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EFFECTS OF QUARRYING ON VEGETATION CHARACTERISTICS IN AKAMKPA LOCAL GOVERNMENT AREA OF CROSS RIVER STATE, NIGERIA

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Abstract

This study assessed the effects of quarrying on vegetation characteristics in Akamkpa Local Government Area (LGA) of Cross River State. The Forest Inventory Method (FIM) was adopted for vegetation sampling. Three sampling sites were identified within areas quarried and abandoned for at least ten (10) years, as well as one control plot within the Cross River National Park (CRNP) were selected for this study; making a total of four sampled locations. For each of these sampled locations a quadrat of 30m x 30m was demarcated for enumeration and measurement of woody vegetation species. Results from the study revealed that quarrying activities have impacted a large area of forest land in the study area; for instance, quarried site I at Old Netim covered the largest area of 0.135133km^2 (13.5 hectares) with a depth of 30.2m. The structural and floristic components of vegetation species in the quarried sites indicate great alterations, consisting of relatively few trees and shrubs, characterized by small girth (diameter at breast height), basal cover and crown cover compared to the same plant species found in the control plot. For instance, within the quarried plots, *Musanga cecropiodes* species recorded a height of 3.50m, crown cover of 0.30m, basal cover of 0.33m and girth of 0.41m in quadrat I and in quadrat II, it recorded a height of 2.38m, crown cover of 0.32m, basal cover of 0.24m and a girth of 0.20m. However, in the control plot, the same plant recorded a height of 17.00m, crown cover of 4.11m, basal area 2.43m and girth of 2.22m. On a whole, the mean height of observed vegetation species varied from 3.27m, 3.43m, 4.23m and 12.39 in quadrats I, II, III (quarried sites) &IV (control) respectively. Mean girth size (DBH) of the species ranged from 0.33m-0.36m within the quarried sites and 1.17m in the control site. The findings suggest that vegetation species found within the abandoned quarried sites were basically woody species at different regenerative stages, yet to attain maturity. The need for reforestation immediately after quarrying activities is recommended to protect and preserve the environment from degradation and as well guard against loss of biodiversity in the area.

Keywords: Akamkpa, Biodiversity, Characteristics, *Musanga cecropiodes*, Quarrying, Vegetation species, Vegetation

1. Introduction

Quarrying refers to the process of extracting rocks and sand from the earth's surface found on top or below the land surface. Quarrying activity provides materials use for several construction works amongst other uses. Traditionally, mines are the sole mineral supply source for diverse industrial purposes. However, quarrying activities are often carried out without giving much regards to the associated negative impacts on the environment, especially on the phytogeographic (vegetation) characteristics of the area (Subrahmanyam, and Sambamurty, 2006). The excavation and

blasting of rocks affect the environment in diverse ways, either directly or indirectly and the damage ranges from destruction of habitat, biodiversity loss to the alteration/modification in the functioning of an ecosystem. These changes in turn influence water and nutrient dynamics and trophic interactions (Lameed and Ayodele, 2010). This has placed the mining industry under the red category, indicating that it is at the top bracket of environmental degradation (Chandra, 2000). The impact of quarrying activities on vegetation characteristics in particular is of great concern because of the invaluable role vegetation plays in the sustenance of an ecosystem. Vegetation especially forest offer watershed protection, protects the soil against erosion and degradation, play a role in carbon sequestration and mitigates climate change, it constitutes habitat to numerous species of organisms, provides food and medicines and also a source of rural income and other ecosystem services that are critical to human welfare (Jimoh, 2001; Tijani, 2007 and FAO, 2010; Philip , Akintoye , Bisong, Utang, and Andrew-Essien. 2013; Akintoye, Olorundami, Ojong, Ukata, Harrison, 2014;Ukata, Akintoye, Digha, Alade, ,Asiyanbi, 2015)**.**

The study area (Akamkpa Local Government Area) is situated within one of the world's biodiversity hotspots and its forest vegetation holds a wide range of plant species composition which has proven to be very useful for medicinal purpose. For example Quinine used for treatment of malaria, is obtained from *Ancistrocladus korupensis* (Cameroonian vine), a plant claimed to have the potency against HIV/AIDS, and *Prunus Africana (African cherry)* a plant acclaimed to have potency against prostate cancer, and several others with high medicinal potentials are amongst the variety of plants in the area. The Oban division of the Cross River National Park (CRNP), which is found within Akamkpa LGA (study area) consists of one thousand five hundred and sixty eight (1568) plant species (belonging to ninety eight (98) families; seventy seven (77) of which are endemic to Nigeria (Cross River National Park 2016; https://en.m.wikipedia.org). However, within the study area, there exist several quarries, with Julius Berger, Expanded Mining, RCC, Zenit Construction, Arab Contractors, Sermatech and Xin-Xin Companies being the biggest players in the industry. Much of the quarrying activity involves the open cast method, characterized by massive deforestation. Vegetation Clearance especially the trees during the quarrying process affects both the status of biodiversity and the livelihood source of the rural community whose health and wellbeing is closely linked to forest vegetation. The destruction of forest land through anthropogenic activities such as quarrying has obvious environmental and socioeconomic implications (Offiong, Offiong and Ekpe, 2014; Adekunle, Olagoke and Akindele, 2013; Ajake and Enang, 2012; Adeyemo and Jegede, 2002; Lameed and Ayodele, 2010 and Bisong, 2006; Mfon, Akintoye, Mfon, Olorundami, Ukata and Akintoye (2014)**.** In view of the huge potentials forest vegetation holds for ecosystem functioning as well as the sustenance of rural livelihood, the need to assess the status of vegetation in the area due human activities becomes imperative. This study seeks to examine the effects of quarrying on selected vegetation characteristics in the study area.

2. Study Area

The study area is located in Akamkpa local government area of Cross River State, Nigeria. It is situated within latitude 5^0 15′ 00″N and 5^0 18′ 26″N of the equator and longitude 8^0 20′ 00″E and 8^0 23′ 26″E of the Greenwich Meridian; covering an area of about 25km^2. It is bordered to the North by Yakurr, Obubra and Etung local government areas; to the South by Akpabuyo and Odukpani LGAs; to the East by the Republic of Cameroon and to the West by Biase local government area (Fig.1).

The area experiences about nine months of rainfall (April to October or November) and is characterized by double maxima rainfall, with peaks in July and September. It receives annual rainfall of between 2000-3000mm with mean annual temperature of about 27℃ and daily mean of 24℃. The relative humidity is 80 to 90 percent (CRADP, 1992). Rivers and streams in Akamkpa LGA are characteristic of water bodies in the Cross River Basin, as regards the temporal and spatial variability in flow pattern (Utang, Andrew-Essien, Akintoye and Upla, 2008).

The vegetation of this area falls under the evergreen tropical rainforest, characterized by a high composition of different types of trees, most of which are tall forming a thick canopy of various plant species. The great floristic richness is attributed to a favourable climatic (high rainfall and temperature) and rich soil condition of the area. However, due to numerous human activities over the years in the area, much of the original plant cover has been modified if not completely destroyed; except perhaps the protected area constituting the Cross River National Park. Examples of plant species include *Khaya ivorensis* (mohagany), *Albizia spp* (silk tree), *Milicia excel* (iroko) amongst others.
The geology of the area is derived from basement complex rocks characterized by crystalline igneous and metamorphic rocks (Ekwueme, 2003); which undergo deep chemical weathering under the prevailing humid conditions to form soil, usually deeper than a 100cm (Aki, Esu and Akpan-idiok 2014).

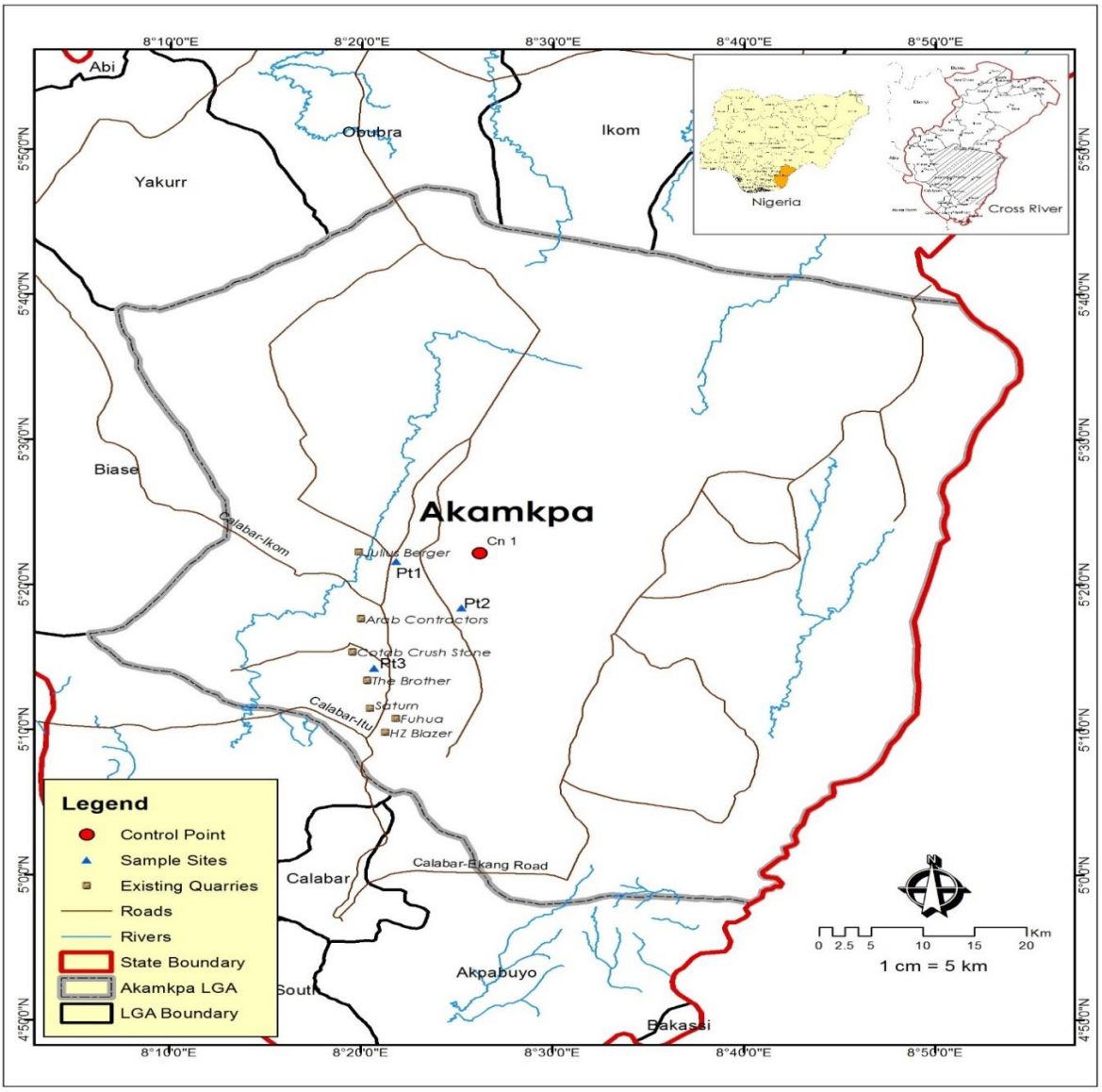

Figure 2: The study area (Akamkpa) showing sampled sites.
Source: Geographic information system (GIS) Laboratory, Department of Geography and Environmental Science, University of Calabar (2019)

3. Materials and Methods

Purposive sampling technique was adopted to select three sites where quarrying activity has stopped for a period of ten years or more and a control plot also selected within the Cross River National Park (CRNP) where no quarrying has taken place. Thus, four

sampling locations were considered for the study to include the quarried sites at Nsan (I), Old Netim (II) and Akamkpa (III) and the control at Obung (IV) for purpose of comparison. Within each of the selected sites, a quadrat of 30m by 30m was demarcated for enumeration and measurement of woody vegetation species (Trees and Shrubs). Vegetation characteristics considered in this study include the types and number of woody plants, plant species height, girth size/diameter at breast height (DBH), basal area and crown area. Identification and enumeration of woody plant species was done with the help of a forester (staff of the Cross River National Park) and a botanist. Both the common and botanical names of the observed woody plants were thus noted. Plant species height (H) was determined by measuring the distance (d) from the base of the tree, the angle to the top of the tree (Tan A) and the height of the viewer's eye (h) from the ground given as follows: H= (TanAxd)+h. The girth size/diameter at breast height of plant species was obtained via measurement with a metric tape and the crown cover (CC) obtained by measuring the trunk diameter (D) of plant species and substituting in formula: $CC= 3.14D^2 /4$; while the basal area BA is estimated from the girth size divided by 4x3.14 . The area of quarried sites and depth of quarried pits were also measured using a measuring tape while the elevation and geographical coordinates of the sites were obtained with the use of a hand global position system (GPS).

4. Results and Discussion

Geographical locations and geometry of the sampled sites.

Table 1, presents the data on the geographical coordinates and geometry of the sampled quarried sites and the control. The results show that the site at Old Netim covered the greatest area of about 14ha ($135133m^{2)}$ and has a quarry pit with the greatest depth of 30.2m. However, it has the lowest altitude of 129m above sea level, out of the three quarried sites examined. This is an indication that massive quarrying activities had taken place within the site. The low altitude of this site must have given it the advantage of easy accessibility, which in turn encouraged prolonged or greater exploitation of quarrying of materials from the site.

TABLE 1: Geographical locations and geometry of the sampled sites.

Sampled site locations	Latitude	Longitude	Area of quarry	Depth of quarry	Altitude of quarry
Nsan (I)	5° 18′ 25.2″ N	8° 25′ 15.43″ E	2ha ($15095m^2$)	14.9m	137m
Old Netim(II)	5° 21′ 34.05″ N	8° 21′ 42.81″ E	14ha ($135133m^2$)	30.2m	129m
Akamkpa(III)	5° 13′ 36.01″ N	8° 20′ 27.97″ E	3ha ($28266m^2$)	16.4m	142m
Obung (control)(IV)	5° 22′ 10.55″ N	8° 26′ 10.49″ E	$120m^2$	-	184m

Source: Authors Fieldwork (2019)

4.1 Composition and number of vegetation species within quarried sites

Table 2, shows the composition and number of plant species identified within quarry site I at Nsan of the study area. From the results, the plant species *Trema guineensis* (pigeon wood) had the highest height of 6.16m, crown cover of 0.63m, basal area of 0.42m and DBH of 0.34m. This specie was observed only once at this site and thus could be considered as rare in terms of ecological status. Similarly, *Hevea brasiliensis* **(**rubber tree) was observed once and had a height of 4.44m and crown cover of 0.51m. *Anthocleista vogelii* (cabbage tree) showed a height of 1.72m, crown cover of 29m, basal area of 31m and DBH of 0.21m. *Musanga ceropioides* (umbrella tree) and *Elaeis guineensis* (oil palm) were the relatively abundant plant species compared to all the other woody species found at this site.

Table 2: Structural composition of vegetation species within quarry site I, at Nsan

S/N	species name	Frequency	Height(m)	Crown	Basal	DBH (m)	Form
				Cover(m)	Cover(m)		
1	*Musanga cecropioides*	5	3.50	0.30	0.33	0.41	Tree
2	*Elaeis guineensis*	7	2.34	0.56	0.34	0.36	Tree
3	*Anthocleista vogelii*	2	1.72	0.29	0.31	0.21	Shrub
4	*Trema guineensis*	1	6.16	0.63	0.42	0.29	Tree
5	*Hevea brasiliensis*	1	4.44	0.51	0.33	0.65	Shrub
6	*Gmelina arborea*	4	1.72	0.57	0.37	0.21	Tree
7	*Heterotis rotundifolia*	4	3.01	0.32	0.11	0.37	Shrub
	Total	24	22.90	3.18	2.21	2.5	
	Mean	n=7	3.27	0.45	0.32	0.36	

Source: Authors Field work (2019)

The data on the structural vegetation characteristics within quarry site II at old Netim is shown on Table 3. A total of four vegetation species were recorded for this plot. Similar to site I, the plant species *Musanga cecropioides* had the highest frequency/occurrence with an average height of 2.38m, crown cover of 0.32m, basal cover of 0.24m, and DBH of 0.20m. While *Irvingia gabonesis* recorded the highest height of 5.60m and crown cover of 1.11m, basal area of 0.72m and DBH of 0.58m appearing as emergent specie. Whereas *Elaeis guineensis* had a height of 4.69m, crown cover of 0.46m, basal cover of 0.26m, and a DBH of 0.38m. It is evident that the

Musanga ceropioides and *Elaieis guineensis* are the most dominant species found in this site. This could be accounted by the fact that they are fast growing trees and can thrive better after the mining activities in the well drained, neutral to acidic soils of the area. All the plant species appear to be secondary re-growth of the cleared vegetation at different succession stages.

Table 3: Structural composition of vegetation species in site II (Old Netim)

S/N	**Species name**	**Frequency**	Height(m)	**Crown** Cover(m)	**basal** cover(m)	**DBH(m)**	**Form**
1	*Musanga cecropioides*	**7**	**2.38**	**0.32**	**0.24**	**0.20**	**Tree**
2	*Elaeis guineensis*	**6**	**4.69**	**0.46**	**0.26**	**0.38**	**Tree**
3	*Gmelina arborea*	**5**	**4.20**	**0.56**	**0.32**	**0.26**	**Tree**
4	*Irvingia gabonensis*	**3**	**5.60**	**1.11**	**0.72**	**0.58**	**Tree**
	Total	**21**	**16.87**	**2.45**	**1.54**	**1.42**	
	Mean	**n=4**	**4.23**	**0.61**	**0.39**	**0.36**	

Source: Authors Field work (2019)

Table 4 shows data on the nature of vegetation characteristics observed within quarry site III at Akamkpa. Four vegetation species were recorded within this quarry site. These include the blood tree *(Harungana madagascariensis*), guava tree (*Psidium guajava),* coconut tree (*Arecaceae*) and oil palm tree (*Elaeis guineensis*). It is evident that in this site there was basically exotic plant species with the medicinal plant scattered here and there among herbs. This may be explained by the fact that these species of economic and medicinal value must have been consciously planted being that this location is relatively close to the town. It also suggests that there has been no form of reforestation done after the many years of quarrying in the area. Hence the area was characterized by grasses of various types. Furthermore, like in quarried site 11, the effect of heavy vehicular movement and acid rock drainage from quarrying operations is associated with compaction of the soil that makes plant growth difficult. Thus, the quarried sites were seen to have few and stunted plant species (Okibe, 2020) and Humphrey and Godwin, 2014). The implication is that the sites disturbed by quarrying operations may stand the risk of biodiversity loss.

Table 4: Structural composition of vegetation species in quadrat III (Akampka)

S/N	Species Name	Frequeny	Height(m)	Crown Cover(m)	Basal Cover(m)	DBH (m)	Form
1	*Harungana madagascariensis*	**3**	**3.91**	**0.46**	**0.39**	**0.33**	**Tree**
2	*Arecaceae*	**4**	**2.93**	**0.38**	**0.32**	**0.27**	**Tree**
3	*Psidium guajava*	**2**	**3.75**	**0.76**	**0.43**	**0.35**	**Tree**
4	*Elaeis guineensis*	**2**	**4.25**	**0.92**	**0.52**	**0.48**	**Tree**
	Total	11	**14.84**	**2.52**	**1.66**	**1.43**	
	Mean	n=4	**3.71**	**0.63**	**0.42**	**0.36**	

Source: Field work, 2019

Table 5 presents data on the structural characteristics of vegetation species in quadrat IV (the control plot) within the CRNP. A total of eleven plant species were enumerated. All apart from *Gnetum africana* (afang or ukase or eruru) were tree species. The trees identified in this plot, are all taller with relatively larger girth sizes/ trunk diameter. For instance, ***Piptadeniastrum africanum*** **(**african green heart**,**ekhimi, agboin**)** was the tallest with a height of 20.65m, crown cover of 5.23m, basal area of 2.89m and DBH of 1.58m, making it the species with the most outstanding structural characteristics. ***Musanga cecrorpoides*** (umbrella tree) followed with a height of 17.00m, crown cover of 4.11m, basal cover of 2.43 and DBH of 2.22m. This specie was observed in all the sampled plots except in site III. The African walnut tree (*Coula edulis*) was however the specie with the lowest height (6.37m). The control plot thus showed relatively high vegetation cover, characterized by larger girth sizes, greater heights, and thick /close canopy relative to the quarried sites (Essoka and Abubakar,2005); an indication that much of the original vegetation to a large extent is not disturbed (Erhenhi and Obadoni, 2016). This is expected since the area falls within the forest reserve, and is protected from human pressure. Therefore, compared to the quarried sites, the control plot would be richer in terms of biodiversity.

Table 5: Structural composition of plants in the (control point)

S/N	Species name	Frequency	Height(m)	crown cover(m)	basal cover(m)	DBH (m)	Form
1	*lophira alata*	2	9.74	2.81	1.42	1.31	Tree
2	*Elaeis guineensis*	2	12.35	2.94	1.83	1.32	Tree
3	*Coula edulis*	2	6.37	1.53	1.26	1.18	Tree
4	*Randia aculeate*	2	12.60	3.24	1.87	1.21	Tree
5	*Musanga cecrorpoides*	3	17.00	4.11	2.43	2.22	Tree
6	*Funtumia Africana*	2	12.15	3.16	1.83	1.48	Tree
7	*Anthocleista vogelii*	5	10.90	2.12	1.48	1.08	Tree
8	*Piptadeniastrum Africanum*	1	20.65	5.23	2.89	1.58	Tree
9	*Irvingia gabonensis*	2	13.06	1.82	0.80	0.79	Tree
10	*Acorus calamus*	5	16.66	2.86	1.36	1.19	Tree
11	*Gnetum africanum*	4	10.00	2.05	0.94	0.27	Vine
	Total	30	148.78	32.8	18.66	14	
	Mean	N=11	13.53	2.98	1.69	1.27	

Source: Researchers Fieldwork (2019)

5. Conclusion

The general observation from the findings of this study is that diverse plant species were seen within the study area; with the control plot however, having more woody species than the quarried/mined (disturbed) sites. The woody plant species found within the quarried sites were not only few and dispersed but appeared stunted in growth; having small girth size, basal and crown cover. The vegetation species: *Musanga ceropiodes* and *Elaeis guineensis* were common to all sampled plots indicating they have better tolerance and are more adaptable to the environmental conditions of the area. In terms of areal extent, quarried sites 11(Old Netim) and 111(Akamkpa) were more affected by the quarry operations; hence showed much fewer vegetation species. From these observations, it can be inferred that the original vegetation of the study area has been greatly altered and the area therefore stands the risk of not only the extinction of woody vegetation species but also habitat destruction and biodiversity loss. Moreover, loss of vegetation species and biodiversity has obvious adverse environmental and socio economic implications for the area, if massive

rehabilitation and reforestation of the quarried sites is not done.

6. Recommendations

On the basis of the potential threat to biodiversity and degradation of the environment as a result of quarrying operations, the enforcement of reforestation program by the quarrying companies concerned is highly recommended. In addition, quarry pits should be re-graded or covered up at the end of quarrying operations and re-vegetated to guard against environmental degradation (erosion, land subsidence, pollution etc).

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