EVALUATION OF PLANT COMMUNITIES OF EARLY SUCCESSIONAL STAGES OF ABANDONED DREDGING SITES AND ADJACENT NATURAL VEGETATION IN TOMBIA COMMUNITY. BAYELSA STATE. NIGERIA

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ABSTRACT
Sand dredging is among the factors contributing to the alteration of riparian forest ecosystems in the Niger Delta Region of Nigeria. However, no study has been conducted to ascertain its effect on the vegetation. This study therefore, evaluated plant species composition, populations and diversity of three chronosequences of abandoned dredging sites (ADSs) representing 1 (ADS_1), 3 (ADS_3), and 5 (ADS_5) years of abandonment, and an adjacent natural vegetation (NV). Non-woody species richness was higher in the ADSs than in the NV with the highest species richness found in ADS_5. Woody species richness (S) and diversity (D) were higher in the NV (S = 17; D: Simpson 1 - D = 0.69; Shannon H= 1.88) than in the ADSs (S-Range = 1 to 4; D-Range: Simpson 1 - D = 0 to 0.58; Shannon H = 0 to 1.09). However, woody species richness and diversity increased with increase in age of the ADSs. Similarity in woody species composition between the NV and the ADSs was generally low (0 to 27%) but also increased with increase in the age of the ADSs. Similarity in non-woody species was higher between the ADSs (Range = 66 to 78%) than between the NV and the ADSs (Range = 22 to 37%). Intra-site quadrat association was closer and stronger than inter-site quadrat association. The study showed that sand dredging and associated activities altered the species composition and reduced the woody species richness and diversity of the vegetation in the study area, and that restoration is possible over time if the ADSs are protected from further degradation.
Key words: Sand dredging, ecosystem disturbance, succession, species composition, diversity

INTRODUCTION
The main aim of dredging is to remove unwanted deposits from water pathways. However, dredging and associated activities have the potential to change the environment. Dredging activities constitute a huge threat to both the marine and the terrestrial environment and are required to be carried out carefully with the right dredger and dredges (Karan, 2016), and with a conscious effort to protect the environment. As well as toxicants, the nutrient elements, particularly nitrogen and phosphorus, which control the rate of marine plant growth, can also be released from sediments during dredging, with a risk of triggering algal blooms. Dredgers have the ability to transport species from one place to another and this could constitute biological risk as alien species which may act as pests can be introduced to new and hitherto healthy ecosystems. Exotic marine pests are now recognized as a major environmental concern and steps must be taken to minimize their transport to new environment (England and Burgess–Gamble, 2013).

Bayelsa State is one of the states in the Niger Delta Region of Nigeria. The vegetation of the State consists mainly of swamp forests due to the deltaic nature. The vegetation found in Tombia community is predominantly fresh water swamp forest, which is a major source of timber and non-timber forest products in the area, and contains important habitats for diverse species of wildlife.

In addition to other anthropogenic activities like farming and logging, dredging activities, to some extent, are responsible for the loss of vegetation in Tombia Community, Bayelsa State. However, there is paucity of information regarding the effect dredging and associated activities on the surrounding vegetation. This study evaluated the plant species composition, species richness and diversity of early successional stages of abandoned dredging sites and adjacent natural vegetation, with a view to ascertaining the impact of dredging on the vegetation.

MATERIALS AND METHODS
3.1 Description of study area
Tombia Community is located along Tombia Amassoma road in Yenagoa Local Government Area of Bayelsa State, one of the states in the Niger Delta Region of Nigeria. The mean monthly temperature is in the range of 25°C to 31°C. Mean maximum monthly temperatures range from 26°C to 31°C. The mean annual temperature is uniform for the entire Bayelsa State. The difference between the wet season and dry season on temperatures is about 2°C at the most. Relative humidity is high in the state throughout the year and decreases slightly in the dry season. Annual rainfall is heavy, between 3,000mm to 3,500mm (Iyorakpo, 2015).The vegetation is predominantly freshwater swamp forest, although mangrove swamp forests and coastal barrier forests are also found in some areas. The major occupations of people of the study area are fishing, farming, palm oil milling, lumbering, palm wine tapping, local gin making, trading, carving and weaving. Figure 1 is the map of Bayelsa State showing the study area.

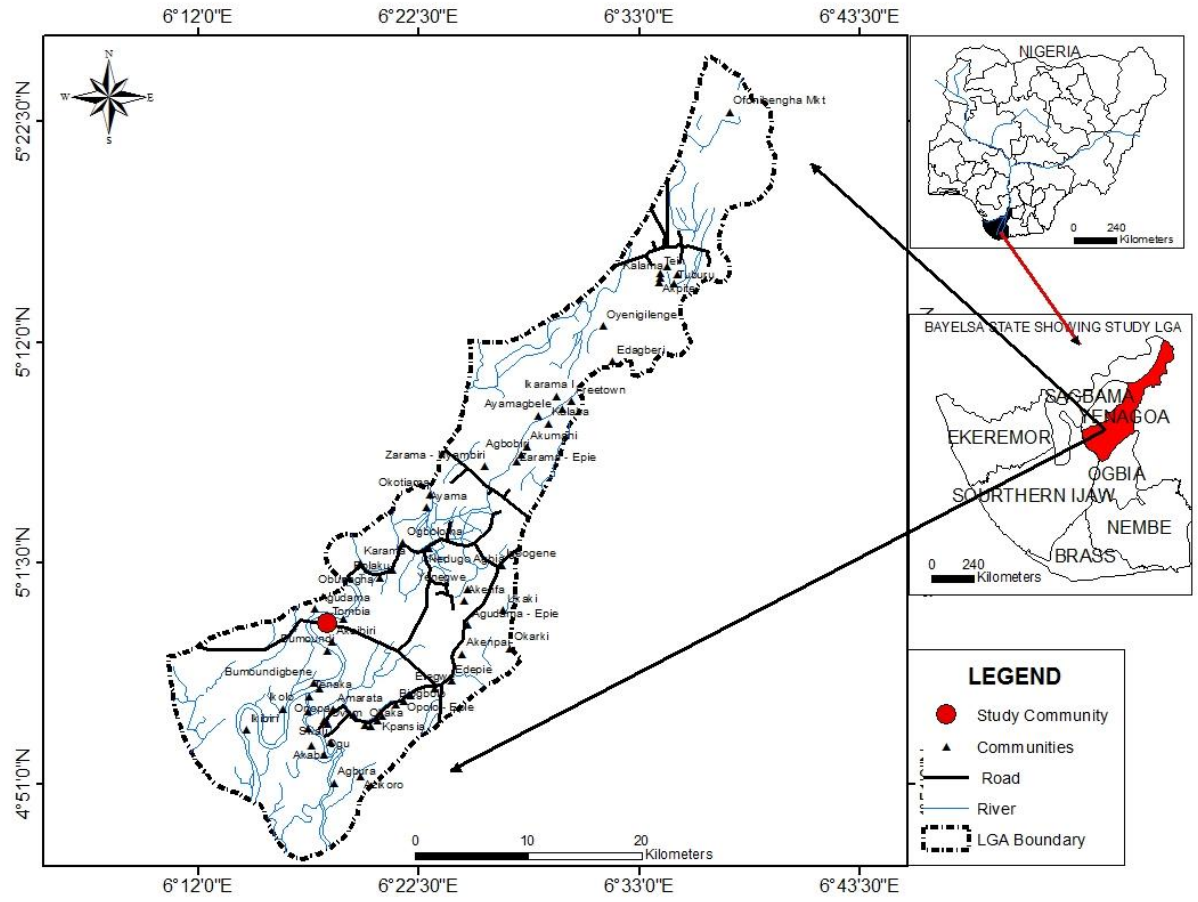

Figure 1: Map of Bayelsa State showing the study area

3.2 Selection of study sites

Four sites – a natural vegetation (forest) and three other sites representing different ages (1, 3, 5) of abandoned dredging sites were purposively chosen for the study after a reconnaissance survey. The sites (Plate 1) were chosen due to their suitability to the objectives of the study.

3.3 Data collection

Five 20m × 20m quadrats were randomly laid in each of the abandoned dredging sites and relatively less disturbed natural forest. This quadrat size falls within the range recommended by Bullock (1996) for the assessment of trees in woodlands and forests and was adopted for the abandoned dredging sites to justify comparisons of the evaluated vegetation attributes. All plant species within the quadrats were identified to species level. The number of individuals enumerated for the woody plant species were counted and recorded. Non-woody species were also identified to species level but could not be counted individually due to their prolific nature. However, they were recorded as being present or absent in the sites. Specimen of woody species that could not be identified in the field were collected and taken to the herbarium for proper identification.

Adjacent Secondary Forest

5 years old abandoned Dredging site

3 years old abandoned Dredging

1 year old abandoned Dredging

Plate 1: The study sites

3.4 Data analysis

Data collected were subjected to statistical analysis using the following methods.

3.4.1 Woody species diversity

The diversity of the woody plant species in each of the sites was computed using both Simpson's index and Shannon-Wiener index as stated below.

- Simpson's Index is expressed as:

$D = \sum ni(ni - 1)/N(NN - 1)$ ……. eqn. 1

Where: ni = the number of individuals in the ith woody species

N = the total number of individuals counted for all woody species

- Shannon-Wiener Index is expressed as:

$H = -\sum_{i=1}^{s} pi \ln pi$ …… eqn. 2

Where: pi = the proportion of individuals in the ith woody species; S = the total number of species

3.4.2 Similarity in plant species composition

Similarity indices measure the degree to which the species compositions of communities or samples are alike. Jacquard and Sorensen are the most common binary similarity coefficients because they rely on presence or absence of data. However, similarity in plant species composition between the natural vegetation and the abandoned dredging sites of different ages, and between the abandoned dredging sites, was evaluated using Sorensen's similarity index (Ss) as follows:

$Ss = 2a/(2a+b+c)$ ---------- eqn. 3

Where: a = number of species common to both sites

b = number of species found in Site 1 but absent in Site 2

c = number of species found in Site 2 but absent in Site 1

3.4.3 Cluster dendogram classification of quadrats in all the sites

Cluster dendogram classification of all the quadrats enumerated in both the natural forest and the abandoned dredging sites was done based on the similarity of the species found in the quadrats, using the Paleontological Statistics software.

RESULTS

Species Composition of the Natural Forest and Abandoned Dredging Sites

The species composition of the natural vegetation (forest) and the abandoned dredging sites is shown in Tables 1 and 2 for woody species and non-woody species, respectively. The highest number of woody species (Table 1) was found in the natural vegetation while the lowest number of species was found in the one-year old abandoned dredging site. In the abandoned dredging sites, the availability of woody species was found to have increased with an increase in the period of abandonment. For non-woody species (Table 2), more species were found at the abandoned dredging sites than in the natural

vegetation with the highest number of species found at the five-year old abandoned dredging site.

Table 1: Checklist of woody species enumerated at the natural vegetation and abandoned dredging Sites

S/No.	Species	Family	Habit	Population			
				NV	ADS_5	ADS_3	ADS_1
1	*Alchornea cordifolia*	Euphorbiacaeae	Tree/shrub	6	2	3	0
2	*Alstonia boonei*	Apocynaceae	Tree	7	2	1	0
3	*Ceiba pentandra*	Malvaceae	Tree	1	0	0	0
4	*Chromolaenea odorata*	Asteraceae	Woody herb	0	0	0	6
5	*Cleistopholis patens*	Annonaceae	Tree	5	0	0	0
6	*Elaeisguineensis*	Aracaceae	Tree	76	0	0	0
7	*Ficus mucosa*	Moraceae	Tree	9	0	0	0
8	*Heterolis rotundifolia*	Melastomataceae	Woody herb	0	1	6	0
9	*Irvingia gabonensis*	Irvingiaceae	Tree	3	0	0	0
10	*Macaranga spinosa*	Euphorbiacaeae	Tree	4	0	0	0
11	*Mangifera indica*	Anacardiaceae	Tree	4	0	0	0
12	*Myrianthus arboreus*	Urticaceae	Tree	1	1	0	0
13	*Newbouldia laevis*	Bignoniaceae	Tree	2	0	0	0
14	*Psidium guajava*	Myrtaceae	Tree	1	0	0	0
15	*Pterocarpus santalinoides*	Fabaceae	Tree	2	0	0	0
16	*Spondias mombin*	Anacardiacaeae	Tree	8	0	0	0
17	*Spondiathus preussii*	Euphorbiaceae	Tree	1	0	0	0
18	*Treculia africana*	Moraceae	Tree	6	0	0	0

NV=Natural vegetation; ADS5=5 Years old abandoned dredging site; ADS3= 3 Years old abandoned dredging site; ADS1= 1 year old abandoned dredging site

Table 2: Checklist of non-woody species enumerated at the various sites

S/No.	Species	Family	Habit	Population			
				NV	ADS_5	ADS_3	ADS_1
1	*Acroceras zizanioides*	Poaceae	Grass	-	+NC	-	-
2	*Calapogon sp*	Malvaceae	Grass	-	+NC	+NC	+NC
3	*Eleusine indica*	Poaceae	Grass	-	+NC	+NC	+NC
4	*Emilia coccinea*	Asteraceae	Herb	+NC	-	-	-
5	*Heliotropium indicum*	Boraginaceae	Grass	-	+NC	-	-
6	*Dissotic rotundifolia*	Melastomatacaea	Grass	-	+NC	+NC	+NC
7	*Hpytis lanceolata*	Lamiaceae	Grass	-	+NC	+NC	-
8	*Imperata cylindrica*	Poaceae	Grass	-	+NC	+NC	+NC
9	*Ipomoea aquatica*	Convoluvlacaea	Creeping Herb	+NC	+NC	+NC	+NC
10	*Ipomoea involucrata*	Convolvulaceae	Creeping Herb	-	+NC	-	-
11	*Kyllinga erecta*	Cyperaceae	Grass	-	+NC	+NC	-
12	*Melastomastrum capitatum*	Melastomataceae	Herb	-	+NC	-	-
13	*Mimosa invisa*	Fabaceae	Grass	-	+NC	+NC	+NC
14	*Panicum maximum*	Poaceae	Grass	-	-	+NC	+NC
15	*Pennis etumpurpurem*	Poaceae	Grass	+NC	+NC	+NC	+NC
16	*Pycerus lanceolatus*	Cyperaceae	Sedge	-	-	+NC	-
17	*Thaumatococcus daniellii*	Marantaceceae	Herb	+NC	-	-	-
18	*Urena lobata*	Malvaceae	Grass	-	+NC	+NC	+NC

NV=Natural vegetation; ADS_5=5 Years old abandoned dredging site; ADS_3= 3 Years old abandoned dredging site; ADS_1= 1 year old abandoned dredging site; - = Absent; +NC = Present but not counted

Diversity of Woody Species in the Natural Vegetation and Abandoned Dredging Sites

The diversity of the woody species in the natural vegetation or forest and the abandoned dredging sites is shown in Table 3. Woody species richness (number of woody species) was highest in the natural forest and lowest in the one-year old abandoned dredging site. Woody species richness and diversity was found to be increasing with increasing period of abandonment of the dredging sites.

Table 3: Woody species diversity indices for the natural vegetation and abandoned dredging sites

Index	NV	ADS_5	ADS_3	ADS_1
No. of species	17	4	2	1
Individuals	142	10	4	6
Simpson 1 - D	0.69	0.58	0.38	0
Shannon H	1.88	1.09	0.56	0

NV=Natural vegetation; ADS_5=5 Years old abandoned dredging site; ADS_3= 3 Years old abandoned dredging site; ADS_1= 1 year old abandoned dredging site.

Similarity in Plant Species Composition

The extent of similarity in the plant species composition of the natural vegetation and the abandoned dredging sites is shown in Table 4 for woody species and Table 5 for the non-woody species. Similarity in woody species between the natural forest and the abandoned dredging sites (Table 4) was generally low but was equally found to be increasing with an increase in the period of abandonment of the dredging sites. Similarity in non-woody species (Table 5) was found to be higher between the abandoned dredging sites than between the natural vegetation and the abandoned dredging sites.

Table 4: Percentage similarity in woody species composition of the sites

SITE	NV	ADS_5	ADS_3	ADS_1
NV	*	27.00	20.00	0.00
ADS_5		*	66.00	0.00
ADS_3			*	0.00
ADS_1				*

NV=Natural vegetation; ADS5=5 Years old abandoned dredging site;
ADS3= 3 Years old abandoned dredging site; ADS1= 1 year old abandoned dredging site

Table 5: Percentage similarity in non-woody species composition of the sites

SITE	NV	ADS_5	ADS_3	ADS_1
NV	*	22.00	23.00	37.00
ADS_5		*	76.00	66.00
ADS_3			*	78.00
ADS_1				*

NV=Natural vegetation; ADS_5=5 Years old abandoned dredging site;
ADS_3= 3 Years old abandoned dredging site; ADS_1= 1 year old abandoned dredging site

Classification of the sites based on the similarity of species enumerated in the various quadrats

Cluster dendogram classification of the quadrats enumerated in both the natural vegetation and the abandoned dredging sites is shown in Figure 2. Generally, intra-site quadrat association was closer and stronger than inter-site quadrat association. The only close association between the natural forest and the abandoned dredging sites was found between Quadrat number 2 in the Natural forest (NV_Q2) and Quadrat Number 3 in the five-year old abandoned dredging site (ADS5_Q3). Considering the abandoned dredging sites alone, association of quadrats was closer and stronger between the 3-year old and the five-year old abandoned dredging sites. Quadrats in the one-year old abandoned dredging site associated more closely to themselves than with quadrats from other abandoned dredging sites.

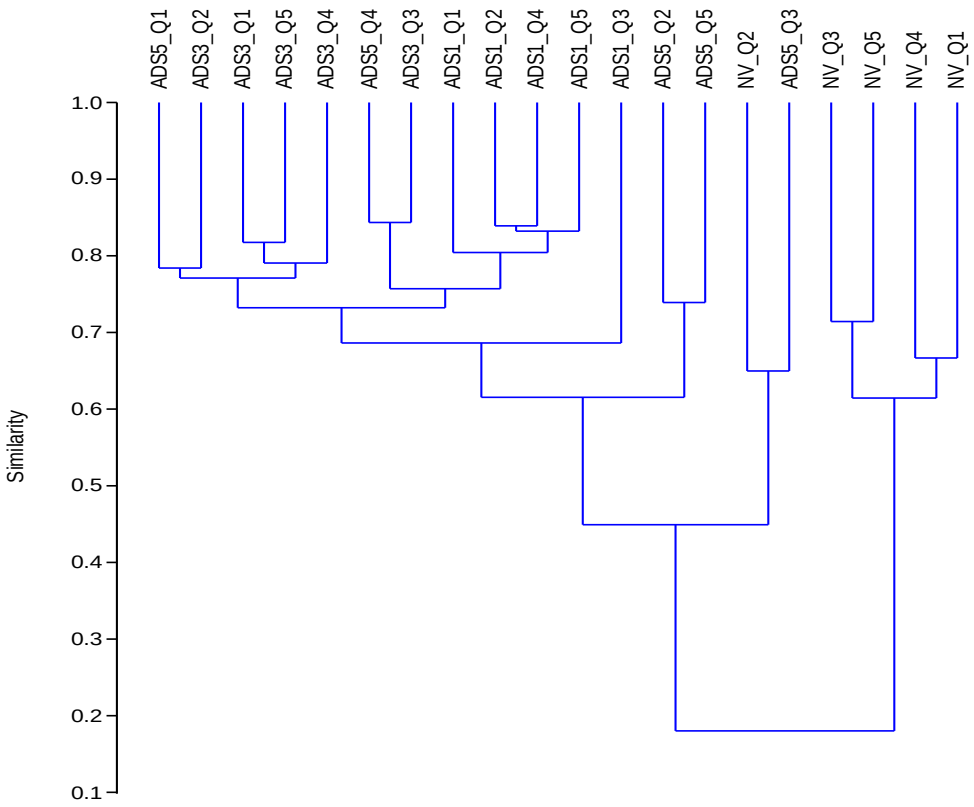

Figure 2: Cluster dendogram of quadrats in the natural vegetation and the abandoned dredging sites based on similarity of species found in them

DISCUSSION

The presence of more woody species in the natural vegetation than in the abandoned dredging sites was due to the fact that the abandoned dredging sites were still at their early stages of succession. The dominance of non-woody pioneer species during the early stages of succession has been reported by several authors including (Dike 1992; Wassie and Teketay, 2006; Chima*et al*., 2013). The possible reasons for this have also been reported by several authors. One possible reason is the variation in seed longevity between species. Milberg (1995) reported that seed longevity in the soil varies among species, as a result of the characteristics of the seeds, burial depth, and climatic conditions while Thompson *et al*. (1997) observed that seed longevity can range from nearly zero (germinating immediately when reaching the soil or even before) to several hundred years. Contrary to the non-woody grasses, seeds of forested species are often short-lived (Garwood, 1989; Wassie and Teketay, 2006). Dike (1992) also reported that forest species often complete their germination processes within eighty-four days after dispersal in two forest reserves in South-western Nigeria, leading to few seeds remaining in the seed stores. Moreover, disturbance of the original forest usually eliminates the seed bank of rain forest species (Guevara *et al*., 2005).

The dominance of the soil seed bank by the seeds of the non-woody species especially grasses explains why the early stages of succession are usually dominated by them. A study into the natural process which influence forest dynamics has shown that soil seed bank is one of the principal sources of recruitment for new individuals in the initial stages of forest succession (Butler and Chazdon, 1998). Another possible reason is the fact that seeds of the pioneer non-woody species like grasses are small in size and this favours dispersal by wind which is not usually the case with seeds of woody species which are bigger in size.

Higher woody species diversity in the natural vegetation than in the abandoned dredging sites is attributable to the relatively low disturbance in the natural vegetation. The activities associated with dredging encourage the removal of the original vegetation which involves the elimination of the hitherto existing woody species and thereafter, the disturbance creates conditions that favour the colonisation of non-woody species. The high dominance of the abandoned dredging sites by the non-woody species explains why similarity in non-woody species was higher between the abandoned

dredging sites than between each of them and the natural vegetation.

However, the improvement in species richness and diversity of the woody species in the abandoned dredging sites and their similarity in species composition with the natural forest with an increase in the age of abandonment, is indicative of the fact that woody species recovery in the abandoned dredging sites is possible with time if the sites can be protected from the destructive activities associated with dredging and other sources of ecosystem degradation. The resilience of forest ecosystems has been reported by several authors and that probably explains why they are classified as renewable natural resource.

Generally, intra-site quadrat association was closer and stronger than inter-site quadrat association. The only close association between the natural forest and the abandoned dredging sites was found between Quadrat number 2 in the Natural forest (NV_Q2) and Quadrat Number 3 in the five-year old abandoned dredging site (ADS5_Q3). Considering the abandoned dredging sites alone, association of quadrats was closer and stronger between the 3-year old and the five-year old abandoned dredging sites. Quadrats in the one-year old abandoned dredging site associated more closely to themselves than with quadrats from other abandoned dredging sites. These associations are explained by the extent of similarity in species composition of the various sites. The higher the similarity, the closer the association, and *vice versa*.

CONCLUSION

Non-woody species richness was higher in the abandoned dredging sites than in the natural vegetation with the highest species richness found in the five years old abandoned dredging site. On the other hand, woody species richness and diversity were higher in the natural vegetation than in the abandoned dredging sites. However, woody species richness and diversity increased with increase in age of the abandoned dredging sites. Similarity in woody species composition between the natural vegetation and the abandoned dredging sites was generally low but also increased with increase in the age of the abandoned dredging sites. Similarity in non-woody species was higher between the abandoned dredging sites than between the natural vegetation and the abandoned dredging sites. The study has shown that sand dredging and associated activities can have negative impact on plant communities by altering the species composition, and reducing woody species richness and diversity. However, the original species composition, richness and diversity can be restored over time if the sites are protected from further destruction and degradation.

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