastomataceae | SH | 25 | 375 | 15.00 | 0.79 | 1.58 | 2.99 | 5.36 | 1.77 | 0.44 | 0.24 | 0.60 | + |
| 54 | *Alchornea laxiflora* (Benth) Pax &K. Hoffm | Euphorbiaceae | SH | 75 | 175 | 2.33 | 2.36 | 0.74 | 0.46 | 3.56 | 1.18 | 0.08 | 0.04 | 0.03 | +++ |
| 55 | *Triumfetta cordifolia* A. Rich. | Tiliaceae | SH | 100 | 525 | 5.25 | 3.15 | 2.22 | 1.04 | 6.41 | 2.12 | 0.69 | 0.38 | 0.05 | ++++ |
| 56 | *Rauvolfia vomitoria* Afzel | Apocynaceae | SH | 25 | 50 | 2.00 | 0.79 | 0.21 | 0.40 | 1.40 | 0.46 | 0.16 | 0.09 | 0.08 | + |
| 57 | *Alchornea cordifolia* (Schum & Thonn) Mull-Arg | Euphorbiaceae | SH | 100 | 300 | 3.00 | 3.15 | 1.27 | 0.60 | 5.02 | 1.66 | 0.37 | 0.21 | 0.03 | ++++ |
| 58 | *Aeschynomene indica* Linn. | Fabaceae | SH | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 59 | *Cnestis ferruginea* DC | Connaraceae | SH | 50 | 375 | 7.50 | 1.57 | 1.58 | 1.49 | 4.64 | 1.54 | 0.29 | 0.16 | 0.15 | ++ |
| 60 | *Voacanga africana* Stapf | Apocynaceae | SH | 25 | 75 | 3.00 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 61 | *Mallotus subulatus* Mull-Arg | Euphorbiaceae | SH | 50 | 175 | 3.50 | 1.57 | 0.74 | 0.70 | 3.01 | 1.00 | 0.00 | 0.00 | 0.07 | ++ |
| 62 | *Urena lobata* Linn. | Malvaceae | SH | 25 | 75 | 25 | 0.79 | 0.32 | 0.60 | 1.71 | 0.57 | 0.14 | 0.08 | 0.12 | + |
| 63 | *Desmodium tortuosum* (Sw)DC | Fabaceae | SH | 75 | 250 | 3.33 | 2.36 | 1.05 | 0.66 | 4.07 | 1.35 | 0.18 | 0.10 | 0.04 | +++ |
| | **TOTAL** | | | **3175** | **23700** | **502.43** | **101.96** | **99.99** | **100.06** | **302.01** | **99.22** | **27.57** | **15.28** | **13.78** | |

**Note: %F= Percentage frequency. D = Density (number of individual m²). A = Abundance. %RF = Relative frequency. %RD = Relative density. %RA = Relative abundance. IVI = Importance Value Index. SdH'= Species diversity richness. SdE = Species diversity evenness. A/F = Ratio A: F distribution pattern** with the "*thumb of rule*" designated as follows: *Regular (<0.03), random (0.03 – 0.05),* and *contiguous (>0.05)* distribution. **+ (1-25) Very scarce, ++ (26-59) Scarce, +++ (60-79) Abundant, ++++> (100-α) Very abundant, NA- Not available, %F- Percentage frequency.**

**Life Form Note: HG = Herbaceous grass. HH = Herbaceous herb. HS = Herbaceous sedge. HCl = Herbaceous climber. SH = Shrubby herb**

**Table 3: Qualitative Representative of Recruit life form (based on environmental adaptiveness), Mode of Regeneration and Demographic Regeneration status of Hydrocarbon Tolerant Species; 4 years after the Ekiugbo oil spill, at Ughelli, Delta State, Niger Delta, Nigeria.**

| S/N | Species | FAMILY | Life Form | Mode of Regeneration | Density $m^2$ | Regeneration status |
|---|---|---|---|---|---|---|
| 1 | *Ischaemum rogosum* Salisb. | Poaceae | HG - Chamaephyte | **C / R** | 550 | **Seedling** |
| 2 | *Panicum maximum* Jacq. | Poaceae | HG - Chamaephyte | **R** | 350 | **Seedling** |
| 3 | *Leersia hexandra* Sw. | Poaceae | HG - Chamaephyte | **R / S** | 375 | **Seedling** |
| 4 | *Acroceras zizanioides* (Kunth) Dandy | Poaceae | HG – Hemi-cryptophyte | **S / C** | 1000 | **Seedling** |
| 5 | *Leptochloa caerulescens* Steud. | Poaceae | HG - Chamaephyte | **S / R** | 75 | **Seedling** |
| 6 | *Panicum laxum* Sw. | Poaceae | HG - Chamaephyte | **S / R** | 550 | **Seedling** |
| 7 | *Brachiaria deflexa* (Schumach.) C.E.Hubb. ex Robyns | Poaceae | HG - Chamaephyte | **S** | 200 | **Seedling** |
| 8 | *Brachiaria lata* (Schumach.) C.E.Hubb. | Poaceae | HG - Chamaephyte | **S** | 125 | **Seedling** |
| 9 | *Paspalum scrobiculatum* Linn. | Poaceae | HG – Hemi-cryptophyte | **S / R** | 375 | **Seedling** |
| 10 | *Perotis indica* (Linn.) O. Kuntze | Poaceae | HG - Chamaephyte | **S / R** | 1000 | **Seedling** |
| 11 | *Setaria barbata* (Lam.) kunth | Poaceae | HG - Chamaephyte | **S** | 100 | **Seedling** |
| 12 | *Setaria megaphylla* (Steud.) T.Dur. & Schinz | Poaceae | HG - Chamaephyte | **S** | 200 | **Seedling** |
| 13 | *Oplismenus burmannii* (Retz.) P. Beauv | Poaceae | HG – Hemi-cryptophyte | **S / C** | 875 | **Seedling** |
| 14 | *Andropogon repens* Steud. | Poaceae | HG – Hemi-cryptophyte | **S / C** | 327 | **Seedling** |
| 15 | *Andropogon tectorum* Schum & Thonn | Poaceae | HG - Chamaephyte | **S /C** | 225 | **Seedling** |
| | **SUBTOTAL** | | | | **6,327** | |
| 16 | *Sphenoclea zeylanica* Gaertn. | Sphenocleaceae | H – Chamaephyte | **S** | 125 | **Seedling** |
| 17 | *Oldenlandia corymbosa* Linn | Rubiaceae | H – Hemi-cryptophyte | **S** | 500 | **Seedling** |
| 18 | *Eclipta alba* (Linn) Hassk | Asteraceae | H - Chamaephyte | **S** | 200 | **Seedling** |
| 19 | *Hydrolea palustris* (Aubl.) Rausch | Hydrophyllaceae | H - Chamaephyte | **S / R** | 375 | **Seedling** |
| 20 | *Conyza sumatrensis* (Retz.) Walker | Asteraceae | H - Chamaephyte | **S** | 75 | **Seedling** |
| 21 | *Croton hirtus* L'Her. | Euphorbiaceae | H - Chamaephyte | **S / C** | 200 | **Seedling** |
| 22 | *Crinum jagus* (Thomps) Dandy | Amaryllidaceae | H – Hemi-cryptophyte | **B** | 300 | **Seedling** |
| 23 | *Spigellia anthelmia* Linn | Longaniaceae | H - Chamaephyte | **S** | 375 | **Seedling** |
| 24 | *Diodia sarmentosa* Sw. | Rubiaceae | H – Hemi-cryptophyte | **S** | 450 | **Seedling** |
| 25 | *Ludwigia decurrens* (DC.) Walter | Onagraceae | H - Chamaephyte | **S** | 700 | **Seedling** |
| 26 | *Cynotis lanata* Benth | Commelinaceae | H– Hemi-cryptophyte | **C** | 1125 | **Seedling** |
| 27 | *Nelsonia canescens* (Lam) Spreng | Acanthaceae | H – Hemi-cryptophyte | **C / S** | 375 | **Seedling** |
| | **SUBTOTAL** | | | | **4,800** | |
| 28 | *Cyperus iria* Linn. | Cyperaceae | HS - Chamaephyte | **S** | 550 | **Seedling** |
| 29 | *Cyperus haspan* Linn | Cyperaceae | HS - Chamaephyte | **R / S** | 725 | **Seedling** |
| 30 | *Cyperus difformis* Linn. | Cyperaceae | HS - Chamaephyte | **S** | 650 | **Seedling** |
| 31 | *Fimbristylis littoralis* Gaudich | Cyperaceae | HS – Hemi-cryptophyte | **S** | 1000 | **Seedling** |
| 32 | *Kyllinga pumila* Michx. | Cyperaceae | HS - Chamaephyte | **R / S** | 700 | **Seedling** |
| 33 | *Kyllinga squamulata* Thonn. ex Vahl. | Cyperaceae | HS – Hemi-cryptophyte | **S** | 375 | **Seedling** |
| 34 | *Mariscus longibracteatus* Cherm. | Cyperaceae | HS - Chamaephyte | **S** | 125 | **Seedling** |
| 35 | *Cyperus rotundus* Linn. | Cyperaceae | HS - Chamaephyte | **S / R / T** | 375 | **Seedling** |
| 36 | *Mariscus alternifolius* Vahl | Cyperaceae | HS - Chamaephyte | **S / R** | 125 | **Seedling** |
| 37 | *Hypolytrum heteromorphum* Nelmes | Cyperaceae | HS – Hemi-cryptophyte | **R / C** | 450 | **Seedling** |
| 38 | *Rhynchosporra corymbosa* (L.) Britton | Cyperaceae | HS - Chamaephyte | **S** | 250 | **Seedling** |
| 39 | *Pycerus lanceolatus* (Poir.) C.B.Clarke | Cyperaceae | HS – Hemi-cryptophyte | **S / R** | 575 | **Seedling** |
| 40 | *Scleria naumanniana* Boeck. | Cyperaceae | HS - Chamaephyte | **S / R** | 300 | **Seedling** |
| 41 | *Kyllinga erecta* Schumach. | Cyperaceae | HS - Chamaephyte | **S / R** | 550 | **Seedling** |
| | **SUBTOTAL** | | | | **6750** | |
| 42 | *Pentodon pentandrus* (Schumach. & Thonn.) Vatke | Rubiaceae | HCl - Chamaephyte | **S** | 125 | **Seedling** |
| 43 | *Ipomoea asarifolia* (Desr)Roem & Schult. | Convolvulaceae | HCl – Hemi-cryptophyte | **S / C** | 150 | **Seedling** |
| 44 | *Ipomoea involucrata* P. Beauv. | Convolvulaceae | HCl – Hemi-cryptophyte | **S / C** | 75 | **Seedling** |
| 45 | *Pueraria phaseoloides* (Roxb.) Benth. | Fabaceae | HCl – Hemi-cryptophyte | **S** | 500 | **Seedling** |
| 46 | *Ipomoea triloba* Linn. | Convolvulaceae | HCl – Hemi-cryptophyte | **S / C** | 125 | **Seedling** |
| 47 | *Calopogonuim mucunoides* Desv | Fabaceae | HCl – Hemi-cryptophyte | **S** | 875 | **Seedling** |
| | **SUBTOTAL** | | | | **1850** | |
| 48 | *Aeschynomene indica* Linn. | Fabaceae | Sh - Nanophanerophyte | **S** | 75 | **Seedling** |
| 49 | *Desmodium tortuosum* (Sw)DC | Fabaceae | Sh - Nanophanerophyte | **S** | 250 | **Seedling** |
| | **SUBTOTAL** | | | | **325** | |
| 50 | *Palisota ambigua* (P. Beauv) C. Bil. | Commelinaceae | H - Chamaephyte | **R / C** | 250 | **Sapling** |
| 51 | *Palisota hirsuta* (Thunb.) K.Schum. | Commelinaceae | H - Chamaephyte | **R / C** | 550 | **Sapling** |

| S/N | Species | FAMILY | Life Form | Mode of Regeneration | Density $m^2$ | Regeneration status |
|---|---|---|---|---|---|---|
| 52 | *Costus lucanusianus* J. Braun & K. Schum. | Costaceae | H - Chamaephyte | **R / C** | 250 | **Sapling** |
| 53 | *Marantochloa leucantha* (K.Schum) Milne-Rich | Marantaceae | H - Chamaephyte | **S / C** | 375 | **Sapling** |
| | **SUBTOTAL** | | | | **1425** | |
| 54 | *Macaranga barteri* Mull-Arg | Euphorbiaceae | Sh - Mesophanerophye | **C** | 200 | **Sapling** |
| 55 | *Melastomastrum capitatum* (Vahl) A. & R. Fern | Melastomataceae | Sh - Microphanerophyte | **S** | 375 | **Sapling** |
| 56 | *Alchornea laxiflora* (Benth) Pax &K. Hoffm | Euphorbiaceae | Sh - Mesophanerophyte | **S /C** | 175 | **Sapling** |
| 57 | *Triumfetta cordifolia* A. Rich. | Tiliaceae | Sh - Microphanerophyte | **S** | 525 | **Sapling** |
| 58 | *Alchornea cordifolia* (Schum & Thonn) Mull-Arg | Euphorbiaceae | Sh - Microphanerophyte | **S / C** | 300 | **Sapling** |
| 59 | *Cnestis ferruginea* DC | Connaraceae | Sh - Microphanerophyte | **S / T** | 375 | **Sapling** |
| 60 | *Rauvolfia vomitoria* Afzel | Apocynaceae | Sh - Microphanerophyte | **S / C** | 50 | **Sapling** |
| 61 | *Voacanga africana* Stapf | Apocynaceae | Sh - Microphanerophyte | **C** | 75 | **Sapling** |
| 62 | *Mallotus subulatus* Mull-Arg | Euphorbiaceae | Sh - Microphanerophyte | **S** | 175 | **Sapling** |
| 63 | *Urena lobata* Linn. | Malvaceae | Sh - Microphanerophyte | **S** | 75 | **Sapling** |
| | **SUBTOTAL** | | | | **2325** | |
| | **TOTAL** | | | | **23,700** | |

**Life Form Note: HG = Herbaceous grass. HH = Herbaceous herb. HS = Herbaceous sedge. HCl = Herbaceous climber. SH = Shrubby herb**

**Regeneration Note: S = Seedling. SA = Sapling. R = Rhizome. C = Coppicing. B = Bulb. T = Tuber.**

**Table 4: Degree and Percentage Mode of Regeneration of Recruits**

| No of individual of life form recruits | Degree of mode of regeneration | % Composition | Remark |
|---|---|---|---|
| | **Herbaceous Grass (HG)** | | |
| 1 | Coppice / Rhizome | 6.67 | Multiplier |
| 1 | Rhizome | 6.67 | Single |
| 5 | Rhizome / Seed | 33.33 | Multiplier |
| 4 | Seed | 26.67 | Single |
| 4 | Seed / Coppice | 26.67 | Multiplier |
| | **Herbaceous Herb (HH)** | | |
| 7 | Seed | 43.75 | Single |
| 1 | Seed / Rhizome | 6.25 | Multiplier |
| 3 | Seed / Coppice | 18.75 | Multiplier |
| 1 | Bulb | 6.25 | Single |
| 1 | Coppice | 6.25 | Single |
| 3 | Rhizome / Coppice | 18.75 | Multiplier |
| | **Herbaceous Sedge (HS)** | | |
| 6 | Seed | 42.86 | Single |
| 6 | Seed / Rhizome | 42.86 | Multiplier |
| 1 | Seed / Rhizome / Tuber | 7.14 | Multiplier |
| 1 | Rhizome / Coppice | 7.14 | Multiplier |
| | **Herbaceous Climber (HCl)** | | |
| 3 | Seed | 50 | Single |
| 3 | Seed / Coppice | 50 | Multiplier |
| **Shrub (Sh)** | | | |
| 6 | Seed | 50 | Single |
| 3 | Seed / Coppice | 25 | Multiplier |
| 2 | Coppice | 16.67 | Single |
| 1 | Seed / Tuber | 8.33 | Multiplier |