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THREAT OF CHARCOAL PROCESSING TO TREE SPECIES DIVERSITY IN OTEMEWO COMMUNITY, OKPE, DELTA STATE, NIGERIA

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Abstract: **The status of tree species used for charcoal processing and its effect on tree diversity in Otemewo community, Okpe Delta State were assessed. Semi-structured questionnaire guide and random sampling technique were used to collect data on the trees species. Besides five points likert rating scale on species preference for charcoal, and paired t-test was used to determine the implication of tree species preference for charcoal production on tree diversity. A major charcoal processing site was selected for the study. Also samplings were done in two randomly selected sample plots. Twenty eight (28) tree species belonging to 13 different families were cited as trees preferred for charcoal processing. Meanwhile, only ten (10) species: B. cogolensis, E. cylindricum, I. gabonensis, K. senegalensis, L. alata, L. lanceolata, P. africana, P. macrophylla, T. orientalisand U. guineensis of the twenty eight (28) trees recorded as charcoal-producing species existed in the two sample plots, and were comparatively rare. Diversity indices reveal that one of the two randomly selected plots was richer in tree species than the other. Consequently, it was observed that high rate of deforestation and unsustainable collection pattern of trees for charcoal threatens forest ecosystem and negatively affected the diversity of tree species in the area. Therefore, strategies that would ensure tree species management and by extension the entire forest ecosystem of the area were suggested.**

Keywords: **Charcoal, Tree diversity, Species preference, Otemewo community,**

I. INTRODUCTION

Trees are the principal constituent of forest domain. They are indicators of physiognomic changes in tropical forest. The level of disturbance to forest structure in Delta State - owing to increase in human population - has since worsened over the last century. Otemewo community, Okpe like other parts of the State is an area supported by abundant vegetation cover. Its territorial precedence is expressed by plant species diversity, which has served the basic needs of the inhabitants since time immemorial. Traditionally, forest is use for subsistence farming, income generating activities, household source of energy, medicine, and socio-cultural purposes [Agbogidi, 2011; Ihinmikaye et al., 2019]. The reliance on forest trees as source of energy inter alia charcoal making has impoverished forestland and its ecosystems. [Adelusi et al., 2002] noted that forest estate in the tropics has suffered undue degradation and depletion with loss of biodiversity as a result of encroachment on areas originally perceived as forest enclaves. It was estimated that wood fuels (firewood and charcoal) account for 50 - 90 % of the fuel used in developing countries [FAO, 2010; Zulu and Rihardson, 2012]. Similarly, [Rotowa et al., 2019] asserted that fuelwood and charcoal are by far the most heavily consumed energy sources in Nigeria. One great concern however is that charcoal unlike firewood is often produced from forest resources [Giraid, 2011], by means of uncontrolled and indiscriminate felling of both mature and nearly-mature trees [Subhoji, 2018].

In Otemewo community charcoal processing activity provides source of income to the people. The effect of such activity on the community's forest ecosystem has not been creditably established. This paper, therefore, seeks to identify charcoal-producing-tree species, the effect of charcoal processing activity on tree diversity, and to suggest sustainable management plan of forest trees in the community.

II. MATERIALS AND METHODS

The study Area

Otemewo community, Okpe is located at the geographical coordinates of 6.31^0N' and 6.45^0E'. The community is located in the tropics with high rainfall in most part of the year. Mean monthly temperature is in the range of 20^0C to 32^0C, with high relative humidity depending on the season of the year.

Survey, Data collection and Analysis

Sampling procedure involving structured questionnaire guide and random sampling technique were used to collect data. A major charcoal production site was selected for the study, the site by Ogborido junction (Otemewo community, Opke LGA). Sixty (60) respondents comprised of charcoal

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makers and wholesalers of the product were selected in Otemewo community and interviewed with the aid of questionnaire guide in respect to their knowledge of tree species used for charcoal production. The respondents had being in the charcoal processing industry for a period not less than ten years and had maintained continuous domicile of ten years in the Area. Further information was obtained from ten loggers, the regular suppliers of logs to the site, and the tree species vernacular names were confirmed with floras of the region [Hutchinson and Dalziel, 2014; Aigbokhan, 2014]. Besides, two sample plots (A and B) measuring 50m x100m were randomly selected from the adjoining forest communities, 500 metres away from the production site in opposite directions. And all trees that are 1.83 metres above ground level within the sample plots were measured by diameter at breast height (dbh≥4.5 feet) after [Hall et al., 2013] using a diameter-tape calibrated in centimeter. The trees encountered were identified by their botanical names and counted: this was done to allow reliable estimate of the present standing stock of the area, also the utility of the species accessed at the sample plots (for charcoal production) were confirmed at the production site. In the meantime, five points likert (tree species preference for charcoal) rating scale after [Dagba et al., 2017] was adopted to determine the impact of charcoal production on tree species diversity of the forest community in the study area. The rating scale was derived from the following values: high=1, moderate=2, low=3, rarely=4, not in use (NIU) =5, for charcoal production. The data obtained was subjected to statistical analysis; paired t-test was used to compare the impact of tree species preference for charcoal production on diversity. The abundance and diversity status of the tree species used by the respondents were compared in relative terms with tree species encountered in the sample plots to draw inference.

Specimens of the tree species that cannot be identified at the site were taken to the University Herbarium of Plant Science and Biotechnology, Federal University Otuoke, Bayelsa State, Nigeria for identification.

Quantification of Species Diversity in the Sample Plots

A number of diversity indices considered as ecological indicators has been used to determine the quality of forest community structure [Adekunle et al., (2008); Kerkhoff, (2010); Humphery and Gogwin, (2015)], consequently, the following indices were used to determine tree species diversity in the sample sites: Shannon-Wiener index of diversity (H), Equitability index (E) and Menhinick's index (d).

Shannon-Wiener index (H) = $-\sum(Pi \ln Pi)$. (1)

Where, Pi is the quantity of individuals of the ith species.
Pi = ni/N
ni= number of individuals of the ith species in the plot
N= total number of individuals in the plot
ln Pi is the natural log of Pi

Equitability index (E) = $H/M_{max} = H/\log s$. (2)

S= number of species in the plot.
'C' value range between 0 and 1. 1 represents infinite diversity and 0, no diversity.
Where **H** = Shannon Wiener index and, **S** = total number of species recorded in the plot.
Evenness assumes a value between 0 and 1, 1 being complete evenness.

Menhinick index (d) $= \frac{S}{\sqrt{N}}$. (3)

Where S= total number of species and N = total number of individuals in the plot.

Estimation of Tree Relative density

Relative density (%) of each species in the sample plots was quantified as follows:

$$RD = \frac{n \times 100\%}{N}. \quad (4)$$

Where RD is the relative density of the species,
n is the number of individual tree species and,
N is the total number of trees sampled per plot.
The abundance of tree species encountered in the sample plots and in the charcoal making site were determined using the scale of abundance in relation to the relative densities (Rd) of the trees as reported by [Ihinmikaiye and Unanaonwi, 2019]: Very abundant (Rd ≥ 5.00); Abundant (Rd, 4.99 – 4); Frequent (Rd, 3.99 – 3); Occasional (Rd, 2.99 – 2); and Rare (Rd, 1.99 – 1). Tree species, which are not found in the sample plots but are mention (by the respondents) as charcoal species are considered Endangered (Rd, 0).

III. RESULTS

Table 1 shows the demographic profile of the respondents at the production site in Otomewo (Opke Local Government Area (LGA)). Most of the folks involved in the production process are literate, within 20-60 year age bracket; and women were the prominent workers in the industry.

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Table1: Demographic Profile of the Respondents at the Charcoal Production Site Otomewo, Opke LGA

Features	Description	Proportion of Respondents
<20		14
Age	20-60	35
	>60	11
Literacy status	Literate	51
	Illiterate	09
Sex	Male	17
	Female	43

Table 2 provides information on charcoal wood in the processing site, twenty eight (28) tree species belong to thirteen (13) different families were assessed, and the table also reveals their preference status for charcoal production. Members of fabaceae scored high species preference, and were the most prevalence species for charcoal processing in the site.

Table 2: Charcoal Species Assessed in the Processing Site

Charcoal Species	Family	Vernacular name	Species Preference
Berliniacogolensis (Baker f.)	Fabaceae	berlinia	Moderate
Berliniagrandiflora (Vahl)	Fabaceae	berlinia, red oak	Moderate
Bobgunniafistuloides (Harms)	Fabaceae	oken	High
Brachystegianigerica (Hoyle & J.)	Fabaceae	okwen	High
Brachystegiaspiciformis (Benth.)	Fabaceae	okwen, achi	High
Entandrophragmacylindricum	Meliaceae	sapele, cedar	Moderate
Erythrophleumsauveolen (G. & B.)	Fabaceae	sasswood	High
Ficussycamorus(L.)	Moraceae	mulberry	Moderate
Irvingiagabonensis (Baill.)	Irvingiaceae	ogbono,	High
Khayasenegalensis (A. Juss.)	Meliaceae	okpe, okpan	High
Lophiraalata (Banks ex)	Ochnaceae	eki, owegbe, red iron	High
Lophiralanceolata (ex Keay)	Ochnaceae	dwarf red ironwood	High
Prosopisafricana(Guill.&Perr.)	Fabaceae	Okpei, Iron wood	High
Naucleadiderrichii (De W. &Dur.)	Rubiaceae	opepe, bilinga	High
Nesogordoniapapaverifera (A. Ch.)	Malvaceae	redwood, danta	High
Pachystelabrevipes (Baker)	Sapotaceae	azimomo, udala	High
Pentaclethramacrophylla(Benth.)	Fabaceae	ogba, ugba	High
Piptadeniastrumafricanum (Hook. f)	Fabaceae	ohen, africa oak	High
Prunusafricana (Hook. f.)	Rosaceae	bitter almond	High
Rhizophora mangle (L.)	Rhizophoraceae	mangrove	Low
Rhizophoraracemosa (R. Br.)	Rhizophoraceae	red mangrove	Moderate
Synsepalumafzelii (Engl.)	Sapotaceae	azimomo	High
Synsepalumstipulatum (Engl.)	Sapotaceae	azimomo, ogeromo	High
Syzgiumguineense (Hochst.)	Myrtaceae	water berry	High
Treculiaafricana (Decne.)	Moraceae	ukwa	High
Tremaorientalis (L.)	Cannabaceae	trema	High
Uapacageuineensis (Mull. Arg)	Phyllanthaceae	red cedar	High
Uapacastaudtii (Pax)	Phyllanthaceae	uapaca	Moderate

The tree species preferred for charcoal production with reference to a likert scale is presented in Table 3. The paired samples (Sp accessed at the Sampling Plot – Sp Mentioned at the Production Site) were correlated for the impact of charcoal production on tree diversity of the forest community in the study area. The results (Table 4) reveals that species preference for charcoal production significantly ($p<0.05$) affect tree species diversity in the study area.

Table 3: Value of Tree Species Prefer for Charcoal Production in the Study Area

Sp. Mentioned at the Production Site	*LSV	Sp. Accessed at the Sampling Plots	*LSV
Berliniacogolensis	2	Albiziaadianthifolia	3
Berliniagrandiflora	2	Albiziazygia	3
Bobgunniafistuloides	1	Alchornea cordifolia	4
Brachystegianigerica	1	Alstonia boonei	4
Brachystegiaspiciformis	1	Alstoniacongensis	4
Entandrophragmacylindricum	2	Anthocleistavogelii	3
Erythrophluemsauveolen	1	Antidesmavenosum	3
Ficussycamorus	2	Aubrevilleaplatycarpa	3
Ivringiagabonensis	1	Berliniagradiflora	2
Khayasenegalensis	1	Canthiumsubcordatum	3
Lophiraalata	1	Carapasprocera	3
Lophiralanceolata	1	Ceibapentandra	4
Nauclea. diderrichii	1	Eleais guineensis	5
Nesogordonia p apaverifera	1	Entandrophragmacylindricum	2
Prospisafricana	1	Ficusexasperata	3
Pachystelabrevipes	1	Funtumiaelastical	4
Pentaclethramacrophylla	1	Garcina kola	3
Piptadeniastumafricanum	1	Harunganamadagascariensi	4
Prunusafricana	1	Heveabrasilensis	4
Rhizophora mangle	3	Irvingiagabonensis	1
Rhizophoraracemosa	2	Khayaivorensis	3
Synsepalumafzelii	1	Khayasenegalensis	1
Synsepalumstipulatum	1	Lophiraalata	1
Syzgiumguineense	1	Lophiralanceolata	1
Treculiaafricana	1	Musangacecropioides	4
Tremaorientalis	1	Pentaclethramacrophylla	1
Uapacageuineensis	1	Prioriamannii	3
Uapacastaudtii	2	Prosopisafricana	1
		Pterocarpusmildbraedii	4
		Pycanthusangolensis	1
		Spodiasmonbins	4
		Tetrapleuratetraptera	3
		Tremaorientalis	1
		Uapacaguineensis	1

*Likert Scale Values, High=1, Moderate=2, Low=3, Rarely Use (RU) =4,Not in Use (NIU)=5

Table 4: Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Species accessed at the Sampling Plot – Species Mentioned at the Production Site	1.57143	1.42539	.26937	1.01872	2.12414	5.834	27	.000

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Table 5 and 6 reveal the abundant status and frequency of the tree species encountered in plot A and plot B. Physiognomic ally, the forest communities sampled have sparse trees with small girths. Table 5 reveals that 28 tree species belong to 16 different families were encountered and counted in 'sample plot A', constituting 71 individual trees, while, sixty (60) individual trees distributed in twenty three (23) species and 15 different families were counted in plot B (Table 6).

Table 5: Diversity and Frequency of Tree Species in Sample 'Plot A' Otemewo community

Tree species	Family	Vernacular	F	RD	*Status
Albiziazygia	Fabaceae	Albizia, Avu	1	1.41	R
Alchorneacordifolia	Euphorbiaceae	Christmas bush	4	5.63	VA
Alstoniaboonei	Apocynaceae	Akpa, Alstonia	4	5.63	VA
Alstoniacongensis	Apocynaceae	Alstonia, Ukhu	2	2.82	O
Anthocleistavogelii	Potaliceae	Cabbage tree	6	8.45	VA
Antidesmavenosum	Phyllanthaceae	Okoloto	2	2.82	O
Berliniagradiflora	Fabaceae	Berlinia	2	2.82	O
Aubrevilleaplatycarpa	Fabaceaea	Aubrevillea	1	1.40	R
Carapasprocera	Maliaceae	Crabwood	1	1.41	O
Ceibapentandra	Bombacaceae	Ceiba, Cotton tree	2	2.82	R
Eleaisguineensis	Arecaceae	Wild oil palm	9	12.8	VA
Entandrophragmacylindricum	Meliaceae	Sapele, Cedar	2	2.82	O
Ficusexasperata	Moraceae	Sandpaper	1	1.41	R
Funtumiaelastica	Apocynaceae	Bush rubber, Ayon	3	4.23	A
Garcina kola	Clusiaceae	Bitter cola	2	2.82	O
Heveabrasilensis	Euphorbiaceae	Rubber tree	5	7.07	VA
Irvingiagabonensis	Irvingiaceae	Ogbono	2	2.82	O
Khayaivorensis	Meliaceae	Lagos mahogany	2	2.81	O
Khayasenegalensis	Meliaceae	Okpe, Okpan	1	1.41	R
Lophiraalata	Ochnaceae	Eki, Red ironwood	1	1.41	R
Lophiralanceolata	Ochnaceae	Dwarf red iron	2	2.82	O
Musangacecropioides	Urticaceae	Umbrella tree	5	7.04	VA
Pentaclethramacrophylla	Fabaceae	Ogba, Ugba	1	1.41	R
Prioriamannii	Caesalpiniaceae		2	2.81	O
Pterocarpusmildbraedii	Fabaceae	Rosewood, Oha	3	4.22	A
Tetrapleuratetraptera	Fabaceae	Aidan	1	1.41	R
Tremaorientalis	Cannabaceae	Charcoal tree, Trema	1	1.41	R
Vitexgrandifolia	Verbenaceae	Black plum	3	4.23	A

***** VA=Abundant, V=abundant, F=Frequency, O=Occasional, R=Rare, E=Endangered

Table 6: Frequency and Diversity of Tree Species in Sample 'Plot B' Otemewo community

Tree species	Family	Vernacular	F	RD	*Status
Albiziazygia	Fabaceae	Albizia, avu	2	3.33	F
Albiziaadianthifolia	Fabaceae	Albizia, avu	2	3.33	F
Alchorneacordifolia	Euphorbiaceae	Christmas bush	4	6.67	VA
Alstoniaboonei	Apocynaceae	Akpa, alstonia	4	5.00	VA
Alstoniacongensis	Apocynaceae	Ukhu, alstonia	3	6.67	VA
Anthocleistavogelii	Potaliceae	Cabage tree	2	3.34	F
Antidesmavenosum	Phyllanthaceae	Okoloto	1	1.67	R
Berliniagradiflora	Fabaceae	Berlinia	3	5.00	VA
Canthiumsubcordatum	Rubiaceae	Ureje	4	6.67	VA
Eleaisgeneensis	Arecacea	Wild oil palm	7	11.7	VA
Funtumiaelastical	Apocynaceae	Bush rubber, Ayon	2	3.33	VA
Garcina kola	Clusiaceae	Bitter cola	1	1.67	R
Harunganamadagascariensis	Clusiaceae	Otere	2	3.33	F

Heveabrasilensis	Euphorbiaceae	Rubber tree	4	6.67	VA
Irvingiagabonensis	Irvingiaceae	Ogbono	2	3.33	F
Khayaivorensis	Meliaceae	Lagos mahogany	2	3.34	F
Lophiraalata	Ochnaceae	Eki, Red ironwood	1	1.67	R
Musangacecropioide	Urticaceae	Umbrella tree	4	6.63	VA
Prioriamannii	Caesalpiniaceae		1	1.67	R
Pycanthusangolensis	Myristicaceae	Africa nutmeg	2	3.33	F
Spodiasmonbins	Anacardiaceae	Monbins, Ijikere	4	6.67	VA
Prosopisafricana	Fabaceae	Okpei, Iron wood	1	1.67	R
Uapacaguineensis	Phyllanthaceae	Red cedar, Uapaca	2	3.33	F

*VA=Very Abundant, A=Abundant, F=Frequent, O=Occasional, R=Rare, E=Endangered

A. cordifolia, Anthocleistavogelii A. boonei, E. guineensis, H. brasilensis, and M. Cecropioides had the highest frequency, and were very abundant in the sample plots. Only ten (10) species(B. cogolensis, E. cylindricum, I. gabonensis, K. senegalensis, L.alata, L. lanceolata, P. africana, P. macrophylla, T. orientalisand U. guineensis) of the twenty eight (28) tree species recorded as trees used for charcoal production existed in the two sample plots, and are comparatively rare. Moreover, 16 of the tree species (B. cogolensis, B. grandifolia, B. fistuloides, B. nigerica, B. spiciformis, E. sauveolen, F. sycamorus, P. brevipes, P. africanum, P. africana, R. racemosa, R. racemosa, S. afzelii, S. stipulatum, S. guineense, and T. africana) cited as charcoal tree species in Table 2 were not encountered in the two sampling plots. Thus, they were considered endangered with the exception of R. racemosa and R. mangle which are exclusively mangroves, and existed only in swampland.

The diversity indices of the trees in plots (A and B) are presented in Table 7. Slight distinction existed in the compared sampling plots.The tree diversity indices show that plot A is richer in tree species compare to plot B. The ‘‘d value’’ for plot A suggests higher richness compare to plot B.

Table 7: Tree Diversity Indices in the Sample Plots of the Study Area

Tree diversity indices	Otemewo community (Okpe)	
	Plot A	**Plot B**
Shannon-Wiener index (H)	3.115	3.000
Quatibility index (E)	0.935	0.909
Menhinick index (d)	3.323	2.969
Total No of individuals	71	60
Total No of species	28	23
No of family	17	15
*Tmdbh range (cm)	9.2 - 48.0cm	8.5 – 43.2cm
*Tree mean diameter at breast height		

IV. DISCUSSION

The results obtained in the present study reveal that charcoal production in the study area yields considerable returns. The involvement of women in charcoal production suggested they were more dependent on income from the business than men. This observation is in line with those of [Anang et al., 2011] and [Smith et al., 2017] who asserted that as far as Charcoal processing is concerned, women are more in the industry than men, since the latter has some other alternative income generating options available to them. Charcoal makers usually operate by selective logging scheme, and the majority of trees mentioned in the production site were highly preferred for charcoal production. Their predilection for charcoal was premised on heaviness, hardness and the ability to yield charcoal which burn slowly with even intense heat.

Sixteen (16) out of the 28 charcoal-producing trees mentioned in the production site were not encountered in the two sample plots, their nonexistent could be due to exhaustion in the study area. Whereas, R. racemosa and R. mangle among the species reportedly mentioned by the interviewees as trees used for charcoal are exclusive mangrove. Most of the species mentioned by the interviewees were poorly represented in the sample plots having been logged. This observation is in consonant with [Hall et al., 2011] and [Mari-Mari, 2011]who noted that selective harvesting creates spatial distribution and reduces the abundance of timber tree species diversity, sometimes up to the point of local extinction. Incessant logging and unsustainable harvesting pattern of forest products incline towards species diversity crisis and the disappearance of forest ecosystem.

Presently majority of the trees in the plots are atypical for charcoal-production, they were far below the number that would be expected in a less-perturbed forest; and were mainly representative of secondary forest. These observations are in line with the earlier submissions of [Appiah, 2012] and [Kiruki, 2017] who asserted that dominance by a few tree species in a tropical forest indicates a less diverse forest community, changes in size class distribution and species composition. It was also observed that lumberer and charcoal makers often manipulate produce by harvesting non charcoal species for melds, to scale up supply in boom (when charcoal demand outweighed supply), yet as availability of preferred species diminishes in the supply base, sometimes lumberer penetrate reserves, and or exploited swampy ecotone for the desired species.

V. CONCLUSION AND RECOMMENDATIONS

The continuous operation of charcoal industry in Otemewo is unsustainable ecologically, although banning the industry outright might be counterproductive, as attempts had been made in several African countries [Girard, 2002], and recently in Kwara and Nasarawa States of Nigeria [Vanguard, 2018 and Independent, 2018] with little successes. Yet conservation of tree species diversity is significant for the survival and welfare of human. In the light of the foregoing, the need to preserve the integrity of the forest community is imperative. Consequently, the following recommendations are made: establishment of proper forest management programme in collaboration with the indigenous people and other stakeholders, this measure would check incessant harvest of forest trees and provide some insurance against tree diversity lose. In addition, there should be an established tree plantation meant for charcoal production as alternative to natural forest. Furthermore, the utilization of sawmill off-cut for charcoal production should be encouraged. It is envisaged that these strategies if properly executed would safeguard forest tree and check species diversity loss.

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