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Laterite Exploitation and its Impact on Vegetation Cover in Calabar Metropolis, Nigeria

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Abstract
The impact of environmental degradation caused by mining activities is not bourne by the construction companies but rather by the inhabitants of the area. The effects of laterite quarrying are degradation of arable land, ecological instability, reduction in fauna and floral population density, contamination of water and air, landslide and landscape alteration. The study was carried out to ascertain the level of impact of laterite exploitation on floral population density in Calabar metropolis. Direct field measurement was utilized for the study and a quadrant of 50 x 50m was used to demarcate the sample area into plots for easy identification of tree, shrub, herb, and grass species of plants lost during the extraction process. The Shannon weaver's index was then used to calculate the diversity index of each species. Aerial photographs and metric tape were used to measure the lateral extent of degraded land and the Magellan meridian GPS was used to obtained the co-ordinates of laterites site. Questionnaires was used to obtained information on socio-economic impacts of laterite extraction. The study revealed that the total area of vegetation cover destroyed was 8,520 hectares. *Elaeis guineensis* was the only plant specie with the diversity index of 1.5 and the mean diversity index for the twenty species of plant identified was 0.5. The major socio-economic impact felt by the inhabitants of the area as obtained from the respondents was the destruction of vegetation cover with 37.5 percent. The R^2 value obtained from multiple regression analysis was 0.856 that means 85.6 percent of the impact of laterite exploitation on vegetation cover was explained by the model. It was then recommended that a proper environmental impact assessment study be carried out before sitting a quarry, to minimize the damage on the environment.
Keywords: Environment, exploitation, laterite flora, and degradation.

Introduction

Mineral resources such as oil, gas, limestone, granite, sand, marble and rock aggregates have been playing an increasing role in the national socio-economic growth because they generate appreciable internal revenue and foreign exchange earnings (UNESCO, 1995). Laterite is a residual ferruginous mineral, commonly found in the tropical regions and has close genetic association with bauxite. It is a highly weathered mineral, rich in secondary oxides of iron, aluminium or both. Laterites are formed from leaching of parent sedimentary rocks which leaves insoluble ions predominantly iron and aluminium (Adekoya, 2003). Rocks are leached by percolating rain water during the wet season, the resulting solution containing the leached ions is brought to the surface by capillary actions during the dry season. Laterite formation is favoured in low topographical reliefs of gentle crests and plateaux which prevents erosion of the surface cover.

Laterite deposits may be described on the basis of the dominant extractable minerals in it such as aluminous laterite (bauxite), Ferruginous laterite (iron ore), Manganiferous laterite (manganese ore), Nickeliferous laterite (nickel ore) and Chromiferous laterite (chrome ore). Laterite with Fe_2O_3:Al_2O_3 ratio more than 1, and SiO_2:Fe_2O ratio less than 1.33 is termed as ferruginous laterite while that having Fe_2O_3:Al_2O_3 ratio less than 1 and SiO_2:Al_2O_3 ratio less than 1.33 is termed as aluminous laterite (Webster & Fittipaldi, 2005).

Large scale exploitation of laterite in the study area has resulted in a high degree of degradation of arable land, vegetation, landscape, loss of endangered species as well as other environmental problems. Severe land degradation caused by mining affects a significant portion of the earths arable lands, decreasing the wealth and economic development of Nations. As the land resource base becomes less productive, food security is compromised and competition for dwindling resources increases, 'thereby' the seeds of farming and potential conflict such as war and communal clashes are sown.

In all areas of laterite exploitation, the predominant form of mining used is the open cast, where all the vegetation and top soil are removed, thus destroying wildlife habitats and preventing economic activities such as farming and hunting (Adekoya, 2003). Laterite is an exhaustible and non-renewable resource of the earth crust. Two fundamental characteristics that distinguish it from all other minerals are its chemical composition and its crystal structure (Aigbedion, 2005). Due to the uncontrolled manner the illegal minerals operates, a lot of damage is done to the environment by haphazard pitting and trenching of the ground in many areas.

Laterites are products of intensive and long lasting tropical rock weathering which is intensified by high rainfall and elevated temperatures. Chemical reactions between exposed rocks at the surface and infiltrated rain water are controlled by the mineral composition of the rocks and their physical properties such as cleavage and porosity which favours the perculation of water. Other relevant factors that accelerate laterite formation are the properties of the reacting water, dissolved constituent, temperature, acidity, pH, redox potential, which are themselves controlled by the climate, vegetation and the morphology of the landscape (Erskine & Green, 2000).

Tropical and subtropical areas such as Calabar metropolis, have a high annual precipitation but its distribution varies strongly between countries with pronounced and long lasting dry seasons to equatorial areas with a more continuous precipitation. Chemical weathering slows down in dry seasons at least above the fluctuating water table. The chemical reactions are further controlled by the activity of the mobile phase of water found within the small pores in the soil stable aggregates. The reaction rate generally, varies from mineral to mineral. Minerals of the same type e.g. kaolinite can show different crystallinity which equally controls their stability.

Laterite weathering is a relevant process which is active in the superficial zone of tropical regions. Erosion or denudation, contributes to an alteration at the surface together with deposition of materials by water.

Reconnaissance survey has shown that construction companies and individual miners operating in the study area are involved in illegal mining of laterite (Akabzaa 2000). The excavations have degraded the environment and posed a great threat to the lives of residents. The excavations are done without any attempt to reclaim the exposed surfaces on these sites, leaving wide holes where water can accumulate. In some places where the water table is high, artificial ponds have been formed. Intense air and water pollution emanates from the exploitation stages of the laterite Vegetation is usually the first casualty of partial destruction during the exploitation of laterite in any locality. The vegetation damage is more extensive at the time of mine development and mining operations. Similarly, laterite exploitation and processing activities causes disturbance of the ecosystem with adverse consequences on the floral and fauna community (Tanko, 2007).

The threat to ecosystem composition and biodiversity has been Reported on repeatedly in terms of these mines, (Okafor, 2006) and it is noted that while they do have a higher yield, they also have tendencies to pose a threat to the immediate environment by crushing and dumping dirt that would otherwise have been left untouched (Akabzaa, 2000). However, operations of mining, whether small or large scale, are inherently disruptive to the environment (Makweba & Ndonde, 1996). Furthermore, mining of aggregates frequently generates land use conflicts in populated areas due to its negative externalities including noise, dust, truck-traffic, pollution and visually unpleasant landscapes (Willis & Garrod, 1999). It can also be a conflict to competitive land uses such as farming, especially in areas where high-value farmlands are scarce and where post-mining restoration is not feasible. As pointed out by environmental activists there are potential linkages between mineral resources and consequential underdevelopment (Moseley, 2005).

Extraction of laterite requires the use of machines, which stress on the natural environment in the form of soil compaction, increase rate of leaching, soil erosion, depletion of soil fertility and crop production capacity. It has to a large extent contributed to land degradation and desertification through the destruction of economically important tress, which are mostly indigenous in nature. This leaves behind bare soils and large expanse of gullies which can collect water during rainy seasons. The most common Negative impacts of surface mining are the destruction of natural landscape, creating open space in the ground and generating heaps of sand wastes that cannot be easily disposed off. Although people are familiar with the need and importance of laterite mining, the awareness of the negative impacts on the vegetation, biodiversity and food security may not be readily known. Deforestation of an area during mine development causes the elimination of some plant and animal species, which need to be properly conserved. For laterite exploitation to be undertaken sustainably, there is the need to adopt techniques which are economically viable and environmentally friendly. In view of these reasons, the study sought to determine the impact of laterite exploitation on the floral population density of Calabar Metropolis.

Study Area

The study area is Calabar Municipality located between longitudes 008^{o} 18'E and 008^{o}20'E, and latitudes 4^{o}.00'N and 4^{o}.50'N respectively. Calabar has equatorial type of climate. The rainfall distribution is bi-modal with its first peak between March and October and the second in July to September. The area has an annual average rainfall of 3000mm and a relative humidity of 85 percent. Evaporation is high due to the average daily maximum temperature of 30^{o}C and a seasonal variation of 28^{o} – 31^{o}C between the hottest month February and the coldest month August.

The soil texture of the study area is mainly sand, Comprising mostly of medium to coarse grained, pebbly moderately sorted with local lenses of fine –grained poorly consolidated sand and silty clay. The soil has a high percentage of sand and it is of great socio-economic importance especially for construction purposes. The area is characterized by dark brown soils, friable, non-sticky in structure and classified as sandy loamy soils found at the valley bottoms which are smoother in nature and used for road constructions. The drainage pattern is drendritic. The sand shale intercalation in the area suggests a multi aquifer system. The vegetation is within the tropical rainforest zone but presently a large portion has been replaced with residential construction. The issue of soil degradation has surfaced as an emerging phenomenon, which impacts negatively on the biodiversity and the environmental conditions.

Material and Methods

The data for this study was collected through direct field observation and measurement. Aerial photomaps obtained from Forestry Commission, Calabar where used to calculate the aerial extent of vegetation cover degradation as result of laterite extraction in the area. The sample site was demarcated into plots, and the extent of vegetation cover destroyed was measured, as well as the species of plants lost during the exploitation of laterites. The questionnaire was basically focused to gather respondents view from the study areas on the impacts of laterite on socio-economic impacts. Target groups were selected for the interviews. These include individual landowners, groups of farmers whose farms were located close to the site, and selected individuals from nearby communities.

The Magellan Meridian GPS was used to obtained co-ordinates around the study area. A linen tape and step count was used to measure the length, breadth and depth of the area of vegetation cover destroyed. A quadrant of 50m x 50m was then used to demarcate the vegetation cover into sample plots. At each of the sample plots we undertook physical counting of shrubs, trees, herbs and grasses to determined the quantity destroyed during exploitation activities. Shannon Weaver's Index was used to calculate the diversity index of each species of plant. It has the form;

Shannon formula = H^1 Eith P_1LnP_1

Where n = Number of specie
p = Proportion of individuals or abundance of the specie
L_n = log base n

Data generated were presented in tables. Both descriptive and quantitative statistics were applied for analysis.

Results and Discussion of Findings

The results and discussion of findings are presented accordingly.

Table 1: Vegetation cover destroyed by laterite mining in Calabar metropolis

S/No	Sampled Site Location	Area of Vegetation cover destroyed (hectare)	Active pits	Abandoned pits
1.	Akai-Efa	1205	5	2
2.	Nyangasang	1145	3	1
3.	Idundu	185	1	1
4.	Ikot Eneobong	190	2	1
5.	Nsidung	1105	2	1
6.	Parliamentary Road	1130	3	1
7.	Adiabo	1165	4	1
8.	Mbukpa	1120	3	1
9.	Ikot Omin	165	1	1
10.	Kasuk	1110	2	1
	Total	**8,520**	**26**	**12**

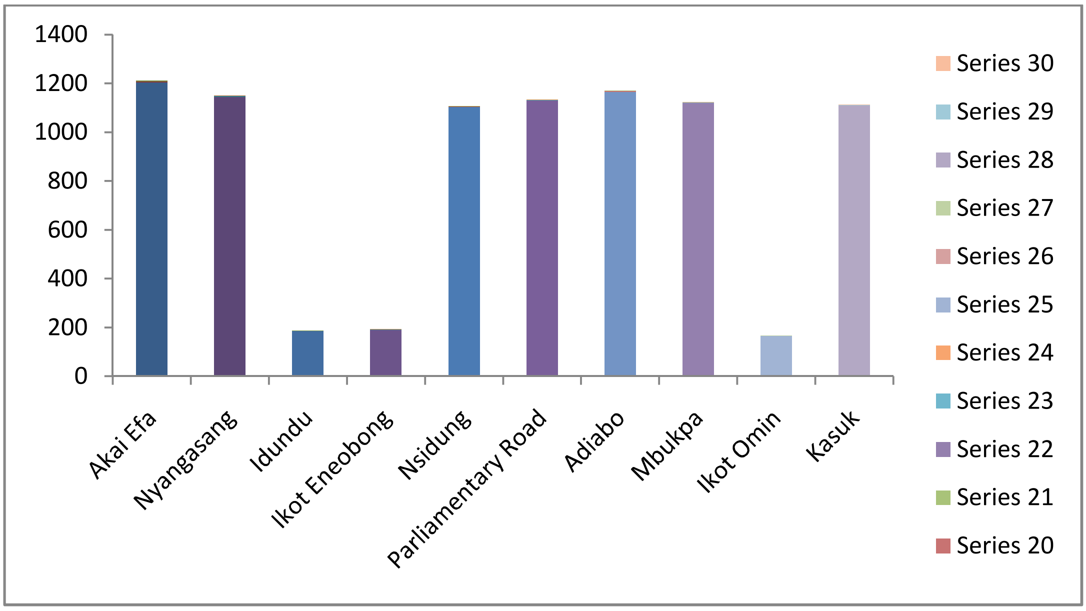

Figure 1: Histrogram showing vegetation cover destroyed

The table above revealed that the total vegetation cover destroyed by laterite mining was 8,520 hectare. At Akai Effa a total of 1205 hectare was degraded this was the highest, but the lowest vegetation cover of 165 hectare was destroyed at Ikot Omin due to mining activities.

Table 2: Diversity of plant species in the study area

S/No	Plant species	Type	Frequency	Diversity Index	GPS Co-ordinates
1.	*Elaeis guineensis*	Tree	98	1.5	N=05º.87' E=008.20 Elevation 257m
2.	*Musanga cecropioides*	Tree	75	0.6	N=05º.98' E=008.20 Elevation 235m
3.	*Cola acuminate*	Tree	84	0.7	N=05º.14' E=008.21 Elevation 227m
4.	*Delonix regia*	Tree	73	0.5	N=05º.59' E=008.21 Elevation 247m
5.	*Musa parasidiaca*	Tree	62	0.4	N=05º.44' E=008.52 Elevation 265m
6.	*Mangifera indica*	Tree	52	0.3	N=05º.44' E=008.52 Elevation 265m
7.	*Plumeria rubra*	Tree	20	0.2	N=05º.33' E=008.43 Elevation 279m
8.	*Citrus sineensis*	Tree	45	0.5	N=05º.46' E=008.49 Elevation 220m
9.	*Carica papaya*	Tree	65	0.6	N=05º.80' E=008.32 Elevation 210m
10.	*Symphonia globulifera*	Tree	54	0.4	N=05º.68' E=008.41 Elevation 270m
11.	*Manihot esculenta*	Shrub	56	0.7	N=05º.43' E=008.63 Elevation 273m
12.	*Cassia alata*	Shrub	45	0.4	N=05º.52' E=008.70 Elevation 290m
13.	*Ixora cocinea*	Shrub	35	0.3	N=05º.44' E=008.62 Elevation 310m
14.	*Ananas comosus*	Herb	46	0.6	N=05º.23' E=008.70 Elevation 205m
15.	*Spigelia anthelma*	Herb	33	0.4	N=05º.33' E=008.41 Elevation 229m
16.	*Vossia cuspidate*	Herb	73	0.8	N=05º.43' E=008.52 Elevation 245m
17.	*Clintoria ternantea*	Herb	24	0.3	N=05º.55' E=008.43 Elevation 238m
18.	*Calopogonium mucunoides*	Herb	15	0.2	N=05º.45' E=008.45 Elevation 255m
19.	*Sida acuta*	Herb	48	0.6	N=05º.46' E=008.26 Elevation 244m
20.	*Panicum maximum*	Grass	36	0.3	N=05º.60' E=008.25 Elevation 257m
				$\bar{x} = \frac{10.3}{20} = 0.51$	

Source: Authors Fieldwork, 2013.

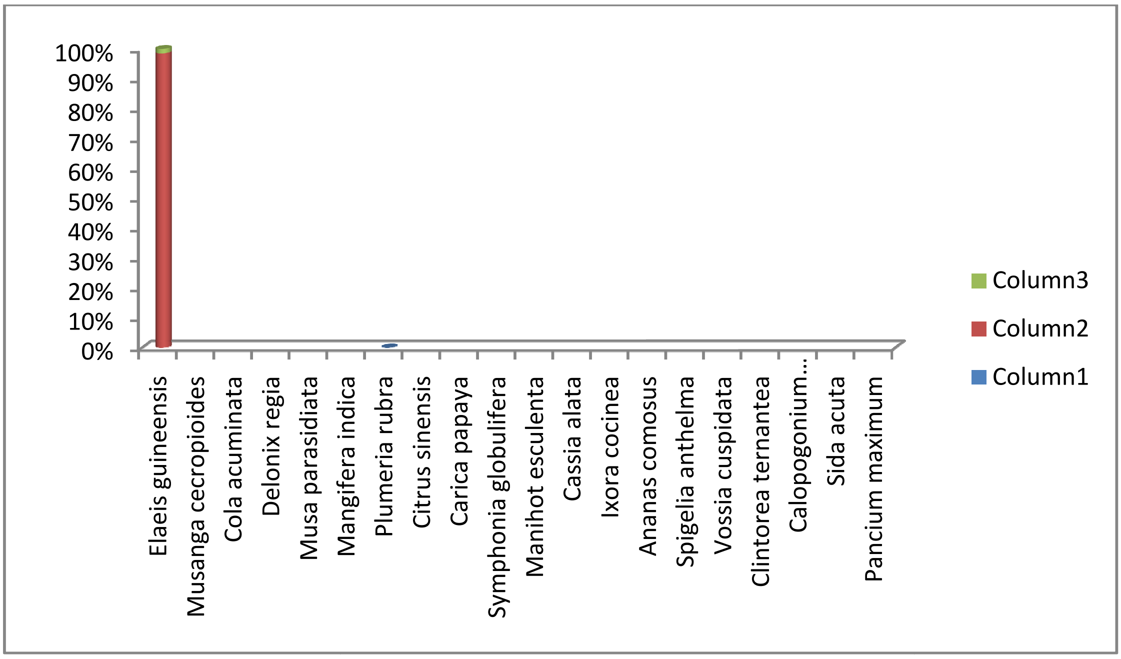

Figure 2: Floral population diversity

Calabar Metropolis is rainforest vegetation but human activities, most importantly farming have reduced most part to a secondary forest. The secondary forest is a complex community of plants in which disturbance has occurred over a long period.
The flora species diversity in the study area was generally very low. A total of 19 species have diversity values of less than 1.0 but *Elaeis guineensis* had a value of 1.5. This indicated that the species had a higher frequency, abundance and was seen to be very dense. The presence of *Elaeis guineensis* in the area proofs that the vegetation cover has been highly devastated and degraded. This buttresses the fact that the area is dominated by secondary forest. The specie forms for tress occupies about 50% shrubs, 15% herbs, 30% and grass 5% of the total forest cover as shown in Table 2. Herbs were seen to be restricted in distribution. This was shown diagrammatically in figure 2.

However the presence of plants like *Manihot esculenta*, *Carica papaya, Musa parasidiata* and *Musanga cecropioides* indicated that there was presence of human activities in the land use. The research also revealed that all the species of plants perform valuable function in the ecosystem, likewise their utilization patterns by the inhabitants. Based on this it was observed that a large number of these species were destroyed and their vulnerable rates very high which indicates that there were at point of extinction.

The mean diversity for the twenty species was calculated to be 0.5. Species that fall below this mean value were highly devastated while those that fall above were not highly threatened.

Table 3: Socio-economic impacts of laterite extraction in Calabar metropolis

S/No	Socio-economic variables	Frequency	Percentage
1.	Destruction of landscape	30	25
2.	Destruction of vegetation	45	37.5
3.	Loss of biodiversity and economic trees	20	16.6
4.	Contamination of groundwater	10	8.31
5.	Loss of agricultural farmland	10	8.31
6.	Spread of diseases	5	4.3
	Total	120	100

Source: Authors Fieldwork, 2013.

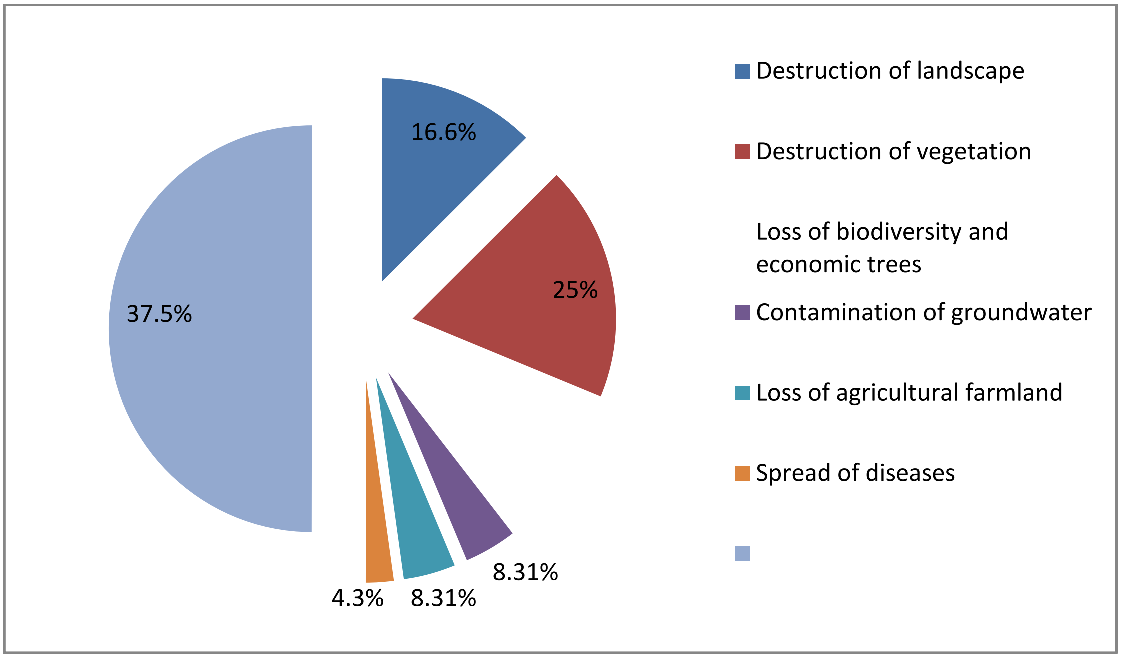

Figure 3: A Pie Chart showing socio-economic impacts of laterite extraction in Calabar metropolis

The research showed that machineries used to extract laterite disturbs the vegetation cover and exposes the area to erosion and degradation. This results in lost of the protection provided by soil. Removal of vegetation cover is the first step taken before quarrying of laterite commences. This activity significantly accelerates erosion and land degradation around the mining arena.

Miners do not preserve the topsoil removed before excavation begins, as a result, the topsoil is often washed away into surface water, carrying with it ecologically valuable seed banks that are necessary for the regeneration of vegetation.

Table 3 above indicates that 37.5 percent of the respondents from the focus group believes that laterite extraction has helped to degrade their vegetation cover. Twenty five(25) percent of the respondents are of the view that their landscape was destroyed, 16.6 percent belief that they have lost their biodiversity and economic trees to laterite exploitation. 8.3 percent of the respondents are of the view that contamination of water body and destruction of agricultural farmland are the consequences of laterite exploitation while only 4.3 percent lead to the spread of various types of diseases. This fact was buttressed in the pie chart illustration as shown in figure 3.

Destruction of vegetation cover and landscape destruction were the two significant effects of mining, common to all the sample locations. This is so because once the vegetation cover is destroyed for mining, the activities of laterite mining leaves the landscape with excavated pits and trenches. This unsightly view renders the land unsuitable for any productive purpose like the cultivation of crops such as cassava and yam. Such destruction of land changes the land surface and this can affect the quantity and quality of water in the aquifers. Loss of economic trees which is the major third impact can cause a set back in the economy and income of the inhabitants of the study area especially if the women depends largely on forest product for the up-keep of their homes.

The study observed that the absence of bye-laws and guidelines for mining gives companies and contractors the freedom to open and abandon mines haphazardly without due consideration for proximity of mining sites to communities, water bodies and other productive agricultural lands, which has been the cause of conflicts and chaos among residents. These conflicts arise because some residents have to live with noise and dust pollution, cracking of buildings and pollution of water bodies near settlements.

Furthermore, the study used the multiple regressions to determine the influence of laterite extraction on floral density. The result is presented as follows:

Table 4: Multiple Regression Analysis of the Influence of Laterite Exploitation on Floral Population Density

(a) Model Summary

Model	R	R Square	Adjusted ® square	Std error of the estimate
1	0.875	0.856	0.815	0.61345

(b) ANOVA

Model	Sum of squares	df	Means square	F	Sig.
1. Regression	43.672	3	12.341	22.441	0.002
Residual	2.532	4	0.523		
Total	46.324	9			

- P<0.05 (significant at the 0.5 level)

The study revealed that the total area of vegetation cover destroyed was 8,520 hectares. The result of the multiple regression analysis is presented in table 4(a) and table (b). From table 4a, R is 0.75, R^2 is 0.856 and the adjusted R^2 is 0.815. The standard error of the estimate associated with the model is 0.61345. Table 4b revealed a total sum of squares of 46.324 of this value, the sum of squares associated with the regression is 43.672, while that associated with the residual is 2.534. The F value is 22.41 and the associated observed significance level is 0.002 ($P < 0.05$).

c. Coefficients

Model	Unstandardized coefficients		Standardized Coefficient	t	Sig.
	B	Std Error	Beta		
(Constant)	157.709	11.413		-16.173	000
Frequency of accumulated (Fo)	-14.572	2.850	-480	-5.829	0.003
Diversity Index (DI)	-10.823	6.342	-354	-4.332	0.002

The regression model for the influence of laterite exploitation on floral population density is given as;

$$y = 157.709 - 14.572\ Fo - 10.823\ DI$$

The model indicates that there is a negative influence in the relationship between laterite exploitation with frequency of occurrence and diversity index of floral population density in the study area. This means that an increase in laterite exploitation will result in a decrease in the vegetation cover within the study area.

With $R^2 = 0.856$, it means that 85.6 percent of the variations in floral population density was explained while 14.4 percent was unexplained. This follows that there is a significant relationship between extraction and vegetation cover.

Conclusion and Recommendations

There is the need for an immediate land use planning to combat the impact of laterite exploitation on vegetation cover since this will go a long way to ensure sustainable quarrying activities with minimal damage to the surrounding environments. The activities of laterite exploitation are completely removal of the vegetation cover, which served as habitations and niches for florals and faunas. Only successional and resistance species of plants will be able to adapt to the unstable situations caused by quarrying activities.

Destruction of the natural landscape is one of the major resultant effect from mining of laterites. This process creates open space in the ground and invariably creates a problem of erosion menace. Another problem visible in the study area is that, this mining activities upsets the geologic equilibrium in the environment, which may result in geologic hazards such as landslide, subsidence, and tremors. Research have shown that exploitation of mineral resources are the major backbone of the economy in many developed and third world countries such as Nigeria. It is therefore pertinent to examine dangers poised by mineral extraction which includes problems such as abandoned sites, biodiversity loss, and landscape deformity. To address the impacts of laterite exploitation on vegetation cover, the following measures are hereby suggested which can help to mitigate the effects of the aforementioned problems through technology initiatives. The measures are:

a. An integrated environmental assessment, management and monitoring programme should be a part of the laterite extraction operation and encourage at both the local, state and federal level.

b. The government should provide guidelines and enforce legislation aimed at minimizing environmental damage. This should be done in consultation and harmonization with all relevant stakeholders in the mining sector.

c. Environmental education and awareness should be created on the potential impacts of laterite quarrying.

d. Afforestation should be encouraged to replace the lost species of plants.

e. Extraction companies should present a prognosis of the possible environmental impact of their operations, as well as the technique for monitoring the impact for approval of the mines department before the commence operation.

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