Faculty of Natural and Applied Sciences Journal of Basic and Environmental Research
Print ISSN: 3026-8184 e-ISSN 3043-6338
www.fnasjournals.com
Volume 2; Issue 1; September 2024; Page No. 54-71.

The Impact of Quarrying Activities on Economic Tree Composition and Diversity: A Study of Selected Quarries in the Federal Capital Territory, Abuja

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Abstract
The paper presents a case study of (two) selected quarries in the FCT, Abuja, Nigeria. The study investigates the impact of quarrying activities on economic trees by analysing the composition, abundance and diversity of different tree species in these two functional quarries. Data was obtained from field surveys and interviews within study areas and quarry operators. The Simpson diversity index was used to measure the diversity index of the economic trees found and identified in the study areas. The study's findings revealed that economic tree composition, abundance and diversity were reduced due to quarrying activities. Quarrying activities also release dust and pollutants into the air, creating an unhealthy and unsuitable environment for the growth of trees. The results of this study have implications for policymakers and quarry operators in Abuja about encouraging and enhancing economic tree diversity within their operations. This case study highlights the importance of sustainable land management and the need to consider economic tree diversity when developing quarrying projects in areas with the predominant growth and cultivation of economic trees, especially edible ones.

Keywords: Quarrying activities, Selected quarries, Economic trees, Diversity, Federal Capital Territory (FCT)

Introduction
Rock quarrying and stone crushing are a global phenomenon and have been the cause of concern everywhere, including in advanced countries (Okafor, 2006). Quarrying activity is a necessity that provides much of the materials used in traditional hard flooring, such as granite, limestone, marble, sandstone, slate and even just clay to make ceramic tiles. However, like many other man-made activities, quarrying activities have a significant impact on the environment (Okafor, 2006). In particular, it is often necessary to blast rocks with explosives to extract material for processing but this method of extraction gives rise to noise pollution, air pollution, damage to biodiversity and habitat destruction (Okafor, 2006). Dust from quarry sites is a major source of air pollution. For example, limestone quarries produce highly alkaline (and reactive) dust, whereas coal mines produce acidic dust (Lameed & Ayodele, 2010). Air pollution is not only a nuisance (in terms of deposition on surfaces) and possible effects on health, in particular for those with respiratory problems, but dust can also have physical effects on the surrounding plants, such as blocking and damaging their internal structures and abrasion of leaves and cuticles, as well as chemical effects which may affect long-term survival (Guach, 2001; Lameed & Ayodele, 2010).

Vegetation which refers to the plant cover of the earth, displays patterns that reflect a wide variety of environmental characteristics as well as temporal aspects operating on it (Kumi-Boateng et al., 2012). This is because it supports critical functions in the biosphere by regulating the flow of numerous biogeochemical cycles like that of water, carbon, and nitrogen; it is also of great importance in local and global energy balance (Kumi-Boateng et al., 2012). Removal of vegetation cover strongly affects soil characteristics, including soil fertility, chemistry and texture (Lameed & Ayodele, 2010). Although vegetation is of high environmental and biological importance, it is often under intense human pressure in mining areas especially where surface mining and illegal small-scale mining activities are prevalent, resulting in changes in land-use/land cover of mine areas (Adewoye, 2005; David & Mark, 2005). Directly or indirectly, mining has been seen to be a major factor responsible for vegetation loss in mining areas the world over (David & Mark, 2005). Directly, it is caused by vegetation clearance for various mining activities and indirectly, by dust pollution as the volume of dust is discharged into the air during the process of quarrying (Adewoye, 2005). This eventually gets deposited on the leaves of plants and flowers as well as the soil supporting the plants (David & Mark, 2005). The overall effect of this is that the photosynthetic and fruiting ability of the plants is impaired (David & Mark, 2005). When calcium, sulphur-dioxide among other chemical constituents enters the plants through the stomata pores it leads to the destruction of chlorophyll and disruption of photosynthesis in plants subsequently leading to stunted growth or death (Ujoh & Alhassan, 2014; Unanaonwi & Amonum, 2017).

Economic trees which are part of vegetation are major components of the ecosystem where there is a complex interaction between the biotic and abiotic entities of the environment (Osha, 2006). The quarry industry, unfortunately, discharges dust that settles on land, plants, and trees including economic trees, and also on surface waters used for drinking and other domestic chores by the community (Osha, 2006). Green plants including economic trees especially, by their photosynthetic activities occupy an important position in the existence of life because of their ability to maintain a balance in the volume of Oxygen and Carbon dioxide which leads to the purification of the environment (Lameed & Ayodele, 2010). They supply man with food, drugs, fibres, fuel, building and other raw materials and serve as ornamentals. Air pollution generally and especially dust from quarry sites is known to be responsible for vegetation injury and crop yield loss and thus becomes a threat to the survival of plants in industrial areas (Iqbal & Shafig, 2001). Such dusts reduce plant cover, height and number of leaves. Apart from the dust emitted, toxic compounds such as fluoride, Magnesium, Lead, Zinc, Copper, Beryllium, Sulphuric acid and Hydrochloric acid are injurious to the vegetation (Iqbal and Shafig, 2001). Several studies (Anand, 2006; Aigbedion & Iyayi, 2007; Adekoya, 2003) have shown the negative impact associated with the environmental effects of quarrying activities. The damage caused to plants by air pollution includes necrosis (dead areas on leaf structure) chlorosis (loss or reduction of chlorophyll leading to yellowing of leaf), epinasty (downward curvature of the leaf due to higher rate of growth on the upper surface), and abscission of leaves (premature fall) (Anand, 2006).

Quarrying is a sensitive and complex issue. On the one hand, quarries supply raw materials to meet many of society's needs, create employment and contribute to the local economy, but on the other hand, they can have a significant negative impact on the environment and local communities (Odunnaike et al., 2008) including economic trees. Therefore, this research paper aims to determine the impact of quarrying activities on the composition, abundance and diversity of economic trees in some selected quarries in the Federal Capital Territory (FCT). The specific objectives are to: Enumerate the economic trees in the study area and to determine the diversity indices of all the economic trees between the quarry and the non-quarry sites.

Materials and Methods

The study was carried out in two selected quarry sites: CCECC quarry located at the Idu industrial area of AMAC designated as Quarry Site A, and Zeberced quarry located along the Kubwa/Bwari area of the FCT designated as Quarry Site B.

Site Selection

Two quarry sites and two non-quarry sites were selected for the research study and these sites were designated Quarry Site A, Non-quarry Site A, and Quarry Site B and Non-quarry Site B. Plots were demarcated at intervals of 100 metres distances apart.

Table 1: GPS of sampling points

Sampling locations	latitude	Longitude
1. CCECC quarry	$9^{o.}$ 0048’	7^{o} .4109’
2. Zeberced quarry	$9^{o.}$ 1631’	7^{o} ·3093’

Sampling Techniques

Economic trees within the different quarry sites at intervals of a hundred (0-100) metres away from the quarry were identified and enumerated to determine the composition of the economic trees. Economic trees were also identified at the control site at about five kilometres away from the quarry.

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Quadrats of size 100m × 100m were laid in the study areas along a transect of 400m in each of the selected quarry sites (Okpara et al., 2017). Economic trees were identified and enumerated, and their diversity index was calculated.

2.3. Measurement of Diversity Index

Simpson's Index of Diversity was employed to measure the diversity index of the economic trees. The Simpson's Index of diversity which has the form Si = 1 – D where D = Σ (n1/N) 2, N1 = some specified importance value for species and N = importance value for all species)

Its scale ranges from 0 to 1, with values close to 1 showing a community of many species but low abundance, while values close to 0 express fewer species with one of them obviously dominant or abundant. The D is an index or dominance or homogeneity.

The index is stated as:

Si = 1 – D

Where D = Σ(n1/N)2

N1 = some specified important value for a species (No. of bions of a species)

N = important value for all the species (No. of bions of all the Species).

Results

3.1. Economic Tree Species Composition

Table 1: Economic Tree (Species) Composition and Abundance at the Selected Sites

S/N	FAMILY	FREQUENCY (Number of Occurrences)	NAME OF SPECIES	NUMBER OF SPECIES
1	*ANACARDIACEAE*	3	*Mangifera indica*	5
2			*Anacardium occidentales*	6
3			*Spondias mombin*	2
4	*ANNONACEAE*	1	*Uvaria chamae*	2
5	*APOCYNACEAE*	1	*Calotropis procera*	1
6	*ARECACEAE*	3	*Raphia palm*	4
7			*Phoenix dactylifera*	3
8			*Cocos nucifera*	3
9	*BIGNONIACEAE*	1	*Spathodea campanulata*	2
10	*CANNABACEAE*	1	*Trema orientalis*	2
11	*CARICACEAE*	1	*Carica papaya*	5
12	*CHRYSOBALANACEAE*	1	*Parinari curatenifolia*	3
13	*COMBRETACEAE*	2	*Terminalia catappa*	1
14			*Terminalia mantaly*	1
15			*Combretum molle*	2
16	*EUPHORBIACEAE*	2	*Alchornea cordifolia*	2
17			*Ricinodendron heudelotii*	3
18	*FABACEAE*	12	*Dailium guineense*	2
19			*Detarium microcarpum*	1
20			*Pakia biglobosa*	3
21			*Prosopis africana*	2
22			*Tamarindus indica*	3
23			*Vachellia nilotica*	1
24			*Delonix regia*	2
25			*Daniella oliveri*	3
26			*Erythrina senegalensis*	2
27			*Gardenia erubescens*	1
28			*Nuclea latifolia*	3
29			*Nauclea diderrichii*	3
30			*Lonchocarpus laxiflora*	2

31			*Berlina grandiflora*	1
32			*Vachellia sieberiana*	1
33			*Afzelia Africana*	2
34			*Acacia seyal*	3
35	*HYPERICACEAE*	1	*Harungana madagasceis*	1
36	*LAMIACEAE*	3	*Gmelina arborea*	3
37			*Tectonia grandis*	2
38			*Vitex doniana*	2
39	*LOGANIACEAE*	1	*Strychnos spinose*	3
40	*MALVACEAE*	2	*Adansonia digitata*	2
41			*Sterculia setigera*	3
42	*MELIACEAE*	2	*Azadirachta indica*	5
43			*Khaya senegalensis*	1
44	*MOARACEAE*	1	*Ficus platyphylla*	1
45		1	*Treculia Africana*	2
46	*MORINGACEAE*	1	*Moringa oleifera*	3
47	*MYRTACEAE*	1	*Eucalyptus camaldulensis*	2
48		1	*Psidium guajava*	4
49	*PALMAE*	1	*Elaeis guineensis*	5
50	*PHYLLANTHACEAE*	1	*Phyllantus muellerinus*	2
51	*RUBIACEAE*	1	*Morinda lucida*	3
52	*RUTACEAE*	1	*Citrus sinensis*	4
53	*SAPINDACEAE*	1	*Blighia sapida*	3
54	*SAPOTACEAE*	1	*Vitellaria paradoxa*	4
55	*STERCULIACEAE*	1	*Cola gigantea*	2
56	*ZYGOPHYLLACEAE*	1	*Balanite aegyptiaca*	1

The result from Table 1 shows the total number of economic tree species identified at the quarry and non-quarry sites. Fifty-six (56) economic tree species were identified and enumerated, and these consist of twenty-seven (27) tree plant families.

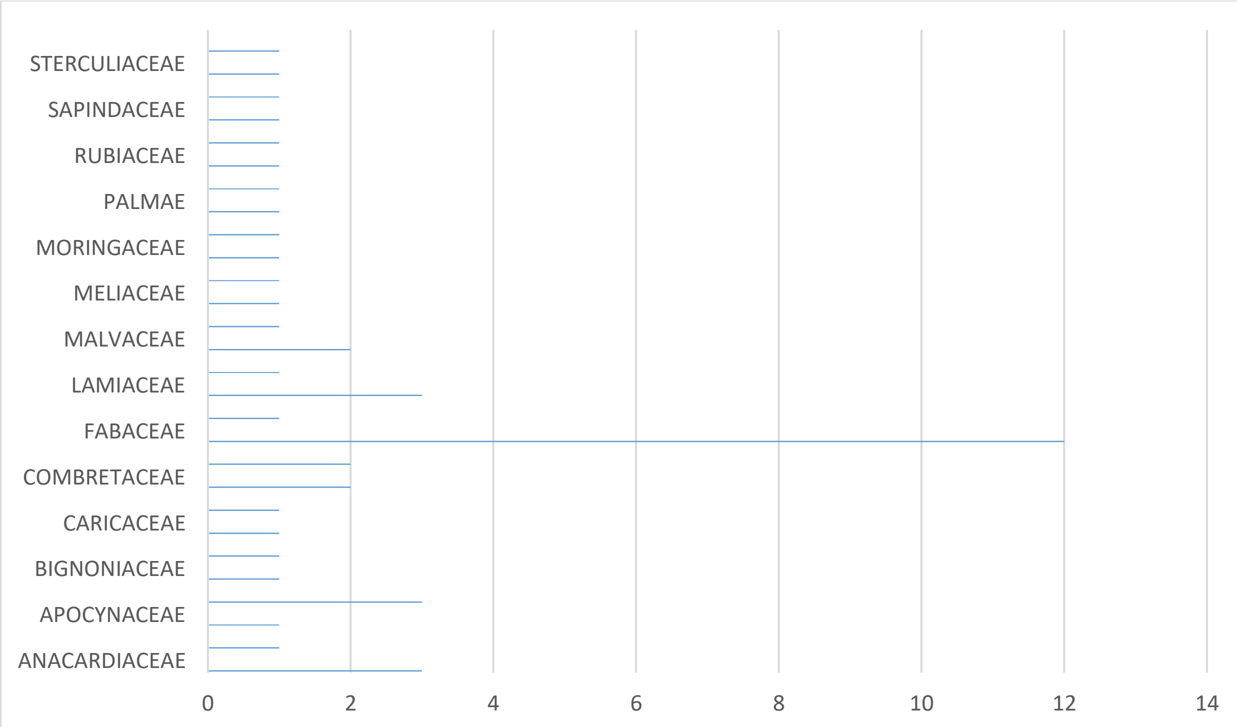

Figure 1: Family Profile Composition of Economic Tree Species identified in the Selected Quarries

Figure 1 illustrates the family composition of the economic trees identified and enumerated at the selected quarries.

3.2 Distribution of Identified Economic Trees at the Selected Sites According to Plots

QUARRY SITE A

Table 2 (PLOT 1): Economic Tree (Species) Composition and Abundance

S/N	FAMILY	FREQUENCY (F)	ECONOMIC TREE SPECIES	NO OF BIONS
1	*ANACARDIACEAE*	3	*Mangifera indica*	3
2			*Anacardium occidentales*	2
3			*Spondias mombin*	2
4	*ANNONACEAE*	1	*Uvaria chamae*	3
5	*APOCYNACEAE*	1	*Calotropis procera*	1
6	*ARECACEAE*	1	*Raphia palm*	4

The result from Table 2 shows the composition of economic tree species in the demarcated area tagged plot 1 within 0 m to 100 m distance away from the main quarry. Plant Four (4) families of economic tree species and six (6) individual economic tree species were identified with Raphia palm having the highest number of four (4).

Table 3 (PLOT 2): Economic Tree (Species) Composition and Abundance

1	*ARECACEAE*	2	*Phoenix dactylifera*	3
2			*Cocos nucifera*	3
3	*BIGNONIACEAE*	1	*Spathodea campanulata*	2
4	*CANNABACEAE*	1	*Trema orientalis*	2

The result from Table 3 shows the composition of economic tree species in the demarcated plot 2 at intervals between 100 m to 200 m distance away from the main quarry. Three (3) families of economic tree species and four (4)

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individual economic tree species were identified with *Phoenix dactylifera* and *Cocos nucifera* recording the highest numbers of three (3).

Table 4 (PLOT 3): Economic Tree (Species) Composition and Abundance

1	*CARICACEAE*	1	*Carica papaya*	3
2	*CHRYSOBALANACEAE*	1	*Parinari curatenifolia*	3
3	*COMBRETACEAE*	2	*Terminalia catappa*	1
4			*Terminalia mantaly*	1
5			*Combretum molle*	2
6	*EUPHORBIACEAE*	1	*Alchornea cordifolia*	2

The result from Table 4 shows the composition of economic tree species in the demarcated plot 3 at intervals of 200 m to 300 m distance away from the main quarry plant. Four (4) families of economic tree species and six (6) individual economic tree species were identified with *Carica papaya* and *Parinari curatenifolia* recording the highest numbers of three (3).

Table 5 (PLOT 4): Economic Tree (Species) Composition and Abundance

1	*EUPHORBIACEAE*	1	*Ricinodendron heudelotii*	3
2	*FABACEAE*	4	*Dailium guineense*	2
3			*Detarium microcarpum*	1
4			*Pakia biglobosa*	3
5			*Prosopis Africana*	2

Table 5 shows the composition of economic tree species in the demarcated plot 4 at intervals of 300 m to 400 m distance away from the main quarry. Two (2) families of economic tree species and five (5) individual economic tree species were identified with *Ricinodendron heudelotii* and *Pakia biglobosa* recording the highest numbers of three (3).

NON-QUARRY SITE A

Table 6 (PLOT 1): Economic Tree (Species) Composition and Abundance

1	*ANACARDIACEAE*	3	*Mangifera indica*	5
2			*Anacardium occidentales*	6
3			*Spondias mombin*	2
4	*ANNONACEAE*	1	*Uvaria chamae*	2
5	*APOCYNACEAE*	1	*Calotropis procera*	2
6	*ARECACEAE*	1	*Raphia palm*	4
7			*Phoenix dactylifera*	3
8			*Cocos nucifera*	3
9	*BIGNONIACEAE*	1	*Spathodea campanulata*	2
10	*CANNABACEAE*	1	*Trema orientalis*	2
11	*CARICACEAE*	1	*Carica papaya*	5
12	*CHRYSOBALANACEAE*	1	*Parinari curatenifolia*	3
13	*COMBRETACEAE*	2	*Terminalia catappa*	1
14			*Terminalia mantaly*	1

The result from Table 6 shows nine (9) families of economic tree species, and fourteen (14) individual economic tree species were identified with *Anacardium occidentales* recording the highest number of six (6).

Table 7 (PLOT 2): Economic Tree (Species) Composition and Abundance

1	*COMBRETACEAE*	1	*Combretum molle*	2
2	*EUPHORBIACEAE*	2	*Alchornea cordifolia*	2
3			*Ricinodendron heudelotii*	3
4	*FABACEAE*	8	*Dailium guineense*	2
5			*Detarium microcarpum*	1
6			*Pakia biglobosa*	3
7			*Prosopis Africana*	2
8			*Tamarindus indica*	3
9			*Vachellia nilotica*	1
10			*Delonix regia*	2
11			*Daniella oliveri*	3

The result from Table 7 shows the composition of economic tree species in the demarcated plot 2 of the non-quarry site at intervals between 100m and 200 m distance. Three (3) families of economic tree species and eleven (11) individual economic tree species were identified with *Ricinodendron heudelotii, Pakia biglobosa, Tamarindus indica and Daniella oliveri* recording the highest number of three (3).

Table 8 (PLOT 3): Economic Tree (Species) Composition and Abundance

1	*FABACEAE*	9	*Erythrina senegalensis*	2
2			*Gardenia erubescens*	4
3			*Nuclea latifolia*	3
4			*Nauclea diderrichii*	3
5			*Lonchocarpus laxiflora*	2
6			*Berlina grandiflora*	2
7			*Vachellia sieberiana*	3
8			*Afzelia Africana*	2
9			*Acacia seyal*	3
10	*HYPERICACEAE*	1	*Harungana madagasceis*	2
11	*LAMIACEAE*	3	*Gmelina arborea*	4
12			*Tectonia grandis*	2
13			*Vitex doniana*	4

The result Table 8 also shows the composition of economic tree species in the demarcated plot 3 of the non-quarry site at intervals between 200m and 300 m distance. Three (3) families of economic tree species and thirteen (13) individual economic tree species were identified with *Gardenia erubescencs, Gmelina arborea* and *Vitex doniana* recording the highest number of four (4)

Table 9 (PLOT 4): Economic Tree (Species) Composition and Abundance

1	*LOGANIACEAE*	1	*Strychnos spinose*	3
2	*MALVACEAE*	2	*Adansonia digitata*	2
3			*Sterculia setigera*	3
4	*MELIACEAE*	1	*Azadirachta indica*	5
5	*MELIACEAE*	1	*Khaya senegalensis*	1
6	*MOARACEAE*	1	*Ficus platyphylla*	1
7		1	*Treculia Africana*	2
8	*MORINGACEAE*	1	*Moringa oleifera*	3
9	*MYRTACEAE*	2	*Eucalyptus camaldulensis*	2
10			*Psidium guajava*	4

The result from Table 9 shows the composition of economic tree species in the demarcated plot 4 of the non-quarry site at intervals between 100m and 200 m distance. Seven (7) families of economic tree species and ten (10) individual economic tree species were identified with *Azadirachta indica* recording the highest number of five (5).

QUARRY SITE B

Table 10 (PLOT 1): Economic Tree (Species) Composition and Abundance

S/N	FAMILY	F	SPECIES	NO OF BIONS
1	*RUBIACEAE*	1	*Morinda lucida*	2
2	*RUTACEAE*	1	*Citrus sinensis*	3
3	*SAPINDACEAE*	1	*Blighia sapida*	2
4	*SAPOTACEAE*	1	*Vitellaria paradoxa*	3
5	*STERCULIACEAE*	1	*Cola gigantea*	1
6	*ZYGOPHYLLACEAE*	1	*Balanite aegyptiaca*	1

The result from Table 10 shows six (6) families of economic tree species, and six (6) individual economic tree species were identified with *Citrus sinensis* and *Vitellaria paradoxa* having the highest number of three (3).

Table 11 (PLOT 2): Economic Tree (Species) Composition and Abundance

1	*MOARACEAE*	1	*Ficus platyphylla*	1
2		1	*Treculia Africana*	2
3	*MORINGACEAE*	1	*Moringa oleifera*	2
4	*MYRTACEAE*	1	*Eucalyptus camaldulensis*	2
5		1	*Psidium guajava*	3
6	*PALMAE*	1	*Elaeis guineensis*	4
7	*PHYLLANTHACEAE*	1	*Phyllantus muellerinus*	2

The result from Table 11 shows five (5) families of economic tree species, and seven (7) individual economic tree species were identified, with *Elaeis guineensis* recording the highest number of four (4).

Table 12 (PLOT 3): Economic Tree (Species) Composition and Abundance

1	*LOGANIACEAE*	1	*Strychnos spinose*	2
2	*MALVACEAE*	2	*Adansonia digitata*	1
3			*Sterculia setigera*	2
4	*MELIACEAE*	1	*Azadirachta indica*	3
5	*MELIACEAE*	1	*Khaya senegalensis*	1

The result from Table 12 shows four (4) families of economic tree species, and five (5) individual economic tree species were identified with *Azadirachta indica* recording the highest numbers of three (3).

Table 13 (PLOT 4): Economic Tree (Species) Composition and Abundance

1	*HYPERICACEAE*	1	*Harungana madagasceis*	1
2	*LAMIACEAE*	3	*Gmelina arborea*	3
3			*Tectonia grandis*	2
4			*Vitex doniana*	2
5	*FABACEAE*	4	*Dailium guineense*	2
6			*Detarium microcarpum*	1
7			*Pakia biglobosa*	3
8			*Prosopis africana*	1

The result from Table 13 shows three (3) families of economic tree species, and eight (8) individual economic tree species were identified, with *Gmelina arborea* recording the highest number of three (3).

NON-QUARRY SITE B

Table 14 (PLOT 1): Economic Tree (Species) Composition and Abundance

1	*MELIACEAE*	2	*Azadirachta indica*	5
2			*Khaya senegalensis*	1
3	*MOARACEAE*	2	*Ficus platyphylla*	1
4			*Treculia Africana*	2
5	*MORINGACEAE*	1	*Moringa oleifera*	3
6	*MYRTACEAE*	2	*Eucalyptus camaldulensis*	2
7			*Psidium guajava*	4
8	*PALMAE*	1	*Elaeis guineensis*	5
9	*PHYLLANTHACEAE*	1	*Phyllantus muellerinus*	2
10	*RUBIACEAE*	1	*Morinda lucida*	3
11	*RUTACEAE*	1	*Citrus sinensis*	4
12	*SAPINDACEAE*	1	*Blighia sapida*	3
13	*SAPOTACEAE*	1	*Vitellaria paradoxa*	4
14	*STERCULIACEAE*	1	*Cola gigantea*	2
15	*ZYGOPHYLLACEAE*	1	*Balanite aegyptiaca*	1

The result from Table 14 shows thirteen (13) families of economic tree species, and fifteen (15) individual economic tree species were identified, with *Azadirachta indica and Elaeis guineensis* recording the highest number of five (5) each.

Table 15 (PLOT 2): Economic Tree (Species) Composition and Abundance

1	*FABACEAE*	4	*Berlina grandiflora*	2
2			*Vachellia sieberiana*	3
3			*Afzelia Africana*	2
4			*Acacia seyal*	3
5	*HYPERICACEAE*	1	*Harungana madagasceis*	1
6	*LAMIACEAE*	3	*Gmelina arborea*	5
7			*Tectonia grandis*	3
8			*Vitex doniana*	3
9	*LOGANIACEAE*	1	*Strychnos spinose*	3
10	*MALVACEAE*	2	*Adansonia digitata*	2
11			*Sterculia setigera*	3

The result from Table 15 shows three (3) families of economic tree species, and eleven (11) individual economic tree species were identified with *Gmelina arborea* recording the highest number of five (5).

Table 16 (PLOT 3): Economic Tree (Species) Composition and Abundance

1	*EUPHORBIACEAE*	2	*Alchornea cordifolia*	3
2			*Ricinodendron heudelotii*	3
3	*FABACEAE*	12	*Dailium guineense*	4
4			*Detarium microcarpum*	1
5			*Pakia biglobosa*	4
6			*Prosopis africana*	2
7			*Tamarindus indica*	3
8			*Vachellia nilotica*	2
9			*Delonix regia*	3
10			*Daniella oliveri*	4
11			*Erythrina senegalensis*	2
12			*Gardenia erubescens*	2
13			*Nuclea latifolia*	4
14			*Nauclea diderrichii*	3
15			*Lonchocarpus laxiflora*	2

The result from Table 16 also shows two (2) families of economic tree species, and fifteen (15) individual economic tree species were identified, with *Dailium guineense, Parkia biglobosa, Daniella oliveri and Nuclea latifolia* recording the highest number of four (4) each.

Table 17 (PLOT 4): Economic Tree (Species) Composition and Abundance

1	*ANACARDIACEAE*	3	*Mangifera indica*	7
2			*Anacardium occidentales*	5
3			*Spondias mombin*	3
4	*ANNONACEAE*	1	*Uvaria chamae*	1
5	*APOCYNACEAE*	1	*Calotropis procera*	2
6	*ARECACEAE*	1	*Raphia palm*	5
7			*Phoenix dactylifera*	4
8			*Cocos nucifera*	4
9	*BIGNONIACEAE*	1	*Spathodea campanulata*	2
10	*CANNABACEAE*	1	*Trema orientalis*	2
11	*CARICACEAE*	1	*Carica papaya*	5
12	*CHRYSOBALANACEAE*	1	*Parinari curatenifolia*	3
13	*COMBRETACEAE*	2	*Terminalia catappa*	2
14			*Terminalia mantaly*	2
15			*Combretum molle*	3
16	*MYRTACEAE*	1	*Psidium guajava*	2
17	*RUTACEAE*	1	*Citrus sinensis*	4

The result from Table 17 shows eleven (11) families of economic tree species, and seventeen (17) individual economic tree species were identified, with *Mangifera indica* recording the highest number of seven (7).

3.3. SIMPSON DIVERSITY INDEX

Table 18: **Summary of Simpson Diversity Index between the Quarry and Non-Quarry Sites**

PLOT	QUARRY SITE A	NON-QUARRY SITE A	QUARRY SITE B	NON-QUARRY SITE B
1	0.87	0.93	0.88	0.94
2	0.82	0.94	0.89	0.93
3	0.88	0.94	0.86	0.95
4	0.85	0.91	0.91	0.95

Field Study 2022

The result from Table 18 shows that Plot 1 has a diversity index value of 0.87, 0.82 for Plot 2, 0.88 for Plot 3 and 0.85 for Plot 4, and these translate to 87 percent, 82 percent, 88 percent and 85 percent respectively with a mean value of 83 percent. For the non-quarry site A, the Simpson diversity index values recorded were 0.93 for Plot 1, 0.94 for Plot 2, 0.94 for Plot 3 and 0.91 for Plot 4, which translates to an economic tree species diversity of 93 percent for Plot 1, 94 percent for Plot 2, 94 percent for Plot 3 and 91 percent for Plot 4 with a mean value of 93 percent. Table 18 equally shows that for Quarry site B, the Simpson diversity index values were 0.88, 0.89, 0.86, and 0.91 for the respective four Plots, and these translates to economic tree species diversity of 88 percent, 89 percent, 86 percent, and 91 percent respectively with a mean value of 88.5. For the non-quarry site B, the Simpson diversity index values were 0.93, 0.94, 0.95, and 0.95 for the four Plots respectively, and these translates to species diversity of 93 percent, 94 percent, 95 percent, and 95 percent for Plots 1, 2, 3, and 4 respectively with a mean value of 94.3.

Figure 2: Simpson diversity index between the quarry and non-quarry sites

Figure 2 illustrates the Simpson diversity index of the economic tree species

Cite this article as:
Adams, A.E., Ndana, R.W., & Ogunlade-Anibasa, G.O. (2024). The impact of quarrying activities on economic tree composition and diversity: A study of selected quarries in the Federal Capital Territory, Abuja. *FNAS Journal of Basic and Environmental Research*,*2*(1), 54-71.

3.4. Individual Economic Tree Species Diversity

QUARRY SITE A

Table 19 (PLOT 1) Individual Economic Tree Species Diversity

FAMILY	F	*SPECIES*	NO OF BIONS	n1/N	∑(n1/N)2 ═ D
ANACARDIACEAE	3	*Mangifera indica*	3	0.20	0.04
		Anacardium occidentales	2	0.13	0.02
		Spondias mombin	2	0.13	0.02
ANNONACEAE	1	*Uvaria chamae*	3	0.20	0.04
APOCYNACEAE	1	*Calotropis procera*	1	0.07	0.01
ARECACEAE	1	*Raphia palm*	4	0.27	0.07
TOTAL			**15**	**1.00**	**0.20**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.80**	

Table 20 (PLOT 2) Individual Economic Tree Species Diversity

ARECACEAE	2	*Phoenix dactylifera*	3	0.30	0.09
		Cocos nucifera	3	0.30	0.09
BIGNONIACEAE	1	*Spathodea campanulata*	2	0.20	0.04
CANNABACEAE	1	*Trema orientalis*	2	0.20	0.04
TOTAL			**10**	**1.00**	**0.26**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.74**	

Table 21 (PLOT 3) Individual Economic Tree Species Diversity

CARICACEAE	1	*Carica papaya*	3	0.25	0.06
CHRYSOBALANACEAE	1	*Parinari curatenifolia*	3	0.25	0.06
COMBRETACEAE	2	*Terminalia catappa*	1	0.08	0.01
		Terminalia mantaly	1	0.08	0.01
		Combretum molle	2	0.17	0.03
EUPHORBIACEAE	1	*Alchornea cordifolia*	2	0.17	0.03
TOTAL			**12**	**1.00**	**0.20**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.80**	

Table 22 PLOT 4 Individual Economic Tree Species Diversity

EUPHORBIACEAE	1	*Ricinodendron heudelotii*	3	0.27	0.07
FABACEAE	4	*Dailium guineense*	2	0.18	0.03
		Detarium microcarpum	1	0.09	0.01
		Pakia biglobosa	3	0.27	0.07
		Prosopis africana	2	0.18	0.03
		TOTAL	**11**	**1.00**	**0.21**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.79**	

The results from Tables 19-22 (Quarry site A) shows the Simpson diversity index for the individual economic tree diversity. *Phoenix dactylefera* and *Cocos nucifera* have the highest value of diversity of 0.09 which shows that they are the most diverse economic tree species in the quarry site. *Calotropis procera*, *Terminalia catappa*, *Terminalia mantaly* and *Detarium microcarpum* has the least diverse value of 0.01 which shows that they are the least diverse economic trees in the quarry site.

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Non-Quarry site A

Table 23 (PLOT 1) Individual Economic Tree Species Diversity

ANACARDIACEAE	3	*Mangifera indica*	5	0.12	0.01
		Anacardium occidentales	6	0.15	0.02
		Spondias mombin	2	0.05	0.03
ANNONACEAE	1	*Uvaria chamae*	2	0.05	0.03
APOCYNACEAE	1	*Calotropis procera*	2	0.05	0.03
ARECACEAE	1	*Raphia palm*	4	0.10	0.01
		Phoenix dactylifera	3	0.07	0.01.
		Cocos nucifera	3	0.07	0.01
BIGNONIACEAE	1	*Spathodea campanulata*	2	0.05	0.01
CANNABACEAE	1	*Trema orientalis*	2	0.05	0.01
CARICACEAE	1	*Carica papaya*	5	0.12	0.01
CHRYSOBALANACEAE	1	*Parinari curatenifolia*	3	0.07	0.01
COMBRETACEAE	2	*Terminalia catappa*	1	0.02	0.0004
		Terminalia mantaly	1	0.02	0.0004
TOTAL			**41**	**1.00**	**0.19**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.81**	

Table 24 (PLOT 2) Individual Economic Tree Species Diversity

COMBRETACEAE	1	*Combretum molle*	2	0.08	0.01
EUPHORBIACEAE	2	*Alchornea cordifolia*	2	0.08	0.01
		Ricinodendron heudelotii	3	0.13	0.26
FABACEAE	8	*Dailium guineense*	2	0.08	0.01
		Detarium microcarpum	1	0.04	0.08
		Pakia biglobosa	3	0.13	0.02
		Prosopis africana	2	0.08	0.01
		Tamarindus indica	3	0.13	0.02
		Vachellia nilotica	1	0.04	0.08
		Delonix regia	2	0.08	0.01
		Daniella oliveri	3	0.13	0.02
TOTAL			**24**	**1**	**0.53**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.47**	

Table 25 (PLOT 3) Individual Economic Tree Species Diversity

FABACEAE	9	*Erythrina senegalensis*	2	0.06	0.004
		Gardenia erubescens	4	0.11	0.01
		Nuclea latifolia	3	0.08	0.01
		Nauclea diderrichii	3	0.08	0.01
		Lonchocarpus laxiflora	2	0.06	0.004
		Berlina grandiflora	2	0.06	0.004
		Vachellia sieberiana	3	0.08	0.01
		Afzelia Africana	2	0.06	0.004
		Acacia seyal	3	0.08	0.01
HYPERICACEAE	1	*Harungana madagasceis*	2	0.06	0.004
LAMIACEAE	3	*Gmelina arborea*	4	0.11	0.01
		Tectonia grandis	2	0.06	0.004
		Vitex doniana	4	0.11	0.01
TOTAL			**36**	**1**	**0.09**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.91**	

Table 26 (PLOT 4) Individual Economic Tree Species Diversity

LOGANIACEAE	1	*Strychnos spinose*	3	0.12	0.01
MALVACEAE	2	*Adansonia digitata*	2	0.08	0.01
		Sterculia setigera	3	0.12	0.01
MELIACEAE	1	*Azadirachta indica*	5	0.19	0.04
MELIACEAE	1	*Khaya senegalensis*	1	0.04	0.002
MOARACEAE	1	*Ficus platyphylla*	1	0.04	0.002
	1	*Treculia Africana*	2	0.08	0.01
MORINGACEAE	1	*Moringa oleifera*	3	0.12	0.01
MYRTACEAE	2	*Eucalyptus camaldulensis*	2	0.08	0.01
		Psidium guajava	4	0.15	0.02
TOTAL			**26**	**1**	**0.12**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.88**	

The results from Tables 23-26 (Non-Quarry site A) show the Simpson diversity index for the individual economic tree diversity in the non-quarry site. *Ricinodendron heudelotii* is the most diverse economic tree species with the highest diversity of 0.26, while *Terminalia catappa and Terminalia mentally* are the least diverse species with diversity indices of 0.0004

QUARRY SITE B

Table 27 (PLOT 1) Individual Economic Tree Species Diversity

FAMILY	**F**	***SPECIES***	**NO OF BIONS**	**n1/N**	**∑(n1/N)2 = D**
RUBIACEAE	1	*Morinda lucida*	2	0.17	0.03
RUTACEAE	1	*Citrus sinensis*	3	0.25	0.06
SAPINDACEAE	1	*Blighia sapida*	2	0.17	0.03
SAPOTACEAE	1	*Vitellaria paradoxa*	3	0.25	0.06
STERCULIACEAE	1	*Cola gigantea*	1	0.08	0.01
ZYGOPHYLLACEAE	1	*Balanite aegyptiaca*	1	0.08	0.01
TOTAL			**12**	**1.00**	**0.2**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.80**	

Table 28 (PLOT 2) Individual Economic Tree Species Diversity

MOARACEAE	1	*Ficus platyphylla*	1	0.06	0.004
	1	*Treculia Africana*	2	0.13	0.017
MORINGACEAE	1	*Moringa oleifera*	2	0.13	0.017
MYRTACEAE	1	*Eucalyptus camaldulensis*	2	0.13	0.017
	1	*Psidium guajava*	3	0.19	0.036
PALMAE	1	*Elaeis guineensis*	4	0.25	0.063
PHYLLANTHACEAE	1	*Phyllantus muellerinus*	2	0.13	0.017
TOTAL			**16**	**1**	**0.17**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.83**	

Table 29 (PLOT 3) Individual Economic Tree Species Diversity

LOGANIACEAE	1	*Strychnos spinose*	2	0.22	0.05
MALVACEAE	2	*Adansonia digitata*	1	0.11	0.01
		Sterculia setigera	2	0.22	0.05
MELIACEAE	1	*Azadirachta indica*	3	0.33	0.11
MELIACEAE	1	*Khaya senegalensis*	1	0.11	0.01
TOTAL			**9**	**1**	**0.23**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.77**	

Table 30 (PLOT 4) Individual Economic Tree Species Diversity

HYPERICACEAE	1	*Harungana madagasceis*	1	0.06	0.004
LAMIACEAE	3	*Gmelina arborea*	3	0.18	0.032
		Tectonia grandis	2	0.12	0.014
		Vitex doniana	2	0.12	0.014
FABACEAE	4	*Dailium guineense*	2	0.12	0.014
		Detarium microcarpum	1	0.06	0.004
		Pakia biglobosa	3	0.18	0.032
		Prosopis africana	1	0.06	0.004
TOTAL			**17**	**1**	**0.12**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.88**	

The results from Tables 27-30 (Quarry site B) show the Simpson diversity index for the individual economic tree diversity. *Azadirachta indica* is the most diverse economic tree, having the highest diverse value of 0.11. The least

Cite this article as:
Adams, A.E., Ndana, R.W., & Ogunlade-Anibasa, G.O. (2024). The impact of quarrying activities on economic tree composition and diversity: A study of selected quarries in the Federal Capital Territory, Abuja. *FNAS Journal of Basic and Environmental Research*,*2*(1), 54-71.

diverse economic trees are *Ficus platyphylla, Harungana madagasceis, Detarium microcarpum and Prosopsis africana,* all having a diverse value of 0.004.

Non-Quarry site

Table 31 (PLOT 1) Individual Economic Tree Species Diversity

MELIACEAE	1	*Azadirachta indica*	5	0.12	0.01
MELIACEAE	1	*Khaya senegalensis*	1	0.02	0.0004
MOARACEAE	1	*Ficus platyphylla*	1	0.02	0.0004
	1	*Treculia Africana*	2	0.05	0.003
MORINGACEAE	1	*Moringa oleifera*	3	0.07	0.005
MYRTACEAE	1	*Eucalyptus camaldulensis*	2	0.05	0.003
	1	*Psidium guajava*	4	0.10	0.01
PALMAE	1	*Elaeis guineensis*	5	0.12	0.01
PHYLLANTHACEAE	1	*Phyllantus muellerinus*	2	0.05	0.003
RUBIACEAE	1	*Morinda lucida*	3	0.07	0.005
RUTACEAE	1	*Citrus sinensis*	4	0.10	0.01
SAPINDACEAE	1	*Blighia sapida*	3	0.07	0.005
SAPOTACEAE	1	*Vitellaria paradoxa*	4	0.10	0.01
STERCULIACEAE	1	*Cola gigantea*	2	0.05	0.005
ZYGOPHYLLACEAE	1	*Balanite aegyptiaca*	1	0.02	0.0004
TOTAL			**42**	**1**	**0.08**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.92**	

Table 32 (PLOT 2) Individual Economic Tree Species Diversity

FABACEAE	4	*Berlina grandiflora*	2	0.07	0.01
		Vachellia sieberiana	3	0.10	0.01
		Afzelia Africana	2	0.07	0.01
		Acacia seyal	3	0.10	0.01
HYPERICACEAE	1	*Harungana madagasceis*	1	0.03	0.001
LAMIACEAE	3	*Gmelina arborea*	5	0.17	0.03
		Tectonia grandis	3	0.10	0.01
		Vitex doniana	3	0.10	0.01
LOGANIACEAE	1	*Strychnos spinose*	3	0.10	0.01
MALVACEAE	2	*Adansonia digitata*	2	0.07	0.01
		Sterculia setigera	3	0.10	0.01
TOTAL			**30**	**1**	**0.12**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.88**	

Table 33 (PLOT 3) Individual Economic Tree Species Diversity

EUPHORBIACEAE	2	*Alchornea cordifolia*	3	0.07	0.005
		Ricinodendron heudelotii	3	0.07	0.005
FABACEAE	12	*Dailium guineense*	4	0.10	0.01
		Detarium microcarpum	1	0.02	0.0004
		Pakia biglobosa	4	0.10	0.01
		Prosopis Africana	2	0.05	0.003
		Tamarindus indica	3	0.07	0.005

	Vachellia nilotica	2	0.05	0.003
	Delonix regia	3	0.07	0.005
	Daniella oliveri	4	0.10	0.01
	Erythrina senegalensis	2	0.05	0.003
	Gardenia erubescens	2	0.05	0.003
	Nuclea latifolia	4	0.10	0.01
	Nauclea diderrichii	3	0.07	0.005
	Lonchocarpus laxiflora	2	0.05	0.003
TOTAL		**42**	**1**	**0.08**
SIMPSON INDEX OF DIVERSITY (1−D)			**0.92**	

Table 34 (PLOT 4) Individual Economic Tree Species Diversity

ANACARDIACEAE	3	*Mangifera indica*	7	0.13	0.02
		Anacardium occidentales	5	0.09	0.01
		Spondias mombin	3	0.05	0.003
ANNONACEAE	1	*Uvaria chamae*	1	0.02	0.0004
APOCYNACEAE	1	*Calotropis procera*	2	0.04	0.002
ARECACEAE	1	*Raphia palm*	5	0.09	0.01
		Phoenix dactylifera	4	0.07	0.01
		Cocos nucifera	4	0.07	0.01
BIGNONIACEAE	1	*Spathodea campanulate*	2	0.04	0.002
CANNABACEAE	1	*Trema orientalis*	2	0.04	0.002
CARICACEAE	1	*Carica papaya*	5	0.09	0.01
CHRYSOBALANACEAE	1	*Parinari curatenifolia*	3	0.05	0.003
COMBRETACEAE	2	*Terminalia catappa*	2	0.04	0.002
		Terminalia mantaly	2	0.04	0.002
		Combretum molle	3	0.05	0.003
MYRTACEAE	1	*Psidium guajava*	2	0.04	0.002
RUTACEAE	1	*Citrus sinensis*	4	0.07	0.01
TOTAL			**56**	**1**	**0.09**
SIMPSON INDEX OF DIVERSITY (1−D)				**0.91**	

The results from Tables 31-34 (Non-Quarry site B) show the simpson diversity index for the individual economic tree diversity. *Gmelina arborea* is the most diverse economic tree with a diverse value of 0.03.

Discussion

The economic tree species composition, richness and abundance show that the family Fabaceae recorded the highest numbers of species. The degree of diversity in the species of economic trees is a dominant feature in the study sites. However, the effects of quarrying activities and clearing of vegetation nay trees have affected the study areas. The study has shown that, generally, there is an increase in the diversity of economic trees as we move farther away from quarry plants or sites due to less interference with quarrying activities. Also, there were high species composition and richness as we moved farther away from areas of quarrying activities, especially in the non-quarry sites where there are no quarrying activities. This research study agrees with the submissions of past research work. Osazuwa et al. (2016) posited an increase in plant diversity as we move farther away from quarry sites. Also, Okpara et al. (2017) corroborated these submissions in their research study where they posited high species composition, richness, and diversity index values in undisturbed areas or vegetation.

Conclusion

Quarry and quarrying activities could be hazardous through the deposition and spread of dust which can be harmful to plants and man. It impedes the photosynthetic activities of plants and the deposition of harmful heavy metals in soil. Many beneficial economic and edible tree plant species have been destroyed due to quarrying activities, impairment of the health of quarry workers, and the general destruction of the ecosystem.

Recommendations

1. The research study, therefore, recommends that: quarry plants should be located out of town or cities, having in mind the conservation of beneficial vegetation, especially the economic and edible tree species.
2. Also, it is recommended that regulations or legislation should be strict on the location of quarry plants in areas where their predominant growth or cultivation of edible economic trees amongst others; green belt development should be encouraged, and the need for a socially responsible quarry industry in the area of pursuing technological advancement for minimizing pollutions and eco-friendly operations.
3. There is a need for further research studies to be carried out on the effect of quarrying activities on economic trees and underlying shrubs as there are vegetations with the growth of some underlying shrubs within the economic trees.

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