Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Pelagia Research Library

Asian Journal of Plant Science and Research, 2013, 3(3):142-156

ISSN : 2249-7412
CODEN (USA): AJPSKY

Floristic and diversity trend of regeneration in a quartz dominated quarry impacted site in parts of Umuoke, in Obowo local government area of Imo State, Nigeria

***[1]Edwin-Wosu N. L., [2]E. A. B. Edu and [1]O. M. Okeke**

[1]Department of Plant Science and Biotechnology, University of Port Harcourt, Choba, Port Harcourt, River State, Nigeria
[2]Department of Botany, University of Calabar, Calabar, Cross River State, Nigeria

---

ABSTRACT

This study reveals the floristic and diversity trend of regeneration status of plant species in a quartz dominated quarry site at Umuoke in Obowo Local Government Area of Imo State, Nigeria. A simple random sampling method based on a standard procedure for ecological assessment along specific transect was adopted for the study. Results show that Poaceae had the highest species diversity in terms of richness with 19 species, Spermacoce verticillata (Rubiaceae) recorded maximum diversity in terms of evenness and very abundant in frequency of occurrence. The study site had an increased herbaceous habit, heterogeneous secondary vegetation, and mosaic nature with a representative 55 species been recorded. The herbaceous increase in the study site is an indication of a primary regenerative succession which seems to be progressive toward shrubby habit and even to a tree forest habit if protected. Also species in their diverse capabilities and various mode of regeneration status established through coppicing, rhizome and seedlings. The total seedling / sapling (density) in the study site recorded 41.4, with the highest relative density of 14.49% recorded for Oldenlandia corymbosa Linn. The highest frequency of occurrence was recorded as 80 □ 4.44% for Spermacoce verticillata Linn, while the highest species abundance was recorded with Oldenlandia corymbosa Linn having 15 Ξ 10.16%, which also recorded the highest Importance Value Index (IVI) of 26.87 and species diversity richness and evenness of 0.09 and 0.05 respectively. The ratio of abundance to frequency (A/F) indicate the distribution pattern with 11 species been regular and 13 species been random, while 55 regenerating species been contiguous in pattern. With the greater number of species in contiguous distribution pattern the present findings provide a complete view of regeneration trend in the study area. It is evident that the degraded forest of the Umuoke quarry site is turning into a heterogeneous natural forest again. The area is dominated by herbaceous regenerating species that could result in the establishment of a diverse natural forest, hence with a greater contagion pattern and if protected to conserve the seedlings or saplings of regenerating species.

Key words: Relative density, relative abundance, relative frequency, Importance Value Index and regeneration.

INTRODUCTION

One of the most important challenges for ecologist is gaining insight into the mechanisms that determines the distribution patterns of species in patchy habitats. Quarry operation is one of the key human induced elements in geological processes, and this adversely determines the distribution of species and their habitat. But the most obvious and dramatic impacts are usually the direct disturbance on biodiversity leading to loss of floral and fauna complex [1]. The environmental impacts of quarry operations have for several decades been envisaged and known to have a multiplier effect. Several studies have also shown a correlation between plant species population and diverse environmental changes.

Over recent decades, several theories have been proposed to explain why some species are rare and others are common [2, 3]. Rare species have a low frequency over habitat patches and consequently a limited contribution to community assembly process. Several factors may restrict species geographical distribution, which ranges from lack of propagules (dispersal limitation) and unsuitable habitat (niche limitation) such as a derelict quarry site [4]. Several other biotic and abiotic factors have been noted as agents of species ecological amplitude [5, 6, 7]. This concomitantly amount to some degree of ecological succession causing direct changes in plant species abundance in terms of frequency of occurrence and density. Other succession impacts involve changes in species diversity (in terms of richness and evenness), relative density, relative frequency, relative abundance, importance value index (IVI), ratio of abundance to frequency (A/F) and plant species regeneration and habit.

Ecological succession is a phenomenon or process by which a community progressively transforms itself until a stable community is formed. It is a fundamental concept in ecology and refers to more or less predictable and orderly changes in the composition and structure of an ecological community. Succession may be initiated either by some formation of new, unoccupied habitat or by some form of disturbance of an existing community [8].

Several works on ecological succession of diverse plant species assemblage involving both rare and invasive species on a quarry site have been documented [9, 10, 11]. In ecosystems, quarry disturbance and stressful abiotic conditions induce profound modifications on the landscape and plant communities. It is thus difficult to estimate the rate or degree of spontaneous vegetation recolonization. Vegetation dynamic relies on species that are both available in the natural surroundings and adapted to local environmental (topography and soil) constraints, such as quartz stones environment. Quartz stone ecosystems are very special habitat characterized by occurrence of pavements of angular quartz debris (by weathering process of quartz veins) embedded in soft bed rocks (shale, phyllite).

The composition of pure quartz is always close to 100 percent SiO_2; however there is usually a complex of iron oxide and/ or manganese staining. As a result of weathering, mineral break down and leaching processes and other anthropogenic influences nutrient elements are lost from the root zone of plants, residual minerals of little chemical benefit to plants (mainly kaolinetics clays, iron and aluminum oxides and oxyhydroxides) tends to accumulate in the soil. As these physical and biotic processes and element depletion processes proceed; the growing conditions for plants of all kinds become more stressful [12] and with the habitat vegetation dominated by leaf-succulent dwarf shrubs [13].

Since it is impossible to avoid habitat destruction during mining operations, options for mitigation lies in protection and provision of alternative rehabilitation areas after operations. Quarry processes are usually carried out for several years and rehabilitation offer a way of returning abandoned sites to a more desirable ecological state. Rehabilitation is any manipulation of a successional sequence that enhances its rate or deflects its trajectory towards a specified goal [14].

Plant species regeneration status is important to determine the potential of an area for biodiversity conservation. Though various studies on population structure and regeneration status have been carried out by many workers in different forest ecosystems [15, 16, 17, 18], but no information has been generated on this aspect of research under local conditions on the quarry site situated at Umuoke in Obowo Local Government Area of Imo State, Nigeria.

MATERIALS AND METHODS

Geomorphological Description of the Study Area/ Location

Obowo local government area among others in Eastern part of Nigeria is located in Imo State. The area is situated between latitude 5^o 35^I 0"N and 5^o 22^I 30"N and longitude 7^o 22^I 30"E and 7^o 25^I 0"E of the State. The local government area is housing about 19 autonomous community as towns with its headquarter at Otoko. Other towns include: Odenkume, Okwuohia, Amuzi, Umuagu, Umoweke, Amanze, Alike, Umuosochie, Achingali,Umuariam, Achara, Umunachi, Umungwo, Umulogho, Avutu, Umuoke, Ehume, Umuifem and Ogbotokwu. (Figs 1, 2 & 3) [19].

The study location: Umuoke is located north-west of Obowo local government area in Imo State. The location is characterized by a quarry site situated between latitude 05^o 34^I 04"N and 05^o 34^I 05"N and longitude 007^o 23^I 18"E and 007^o 23^I 19"E of its location in Imo State. The site is being under exploitation for it solid minerals which act as source of raw material supply for diverse production of earthen materials or products.

The study area is characterized by two season-rainy and dry seasons. The rainy season falls between April and October with annual rainfall varying from 1500-2200mm (60-80inches). A mean temperature of above 20^oC (68^oF)

and relative humidity of 75%-90% at peak rainfall. The dry season between November and March experiences two months of harmattan from December to February with peak temperature and humidity between January and March. This favours the luxuriant vegetation growth of the area [20].

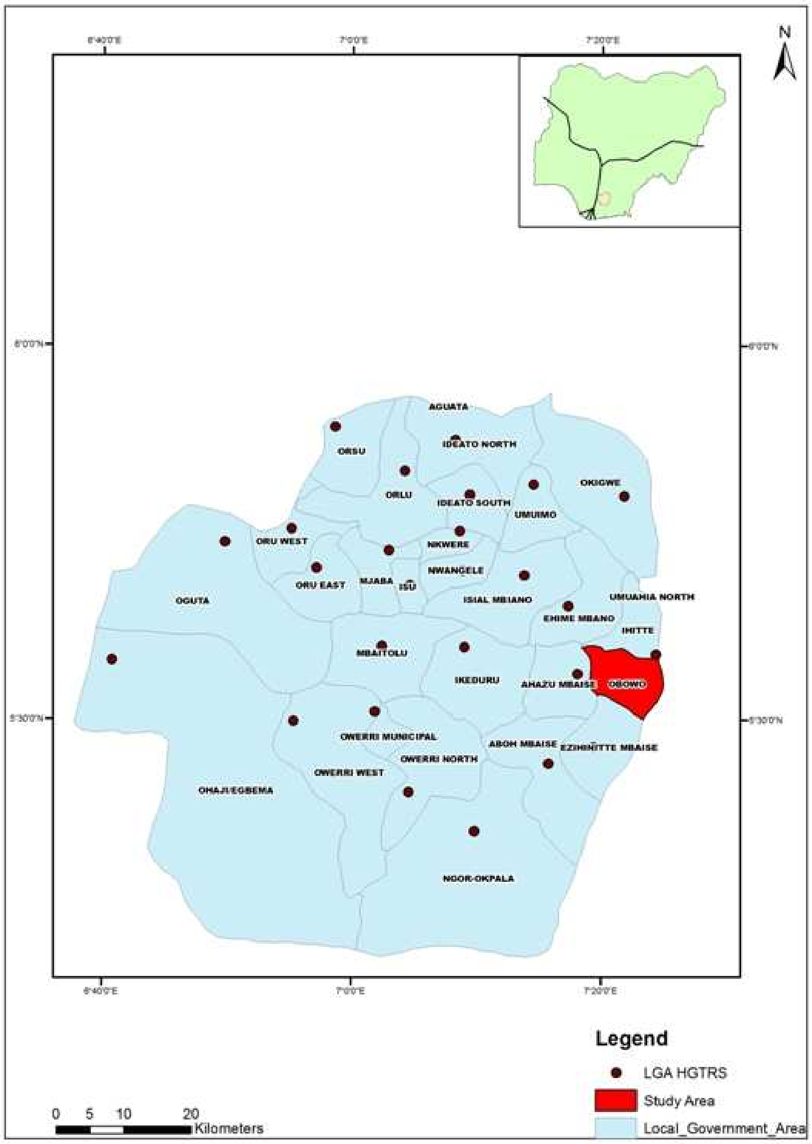

FIG. 1: Imo State Showing Study Area (Obowo LGA.)

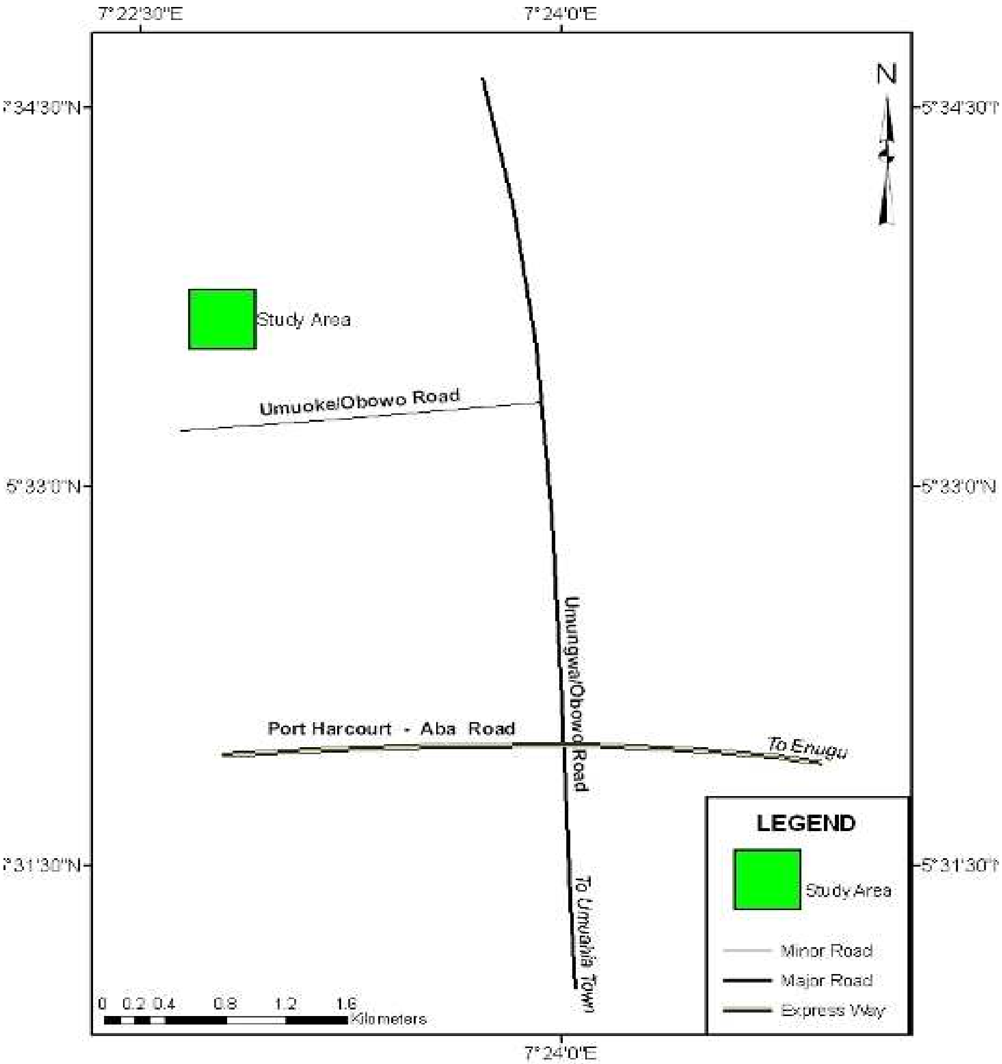

FIG. 2: Road direction to study location

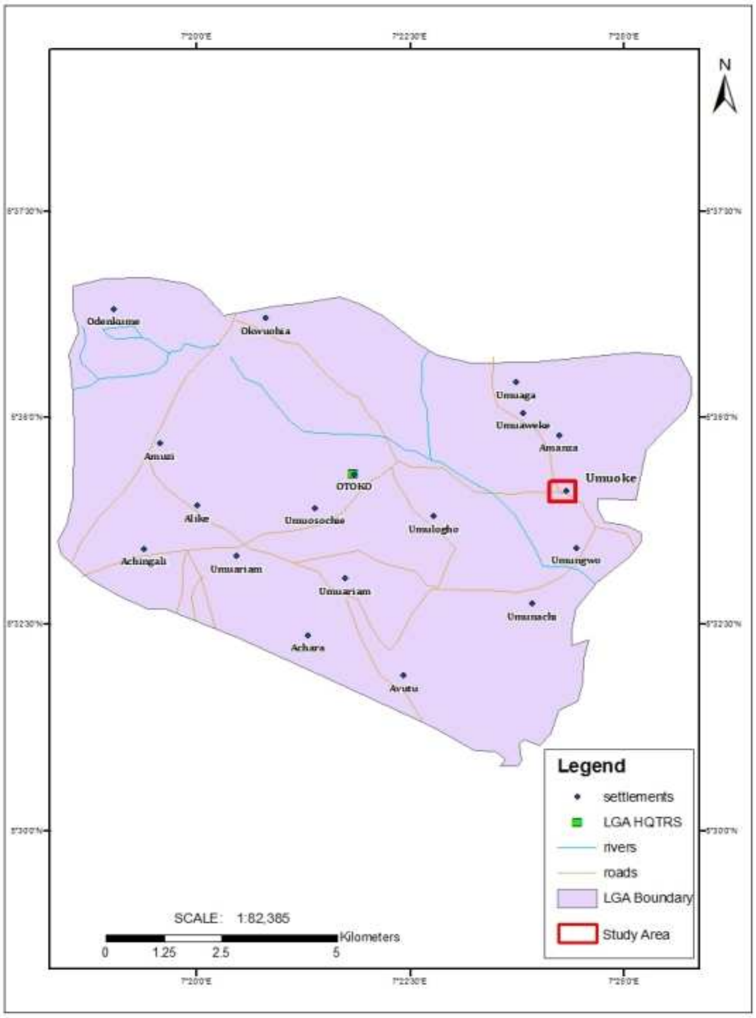

FIG. 3: Obowo Local Government Area Showing Sampled Location

The area in its edaphic status is underlain by the Benin formation of coastal plain sands. This formation which is of late tertiary age is rather deep, porous, infertile and highly leached. In some areas like Okigwe, impermeable layer of clay occur near the surface while in other areas, the soil consists of lateritic material under a superficial layer of fine grained sand. In Umuoke quarry site the soil is dominantly composed of quartz and ferromagnetic iron minerals with its lateritic coloration due to the rainfall weathering and oxidation processes of iron (II) to iron (III) oxide ($Fe^{2+} \rightarrow Fe^{3+}$) causing colour change. The area is also rich in lead, zinc, hydrocarbon formation.

The study area is in the centre of one of the agricultural zones of the State. The vegetation primarily though of climax nature, is of a typical secondary nature with its prevalent species of ecological succession regenerating from the effect of quarry activities. The successive vegetation of the area is characterized by prevalent species of shrubs, herbs, climbers, lianers, and dominantly members of *Poaceae*, *Rubiaceae*, *Sterculiaceae*, *Malvaceae*, *Anacardiaceae*, *Acanthaceae*, *Fabaceae*, *Asteraceae* and *Onagraceae*. Others are *Lamiaceae*, *Cyperaceae*, *Liliaceae*, *Myrtaceae*, *Nyctaginaceae*, *Melastomataceae*, *Tiliaceae*, *Loganiaceae*, *Euphorbiaceae and Convolvulaceae* plant families, typical of secondary succession fallowed bush. The environment has also witnessed some form of human activities such as farming far and near residential areas by the local communities leaving fields of plantations such as *Manihot* spp. (*Euphorbiaceae*), *Musa* spp. Linn (*Musaceae*); *Xanthosoma malfaffa* Schott (*Araceae*) and *Coloccasia esculenta* (Linn.) Schott (*Araceae*)

Though primarily, a climax vegetation of various strata composed of such species as *Milicia excelsa* (Welw.) C.C. Berg (*Moraceae*) Iroko; *Khaya ivorensis* A. Chev.(*Meliaceae*) mahogany; *Triplochiton scleroxylon* K.Schum. (*Sterculiaceae*) obeche; *Bambusa vulgaris* Schrad (*Poaceae*) Indian bamboo; *Elaeis guineensis* Jacq, (*Arecaceae*) oil palm; *Gmelina arborea* Roxb. (*Verbenaceae*) *Gmelina* and *Hevea brasiliensis* (Willd) Mull-Arg. (*Euphorbiaceae*) rubber. The effect of these human activities (quarry farming and fuel wood logging) has consequently left it with some form of irregular vegetation features. This can therefore be categorized as a low and secondary mosaic forest as described by Hopkin [21]. However, the vegetation is yet described as rainforest vegetation in relation to similar view of vegetation analysis by SAF, [22] and Edwin-Wosu, [23, 24, 25, 26].

Vegetation Assessment

It was carried out by adopting the simple random sampling based on standard procedures for ecological assessment studies [27] with specific quadrate direction of 100 x 100m² to determine the regeneration status of the quarry site. This was divided into sampling unit to give a total of five quadrate sampling plot of 100 x 20m each and was systematically sampled (Fig.4). All the important representative plant species sampled were identified in the field as far as possible and were properly authenticated using flora such as [28, 29, 30, 31, 32, 33, 34, 35]. All the seedlings, coppice and rhizomes were recorded.

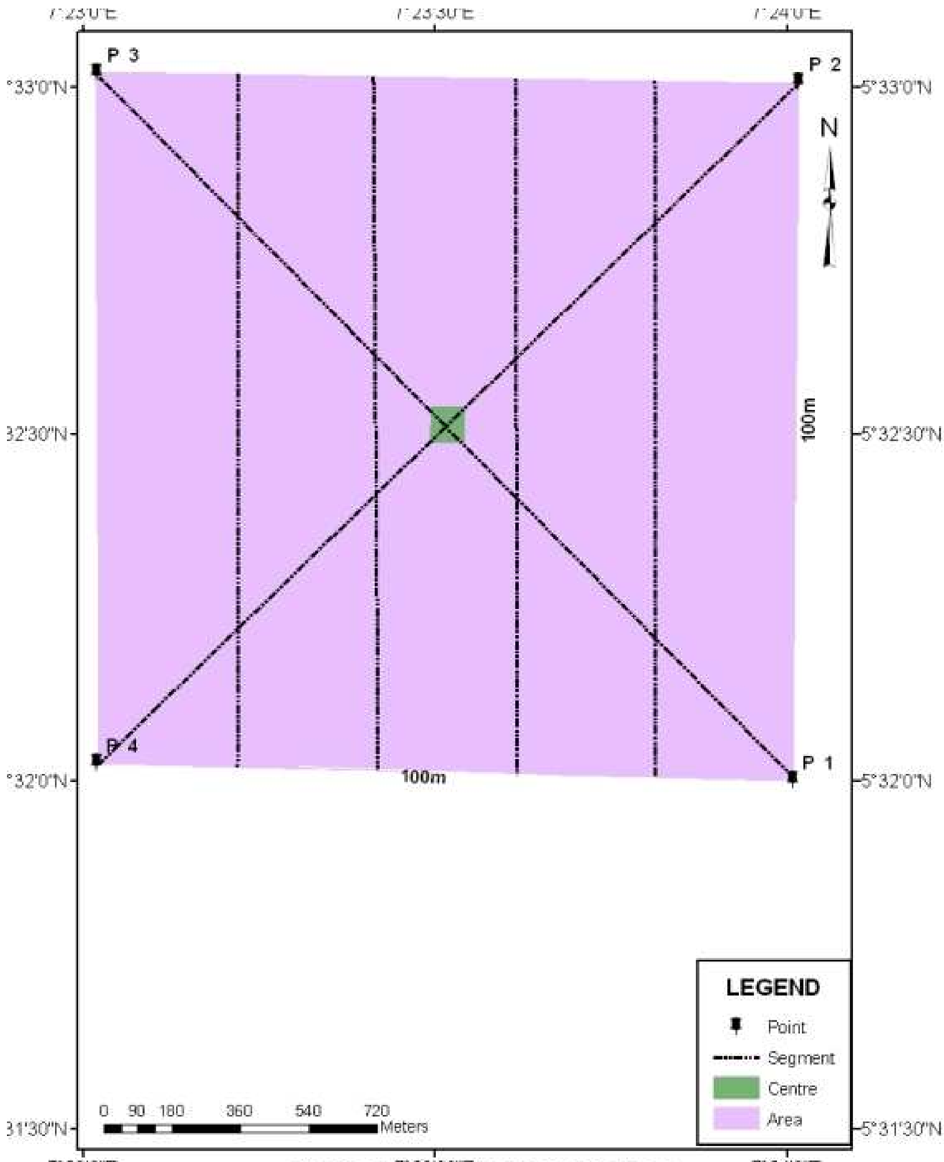

FIGURE 4: OUTLAY TRANSECT

The frequency of distribution, abundance, and density of the representative species of the study site were estimated using the methods of Austin & Greig-Smith [36]; Kershaw, [37] and Shukla & Chandel, [38] approach as modified in Bonham, [39]. The species diversity and dominance over the study site was estimated using the Shannon-Weiner, [40] index. Vegetation was described in semi-quantitative terms [41] and in accordance species with a wide frequency of distribution with many stands are described as very abundant (++++). Some species with similarly wide frequency of distribution but with few stands are said to be less frequent, abundant or restricted species (+++).

The species with limited geographical distribution and with a few stands are termed scarce or occasional (++) and very scarce or rare (+) species. The species designated (++) and (+) are often seen as being prone to elimination due to their limited extent alone beside any other factors. Relative density, relative abundance and relative frequency were estimated following Misra [42] method, while the importance value index (IVI) was estimated by adding the values of RD, RA and RF using the Shukla & Chandel [38] method. The ratio of abundance to frequency for different species was determined for distribution patterns. Thus with the "Thumb of rule" designated as follows: Regular (<0.03), Random (0.03-0.05) and Contiguous (>0.05) distribution as adopted by Curtis and Cottam [43].

RESULTS

The study location by field observation is secondary mosaic vegetation, heterogeneous in nature. The heterogeneity is composed of fields of "volunteer plants" and their families mainly shrubby and herbaceous in habit including lianers among other plant species in the study area. The nature of any forest community largely depends on the ecological characteristics of the sites, species diversity and regeneration status of the species.

Despite the heterogeneous secondary vegetation, the mosaic nature and ecological succession of the project location induced by the quarry operations by the inhabitants of the area, the regeneration and floristic succession of the project location has recorded a total representative of 64 plant species with diverse mode of regeneration and habit under 19 families (Table 1). Six families (*Poaceae, Fabaceae, Rubiaceae, Asteraceae, Cyperaceae* and *Lamiaceae*) were prevalent and dominant in which *Poaceae* had the highest species diversity in terms of richness with 19 species, while *Fabaceae* (12 spp); *Rubiaceae* (6 spp); *Asteraceae* (5 spp); *Cyperaceae* (4 spp); and *Lamiaceae* (3 spp) were recorded respectively. The remaining 13 families recorded lower species diversity in richness with one to two species respectively. However, among the species under the 19 families, *Spermacoce verticillata* (*Rubiaceae*) recorded maximum diversity in terms of evenness and very abundant in frequency of occurrence. Two species *Emilia sonchifolia* (*Asteraceae*) and *Cuscuta australis* (*Cuscutaceae*) recorded abundance and non evenness in diversity. While the rest species were scarce and very scarce in frequency of occurrence with non evenness in diversity.

There was increase in herbaceous status in terms of habit with a representative total of 55 species recorded as herbs; seven (7) as shrubby- herbs and two as shrubs. The herbaceous increase in the study site is an indication of a primary regenerative succession which seems to be progressive toward shrubby habits. The study has shown that open canopy may favour germination and seedling establishment through increased solar radiation incident on the forest floor. New species were found regenerating, which were absent as adults. Results have also shown that the species in their diverse capabilities have reestablished through various mode of regeneration status with few species exhibiting multiplier effect in such regeneration. The species were establishing through coppicing, rhizome and seedlings, though few species- *Panicum laxum*, and *Chromolaena odorata* exhibited rhizome/seedling while *Psidium guajava* exhibited seedling / coppice modes of regeneration respectively.

Table 2 shows the quantitative structure of regeneration in the quarry site. The total seedling/sapling in terms of density in the study site is 41.4. The highest density (DΞ RD) of 6 Ξ 14.49 was recorded for *Oldenlandia corymbosa* Linn, followed by *Oldenlandia herbaceae*. (Linn) Roxb with 4Ξ 9.66 and *Sida linifolia* 2Ξ 4.83. *Sporobulus pyramidalis* P. Beauv had 1.2Ξ 2.90 while *Panicum repens* Linn and *Digitaria gayana* (Kennth.) Stapf *ex* A. Chev had 1Ξ 2.42 respectively. The rest species in the study site recorded value between 0.2Ξ0.48 and 0.8Ξ1.93 as density respectively. The highest frequency of occurrence was recorded as 80Ξ 4.44% for *Spermococe verticilata* Linn, while *Emilia sonchifolia* (Linn.) Dc. and *Cuscuta australis* R. Br. recorded 60Ξ 3.33% respectively. The rest species has recorded % frequency between 20Ξ 1.11 and 40Ξ 2.22 respectively.

The highest species abundance was recorded with *Oldenlandia corymbosa* Linn having 15Ξ 10.16, *Sida linifolia* 10Ξ 6.77 while *Panicum repens* and *Digitaria gayana* had 5Ξ 3.39 abundance respectively. The rest species recorded abundance ranging from 0.5Ξ 0.39 to 4Ξ 2.71 respectively.

Oldenlandia corymbosa had the highest Importance Value Index (IVI) (26.87) with a highest species diversity of 0.09 and 0.05 in terms of richness and evenness, followed by *Sida linifolia* (12.71), and *Oldenlandia herbacea* (12.12). While *Sporobulus pyramidalis* had 8.07 IVI, *Spermacoce verticillata* recorded 7.05 and *Panicum repens* and *Digitaria gayana* had 6.92 respectively. The rest species had recorded IVI ranging between 2.27- 5.75.

Table 1: Present Status of Species Regeneration and Their Reproductive Strategies in Parts of the Study Area at Umuoke Quarry Site in Obowo Local Government Area of Imo State, Nigeria.

S/N	Species	%F	Family	Common name	Mode of regeneration	Habit	Remark
1	*Sporobolus pyramidalis* P. Beauv.	20	Poaceae	Rat tail grass	Rhizome	Herb	+
2	*Perotis indica* (Linn.) O. Kitze	40	Poaceae	Grass	Rhizome	Herb	++
3	*Paspalum conjugatum* Berg	20	Poaceae	Buffalo grass	Rhizome	Herb	+
4	*Panicum repens* Linn.	20	Poaceae	Torpedo grass	Rhizome	Herb	+
5	*Oplismenus burmanmi* (Rertz) P. Beauv.	40	Poaceae	Grass	Rhizome	Herb	++
6	*Eragrostis ciliaris* (Linn.) R.Br.	40	Poaceae	Love grass	Seed	Herb	++
7	*Digitaria gayana* (Kennth.) Stapf *ex* A. Chev.	20	Poaceae	Grass	Rhizome	Herb	+
8	*Digitaria horizontalis* Willd.	20	Poaceae	Grass	Rhizome	Herb	+
9	*Chloris pilosa* Schumach.	20	Poaceae	Finger grass	Rhizome	Herb	+
10	*Brachiara lata* (Schumach) C.E. Hubbard	20	Poaceae	Grass	Seed	Herb	+
11	*Brachiara deflexa* (Schumach.) C.E. Hubbard *ex* Robyris	40	Poaceae	Grass	Seed	Herb	++
12	*Axonopus compressus* (Sw.) P. Beauv.	40	Poaceae	Carpet grass	Rhizome	Herb	++
13	*Anthephora ampullaca* Stapf & C.E. Hubbard	40	Poaceae	Grass	Rhizome	Herb	++
14	*Spermacoce verticillata* Linn.	80	Rubiaceae	Shrubby false	Seed	Herb	++++
15	*Mitracarpus villosus* (Sw) DC.	20	Rubiaceae	Button grass	Seed	Herb	+
16	*Spermacoce ocymoides* Burn. F	20	Rubiaceae	N.A	Seed	Herb	+
17	*Melochia pyramidata* Linn.	20	Sterculiaceae	Pyramid flower	Rhizome	Herb	+
18	*Malvastrum coromandelianum* (Linn.) Garcke	20	Malvaceae	Hibiscubur congo jute	Rhizome	Herb	+
19	*Anacardium occidentalis* Linn.	40	Anacardiaceae	Cashew plant	Coppice	Shrub	++
20	*Asystassia gangetica* (Linn.) T. Adams	40	Acanthaceae	Chinese violet	Seed	Herb	++
21	*Desmodium scorpiurus* (Sw) Desv.	20	Fabaceae-papilio	Beggar weed	Seed	Herb	+
22	*Desmodium tortuisum* (Sw) Dc	20	Fabaceae-papilio	Florida beggar weed	Seed	Herb	+
23	*Emilia sonchifolia* (Linn.)Dc	60	Asteraceae	Lilac tassel flower	Seed	Herb	+++
24	*Scleria naumanniana* Boeck. C	20	Cyperaceae	Bush knife	Seed	Herb	+
25	*Cuscuta australis* R. Br *(C. Campestris* Yuniker)	60	Cuscutaceae	Dodder	Seed	Herb climber	+++
26	*Melastomastrum capitatum* (Vahl.) A. & R. Fern	20	Melastomataceae	N.A	Seed	Shrubby herb	+
27	*Scleria verrucosa* Willd	20	Cyperaceae	Bush knife	Seed	Herb	+
28	*Triumfetta cordifolia* A. Rich.	20	Tiliaceae	Bur weed	Seed	Herb	+
29	*Alchornea cordifolia* (Schum. & Thonn.) Mull-Arg	40	Euphorbiaceae	Christmas bush	Seed	Herb	++
30	*Spigelia anthelmia* Linn.	40	Loganiaceae	Worm bush	Seed	Herb	++
31	*Panicum maximum* Jacq.	40	Poaceae	Guinea grass	Rhizome	Herb	++
32	*Zonia latifolia* Sm.	20	Fabaceae-papilio	N.A	Seed	Herb	+
33	*Tephrosia bracteolata* Guill & Perr	20	Fabaceae-papilio	Harry pig	Seed	Shrubby herb	+
34	*Andropogon tectorum* Schum. & Thonn.	40	Poaceae	Giant blue stem grass	Seed	Herb	++
35	*Ludwigia hyssopifolia* (G.Don.) Excell	20	Onagraceae	Water primrose	Seed	Herb	+
36	*Pentodon pentandrus* (Schum. & Thonn.) Vatke	20	Rubiaceae	N.A	Seed	Herb	+
37	*Chamaecrista mimosoides* (Linn.) Greene	40	Fabaceae-mimo	Japanease tea	Seed	Shrubby herb	++
38	*Hyptis lanceolata* Poir.	20	Lamiaceae	N.A	Seed	Herb	+
39	*Hyptis spicigera* Lam.	20	Lamiaceae	Mosquito guide	Seed	Herb	+
41	*Leucas Mortinicensis* (Jacq) Ait. F	20	Lamiaceae	Wild tea bush	Seed	Herb	+
41	*Tephrosia pedicellata* Bak	20	Fabaceae	N.A	Seed	Herb	+
42	*Sida linifolia* Juss *ex* Cav	20	Malvaceae	N.A	Seed	Shrubby herb	+

43	*Oldenlandia corymbosa* Linn.	40	Rubiaceae	N.A	Seed	Herb	++
44	*Oldenlandia herbacea* (Linn.) Roxb	20	Rubiaceae	N.A	Seed	Herb	+
45	*Eleusine indica* Gaertn.	40	Poaceae	Goose grass	Rhizome	Herb	++
46	*Mimosa pudica* Linn.	20	Fabaceae-mimo	Sensitive plant	Seed	Herb	+
47	*Centrosema pubescens* Benth.	20	Fabaceae-caesal	N.A	Seed	Herb	+
48	*Aspilla busei* O. Hoffon & Musehl	20	Asteraceae	White flowered haemorrhage plant	Seed	Herb	+
49	*Desmodium ramosissimum* G. Don.	20	Fabaceae-papi	N.A	Seed	Herb	+
50	*Mariscus alternifolius* Vahl.	40	Cyperaceae	Sedge grass	Seed	Herb	++
51	*Kyllinga squamulata* Thonn. *ex* Vahl.	40	Cyperaceae	Sedge	Seed	Herb	++
52	*Panicum laxum* Sw.	40	Fabaceae-papilio	Panic grass	Seed/rhizome	Herb	++
53	*Desmodium triflorum* (Linn.) De	40	Fabaceae-papilio	Three flower ticktre foil	Rhizome	Herb	++
54	*Calapogonium mucunoides* Desv	20	Fabaceae-papilio	Dead man's yam bean	Seed	Herb	+
55	*Mimosa pigra* Linn.	20	Fabaceae-Mimo	N.A	Seed	Shrubby herb	+
56	*Pueraria phaseoloides* (Roxb) Benth	20	Fabaceae-papilio	Tropical kudzu	Seed	Herb	+
57	*Psidium guajava* Linn.	20	Myrtaceae	Guava	Seed/coppice	Shrub	+
58	*Chromolaena odarata* (L) R.M King & Robinson	20	Asteraceae	Siam weed	Seed/rhizome	Herb	+
59	*Tridax procumbens* Linn.	20	Asteraceae	Wat buttons	Seed	Herb	+
60	*Boerhavia coccinea* Mill	20	Nyctaginaceae	Red spiderling	Seed	Herb	+
61	*Aspilla africana* (Rers.) C.D. Adams	20	Asteraceae	Haemorrhage plant	Seed	Herb	+
62	*Bambusa vulgaris* Schard	20	Poaceae	Indian bamboo	Coppice	Shrub	+
63	*Draceana aborea* (Willd) Link	20	Liliaceae	Landmark plant	Coppice	Shrubby herb	+
64	*Sorghum arundinaceum* (Desv) Stapf	20	Poaceae	Kamerum grass	Seed	Shrubby herb	+
	TOTAL	**1800**					

Note: + (1-20) Very scarce, ++ (21-50) Scarce, +++ (51-80) Abundant, ++++> (81-α) Very abundant, NA- Not available, %F- Percentage frequency.

Table 2: Quantitative Estimation of Regenerating Species in Parts of the Study Area at Umuoke Quarry Site in Obowo Local Government Area of Imo State, Nigeria

S/No	Species	%F	D	A	%RF	%RD	%RA	IVI	SDR	SDE	A/F
1	*Sporobolus pyramidalis* P.Beauv.	20	1.2	6	1.11	2.90	4.06	8.07	0.04	0.02	0.3
2	*Perotis indica* (Linn.) O. Kitze	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
3	*Paspalum conjugatum* Berg.	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
4	*Panicum repens* Linn.	20	1	5	1.11	2.42	3.39	6.92	0.04	0.02	0.25
5	*Oplismenus burmanmi* (Rertz) P. Beauv.	40	0.2	0.5	2.22	0.48	0.39	3.09	0.02	0.01	0.01
6	*Eragrostis ciliaris* (Linn.) R.Br.	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
7	*Digitaria gayana* (Kennth) Stapf *ex* A. Chev.	20	1	5	1.11	2.42	3.39	6.92	0.04	0.02	0.25
8	*Digitaria horizontalis* Willd.	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
9	*Chloris pilosa* Schumach	20	0.8	4	1.11	1.93	2.71	5.75	0.02	0.01	0.2
10	*Brachiara lata* (Schumach) C.E.Hubbard	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
11	*Brachiara deflexa* (Schumach) C.E.Hubbard *ex* Robyris	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
12	*Axonopus compressus* (Sw) P. Beauv.	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
13	*Anthephora ampullaca* Stapf & C.E.Hubbard	40	0.2	0.5	2.22	0.48	0.39	3.09	0.02	0.01	0.01
14	*Spermacoce verticillata* Linn.	80	0.8	1	4.44	1.93	0.68	7.05	0.04	0.02	0.01
15	*Mitracarpus villosus* (Sw.) DC.	20	0.2	1	1.11	0.48	0.68	2.27	0.02	0.01	0.05
16	*Spermacoce ocymoides* Burn. F	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
17	*Melochia pyramidata* Linn.	20	0.2	1	1.11	0.48	0.68	2.27	0.02	0.01	0.05
18	*Malvastrum coromandelianum* (Linn.) Garcke	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
19	*Anacardium occidentalis* Linn.	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
20	*Asystassia gangetica* (Linn.) T. Adams	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
21	*Desmodium scorpiurus* (Sw.) Desv	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
22	*Desmodium tortuisum* (Sw.) DC	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
23	*Emilia sonchifolia* (Linn.) DC	60	0.6	1	3.33	1.45	0.68	5.46	0.03	0.02	0.02
24	*Scleria naumanniana* Boeck. C	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
25	*Cuscuta australis* R. Br (*C. Campestris* Yuniker)	60	0.4	0.66	3.33	0.97	0.45	4.75	0.03	0.02	0.01
26	*Melastomastrum capitatum* (Vahl) A. & R. Fern	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
27	*Scleria verrucosa* Willd	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
28	*Triumfetta cordifolia* A. Rich	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
29	*Alchornea cordifolia* (Schum. & Thonn.) Mull- Arg	40	0.6	2.5	2.22	1.45	1.69	5.36	0.03	0.02	0.06
30	*Spigelia anthelmia* Linn.	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
31	*Panicum maximum* Jacq.	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
32	*Zonia latifolia* Sm.	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
33	*Tephrosia bracteolata* Guill & Perr	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
34	*Andropogum tectorum* Shum & Excell	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
35	*Ludwigia hyssopifolia* (G. Don) Excell	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
36	*Pentodon pentandrus* (Schum & Thonn) Vatke	20	0.4	2	1.11	0.97	1.35	3.42	0.02	0.01	0.1
37	*Chamaecrista mimosoides* (L) Greene	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
38	*Hyptis lanceolata* Poir	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
39	*Hyptis spicigera* Lam.	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
40	*Leucas mortinicensis* (Jacq.) Act. F	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
41	*Tephrosia pedicellata* Bak	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
42	*Sida linifolia* Juss *ex* Cav.	20	2	10	1.11	4.83	6.77	12.71	0.06	0.03	0.5
43	*Oldenlandia corymbosa* Linn.	40	6	15	2.22	14.49	10.16	26.87	0.09	0.05	0.38

44	*Oldenlandia herbacea* (Linn.) Roxb	20	4	2	1.11	9.66	1.35	12.12	0.06	0.03	0.1
45	*Eleusine indica* Gaertn.	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
46	*Mimosa pudica* Linn.	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
47	*Centrosema pubescens* Benth.	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
48	*Aspilla busei* O.Hoffon & Musehl.	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
49	*Desmodium ramosissimum* G.Don	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
50	*Mariscus alternifolius* Vahl	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
51	*Kyllinga squamulata* Thonn *ex* Vahl	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
52	*Panicum laxum* Sw	40	0.4	1	2.22	0.97	0.68	3.87	0.02	0.01	0.03
53	*Desmodium trifflorum* (Linn) De	40	0.6	1.5	2.22	1.45	1.02	4.69	0.03	0.02	0.04
54	*Calapogonium mucunoides* Desv	20	0.2	1	1.11	0.48	0.68	2.27	0.02	0.01	0.05
55	*Mimosa pigra* Linn.	20\	0.2	1	1.11	0.48	0.68	2.27	0.02	0.01	0.05
56	*Pueraria phaseoloides* (Roxb) Benth	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
57	*Psidium guajava* Linn.	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
58	*Chromolaena odarata* (L) R. M King & Robinson	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
59	*Tridax procumbens* Linn.	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
60	*Boerhavia coccinea* Mill	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
61	*Aspilla africana* (Rers) C.D.Adams	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
62	*Bambusa vulgaris* Schard	20	0.6	3	1.11	1.45	2.03	4.59	0.03	0.02	0.15
63	*Draceana aborea* (Willd) Link	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
64	*Sorghum arundinaceum* (Desv) Stapf	20	0.4	2	1.11	0.97	1.35	3.43	0.02	0.01	0.1
TOTAL		**1800**	**41.4**	**147.66**	**99.9**	**90.12**	**115.89**	**300.06**			

Note: %F- Percentage frequency, D-Density, A-Abundance, %RF-Relative frequency, %RD-Relative density, %RA-Relative abundance, IVI-Importance Value Index, SDR – Species diversity richness, SDE – Species diversity evenness, A/F-Ratio of abundance to frequency

The ratio of abundance to frequency (A/F) indicates the distribution pattern of the species. Eleven (11) species had a regular distribution pattern and thirteen (13) had random distribution, while greater number (55) of the regenerated species are more contiguous in nature. The findings of the present study provide a complete view of regeneration status in the study area. It is evident that the degraded forest of the Obowo quarry site is turning into a heterogeneous natural forest again. The area is dominated by herbaceous regenerating species that could result in the establishment of a diverse natural forest, hence with a greater contiguous distribution pattern and if projected to conserve the seedlings or saplings of the regenerating species.

DISCUSSION

Quarry operations induce ecosystem disturbance and profound modifications on the substration and the topographical profile of a site. On such heavily disturbed areas, spontaneous colonization is slow [44] and the natural vegetation succession is often inefficient to ensure proper protection against natural environmental degradation such as erosion [45, 46]. Several studies have shown a correlation between plant species population and diverse environmental changes.

Community structure can be examined through the determination of various attributes of its component species and their relationship to each other. Such attributes among others may include plant species composition, abundance, density, frequency, diversity, basal cover, Importance Value Index (IVI) etc. The ecological characteristic of an area, its species diversity and regeneration status of species and habit influences the nature of any forest community [47].The species richness is one of the major criteria in recognizing the importance of an area for conservation [48]. Conservation is a fundamental component of sustainable ecosystem functioning which aims at recreating habitat for wildlife and flora.

In the present research the heterogeneity of the vegetation of the study area is being attributed to a retrogressive process such as the influence of quarry operations, other forms of human activities, the regeneration and floristic succession of the study site. This has resulted to changes in vegetation structure in terms of abundance and species diversity. This corroborates Cubizolle, *et al*. [49] who observed human activity as an important factor influencing plant species biodiversity. On such quarry impacted areas, spontaneous colonization is slow and the natural vegetation succession is often inefficient to ensure proper protection against other post impact environmental influences. This also corroborates the assertions of Whitenant, *et al*. [44] and Bradshaw, [45, 46]. The existence of plant species in forest community largely depends also on its regeneration establishment under varied environmental condition such as increased solar radiation incident on the forest floor. Consequently this could also influence the growth stages in seedling, sapling and young herbs, shrubs and trees of plant communities that maintain the population structure of any forest.

Poaceae, Fabaceae, Rubiaceae, Asteraceae, Cyperaceae and *Lamiaceae* were the dominant families in the study site possibly as a result of such environmental condition involving direct insolation on plant species which favour germination and seedling establishment in such open canopy. This confirms the assertion that open canopy may favour germination and seedling establishment through increased solar radiation on forest floor [50] and also corroborates the assertion that grass biomass was correlated with canopy cover [51]. Similarly several works have shown that vegetation dynamic relies on species that are available and adapted to local environmental (topography and soil) constraints [52].

Regeneration is a critical phase of forest management, because it maintains the desired species composition and stocking after disturbance [53]. This may also be true for the present research. Many new species were found regenerating, which were absent as adults and with many exhibiting multiplier effect through coppicing, rhizomes and seedlings in their mode of regeneration status.

The quantitative structure of regeneration in the study area also reveals the biometric ecology of the study site. The study area was found to be dominated by the seedlings/ saplings of *Oldenlandia corymbosa, Sida linifolia, Oldenlandia herbacea, Sporobulus pyramidalis, Spermacoce verticillata, Panicum repens* and *Digitaria gayana.* However among the recorded species, the dominant species are not only important for biodiversity conservation but also of commercial importance in ethno-botany and ethno-medicine.

The greater abundance of lower vascular species among the families is an indication of a secondary vegetation structure heterogeneous in nature as a result of the regeneration process with new species that were absent as adult. However, there were still differences in the ranks of species frequency, diversity (richness and evenness), density and abundance. Khater *et al*. [54] compared levels of degradation and the resulting communities. They found that less degraded sites favoured woody shrubs and perennial herbs while more degraded site favored annual plants.

There was a tremendous change in the floristic composition of the study area with regard to difference in species time-lag adaptation associated with post quarry regeneration. This also confirms the observation that vegetation is an anthropogenic influenced habitat is linked to ever increasing synanthropisation [55]. This was attributed to a number of direct human activities resulting to total changes in plant species biodiversity cover and loss of habitat connectivity [56, 57].

The present study shows that the study area can be brought under complete forest by natural regeneration of forest establishment. Complete absence of seedlings and sapling indicates poor regeneration, while presence of population indicates successful regeneration [58]. The density, frequency, abundance, species diversity, RD, RF andRA considered as indices of success in reforestation [59] suggests that it is possible to re-establish a complete forest cover from the degraded quarry site by natural regeneration. Ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the regenerated species was contagious. According to Odum [60] contagious distribution is the commonest pattern in nature while random distribution is found in very uniform environments. Similarly is the report by several other workers such as [61, 62, 37]. From the research findings it is evident that the quartz dominated quarry site in Umuoke, Obowo over times has the potential in turning into diverse heterogeneous natural forest vegetation again.

CONCLUSION

The findings of present study provide a complete view of regeneration status in the study area, which is rich in regenerating species that could result in the establishment of a diverse natural forest if protected to conserve the seedlings or saplings of the regenerating species. The result shows that it is possible to bring the depleted area under complete forest cover through the protection of natural regeneration.

REFERENCES

[1] John, R. H. *Ecological Restoration of Quarry Site: A Systematic Review of Literature Draft.* Barnaby Letheren, School of the Environment and Natural Resources. Bangor University **2009**.
[2] Gotelli, N.J. *American Nature Publication.* **1991**. 138: 768-776.
[3] Tokeshi, M. *Research Ecology*, **1992**. 34: 249-273.
[4] Bossuyt, B; Honnay, O; Hermy, M. *Journal of Vegetation Science,* **2004**. 15:321-328.
[5] Wilcox, C.A.; Chun, Y.M.; Choi, Y.D. *American Midland Naturalist,* **2005**. 154: 11-27.
[6] Yuan, J.G.; Fang, W.; Fan, L.; Chen, Y.; Wang, D.Q.; Yang, Z.Y. *Restoration Ecology* **2006**.14, 349-356.
[7] Duan, W.J.; Ren, H.; Fu, S.L.; Wang, J.; Yang, L.; Zhang, J.P. *Journal of Environmental Science* **2008**. 20: 476-481.
[8] en.wikipedia.org/wiki/Ecoloogical_succession. Retrieval date: 1st Sep, **2011**)
[9] Lyngdoh, T.; Tripathi, R.S.; Das, A.K. *Acta Oecologica- International Journal of Ecology* **1992**. 13: 767-776.
[10] Novak, J.; Prach, K. *Applied Vegetation Science* **2003**. 6: 111-116.
[11] Khater, C. *Dynamiques végétales post perturbations sur les carriérs au Liban. Strategies pour L'ecologie de la restauration en regionsMéditerrenéennes.* Thése de doctorat. Académie de Montpellier, Université Montpellier 11. **2004**.
[12] Conventry, R.J. *Minerals Essential for Good Plant Growth Rock Minerals: Condition Soil and Re-mineralise a tool for efficient and cost Effective use of soils and fertilizers in the humid tropics.* **1992**. (http://www.minplus.com.au/prodpro/ Retrieved date: 6th Sep, 2011).
(http://www.jcu.edu.au/school/tropbiol/staff/conventry/Retrieved date: 6th Sep, 2011)
[13] Schmied, U.; Mucina, L. *Philocoenologia,* **2006**. 36(1): 1-44.
[14] Walker, L.R.; Del Moral, R. *Primary succession and ecosystem rehabilitation*. Cambridge University Press. London. **2003**.
[15] Ashton, P.S.; Hall, P. *Journal of Ecology* **1992**. 80: 459- 481.
[16] Cao, M.; Zhang, J.H.; Feng, Z.; Deng, J.; Deng, X. *Tropical Ecology* **1996**. 37(2): 183- 192.
[17] Gunatilleke, C.V.S.; Weerasekeras, N.; Gunatilake, I.A.U.N.; Kathriarachchi, H.S. The role of dipterocarps, their population structures and spatial distributions in the forest dynamics plot a Sinharaja, Sri Lanka. In: Ganeshaiah, K.N. Uma Shaanker, R. & Bawa, K.S. (eds.) *Tropical Ecosystems: Structure Diversity, and Human Welfare. Proceedings of the International Conference on Tropical Ecosystems.* pp. 591-594. New Delhi, Oxford and IBH Publishing, NewDelhi, **2001**.
[18] Uma, S. *Current Science* **2001**. 81: 776-786.
[19] WWW.obowo.gov.ng. Aug 13, 2011. Retrieval date: 13th Sep, **2011.**
[20] en.wikipedia.org/wiki/imo_state. Retrieval date: 13th Aug, **2011**.
[21] Hopkin, B. *Nigeria Journal of Ecology* **1968**. 56:97-115

[22] SAF, *Forest Cover Types of North America*. Washington D.C. Society of American Foresters **1954**.
[23] Edwin-Wosu, N. L. Eco-taxonomic Baseline Assessment of vegetation of Pirigbene –Obama – Agip oil field further development project in Southern Ijaw Local Government Area, Bayelsa State. Final Draft Report, NAOC / Sydney Gate-way (Nig) Limited. October, **2010**.
[24] Edwin-Wosu, N. L. Eco-taxonomic Post-impact Assessment of vegetation of GOI lake oil spillage (EIA SHEWING) – Vegetation survey claim of Goi Community against Shell Petroleum Development Company (SPDC) in Gokana Local Govt. Area **2011**.
[25] Edwin-Wosu, N. L. Environmental Evaluation Study of Vegetation of the Disused Imo River, Nkpoku, Obigbo North, Ebubu Pipeline (ROW) in Rivers State / and Abia State, February, 2012. MACPHED / SPDC. Wet Season Draft Report. **2012**.
[26] Edwin-Wosu, N. L. EIA Baseline Study of Vegetation / Wildlife for the OBIAFU / OBRIKOM- Indorama Eleme Fertilizer Company Limited (IEFCL) Gas Delivery Pipeline Project, August 2012. **2013**.
[27] Kinako, P.D.S. *Fundamental of Quantitative and Applied Plant Ecology.* Belk Publishers. Port Harcourt, **1988**.
[28] Hutchinson, J.; Dalziel, J.M. *Flora of West Tropical Africa*, Vol. 1. (Part1.) Crown Agents for Oversea Government and Administrations. Millbank London. **1954**.
[29] Hutchinson, J.; Dalziel, J.M. *Flora of West Tropical Africa*, Vol. 1. (Part2.) Crown Agents for Oversea Government and Administrations. Millbank London. **1958**.
[30] Hutchinson, J.; Dalziel, J.M. *Flora of West Tropical Africa*, Vol. 2. Crow Agents for Oversea Government and Administrations. Millbank London. **1963**.
[31] Hutchinson, J.; Dalziel, J.M. *Flora of West Tropical Africa*, Vol. 3. (Part1) Crown Agents for Oversea Government and Administrations. Millbank London. **1968**.
[32] Hutchinson, J.; Dalziel, J.M. *Flora of West Tropical Africa*, Vol.3. (Part2.) Crown Agents for Oversea Government and Administrations. Millbank London. **1972**.
[33] Joyce, L.; Stanfield, D.P. *The Flora of Nigeria Sedges (Cyperaceae).* Ibadan University Press. Ibadan Nigeria. **1974**.
[34] Joyce, L. *Flora of Nigeria Grasses*. Ibadan University Press. Ibadan Nigeria **1989**.
[35] Keay, R.W.J. *Trees of Nigeria*. Clarendon Press. **1989**.
[36] Austin, M.P.; Greg-smith, P. *Journal of Ecology* **1968**. 56:851-884.
[37] Kershaw, K.A. *Quantitative and Dynamic Plant Ecology*. pp. 308. Edward Arnold Ltd. London. **1973**.
[38] Shukla, S.R; Chandel, S.P. *Plant ecology*, 4th edn. pp.197. Chandel and Co. Ramnagar, New Delhi. **1980**.
[39] Bonham, C.D. *Frequency: Measurement of Terrestrial Vegetation*, pp 90-96. John Wiley and Sons Incorporated, New York. **1989**.
[40] Shannon, C.E.; Weiner, W. *The mathematical theory of communications*. University of Illinois Press. Urbana, Illinois. **1949**.
[41] Pryor, L.D. *Australian endangered species. Eucalyptus.* 139 pp. Australian National Parks and Wildlife Service's Special Publication Australia Canberra. **1981**.
[42] Misra, R. *Ecology Workbook*. Pp.244. Oxford and IBH Publishing Co. Ltd. New Delhi. **1968**.
[43] Curtis, J.T.; Cottam, G. *Plant Ecology Work Book: Laboratory field reference manual*. 193 pp Burgess Publishing Company, Minnesota. **1956**.
[44] Whisenant, G.S.; Thurow, T.L.; Maranz, S.J. *Restoration Ecology* **1995**. 2(1): 61-67.
[45] Bradshaw, A.D. *Understanding the fundamentals of succession. Primary succession.* Blackwell, Scientific Publications, London. **1993**.
[46] Bradshaw, A.D. *Ecological Engineering* **1997**.8: 255-269.
[47] Mohammed, A.; Al-Amin, M. *Proceeding Pakistan Academy Science* **2007**. 44(3): 165-172.
[48] Khumbongmayun, A.D.; Khan, M.L.; Tripathi, R.J. *Biodiversity and Conservation* **2005**.14: 1541-1582.
[49] Cubizolle, H.; Tourman, A.; Argant, J.; Porteret, J.; Oberlin, C.; Serieyssol, K. *Landscape Ecology* **2003**.7:211-227.
[50] Srinivas, C. *Plant Biomass, Net Primary Productivity and Nutrient Cycling in Oak (Quercus serrata Thumb). Forests of Manipur*. Ph. D. thesis Manipur University, Manipur, India. **1992**.
[51] Singh, A.; Jha, A. K.; Singh, J. S. *Journal of Vegetation Science* **1997**. 8: 537- 540.
[52] Carla, K.; Martin, A. *Application of Restoration Ecology Principle to the Practice of Limestone Quarry Rehabilitation in Lebanon*. **2007**.
[53] Duchok, R., Kent, K., Khumbongmayun, A.D., Paul, A., Khan, M.L. *Current Science* **2005**. 89 (4): 673-676
[54] Khater, C., Martin, A., Maillet, J. *Applied Vegetation Science* **2003**. 6: 199-204.
[55] Ahmed, S.S., Ahmed, T., Akbar, K.F. *Journal of Applied Science* **2004**. 4 (2): 266-270.
[56] Luoto, M., Rekolianen, S., Aakkula, J., Pykala, J. *Anibio* **2003**. 32(7): 447-452.
[57] Paciencia, M.L.B., Prodo, J. *Plant Ecology* **2005**. 18(1): 87-104.
[58] Saxena, A.K., Singh, J.S. *Journal of Environmental Management.* **1984**. 19:307- 324.
[59] Rajivar, G.S., Dhaulakhandi, M., Kumar, P. *Indian Forester*, **1999**. 125: 623- 630.
[60] Odum, E.P. *Fundamentals of Ecology*. Saunders Co. Philadelphia, USA. **1971**.

[61] Verma,R.K. Shadangi, D.K., Totey, N.G. *The Malaysian Forester* **1999**. 62: 95-106.
[62] Greig -Smith, P. *Quantitative Plant Ecology*. London, Butter Worth **1957**.