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EFFECT OF LAND COVER VARIATIONS ON THE FERTILITY STATUS OF SOILS OF UMUHU IN NGOR-OKPALA AREA OF IMO STATE

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ABSTRACT: *The study was conducted to ascertain the effect of four different land covers (cassava cultivated field (CCF), oil palm plantation (OPP), plantain plantation (PP) and forest land (FL)) on the fertility status of soils of Umuhu in Ngor-Okpala area of Imo State, Nigeria. Random sampling technique was used in the collection of soil samples from the four different land covers. The sampling was done at the beginning, middle and end of each land cover. Twelve (12) composite samples were collected from all the land cover types with 3 per land cover. The composite samples were prepared for routine laboratory analyses. Data generated were analyzed statistically using analysis of variance. The textural classes of all the sampled soils were of loamy sand. The soil which had plantain plantation as its cover had the highest pH (6.4), Total N (0.229 %), Soil organic matter 4.70%, Available P (27.05 mg kg^{-1}), Exch. Ca (6.492 cmolc kg^{-1}), Exch. Mg (3.942 cmolc kg^{-1}), Exch. K (0.953 cmolc kg^{-1}), Exch. Na (0.06 cmolc kg^{-1}), Exch. H (1.2 cmolc kg^{-1}) and CEC (28.4 cmolc kg^{-1}) with its Exch. Al in trace amount (<0.001 cmolc kg^{-1}). The soil under CCF, despite being under low cover, did not show much degeneration due to the shifting cultivation being practiced in the study location. However, the result obtained from the study indicated that the different land covers especially that under plantain plantation (PP) have affected the soils fertility at different rates. This observed factor is strongly controlled by high content of organic materials, a dense vegetative cover which mitigates erosion effects and the addition of ash as a means of fertilizing the soils under plantain plantation being practiced in the study area.*

KEYWORDS: Land Cover Variations, Land degradation, Soil Fertility Status, Shifting cultivation, Umuhu.

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INTRODUCTION

Presently, food security has been a major challenge facing many third world countries. The people residing in the Southeastern part of Nigeria spend over 70% of their monthly income on food due to the high cost of food items (Senjobi, 2007). John *et al.* (2013) reported that one of the greatest problems facing most African countries is the inability to grow enough food for their increasing population. This problem has resulted in malnutrition and poverty among the rural dwellers (Senjobi, 2007). Investigations have shown that soil infertility due to land degradation has been a major constraint to food production (Agbede & Adekiya, 2012; Eswaran *et al.,* 2001).

A combination of biophysical, socio-economic and political factors is the major cause of land degradation. Among socio-economic factors, population pressure plays a great role in the process through increasing deforestation, overgrazing, intensive cultivation and overexploitation of other natural resources (Geist & Lambin, 2004). This diminishes potential productivity and the economic utility of land. Not only the size or density of the population but also how the people use the land increases land degradation (Mitiku *et al*., 2006). The deterioration in agricultural productivity reduces the economic value of the land and forces the farmers to invest in more input and cultivating marginal lands. The recent global land use change assessment estimates that the 10% (1.5 billion hectare) of present agricultural land will become 30% of the global land at the expense of forest land, particularly in tropical regions, by the year 2050 (Bringezu *et al*., 2014).

According to Nyssen *et al.* (2004), the unsustainable land cover changes are recognized as the main factors in the process of land resource degradation. Land cover is the physical and biological cover of the earth's surface, such as vegetation, water, organisms, soil, and structures created by human activities (Lambin *et al*., 2003). The human activities in utilizing and managing these land resources mainly affect the biophysical characteristics. This may include conversion of grazing to cropping, from traditional farming to modern and intensive cultivation, deforestation and planting exotic species, and conversion to non-agricultural uses. Globally, natural events like volcanic eruptions, flooding, fire, climate fluctuations, and ecosystem dynamics may modify the earth's land cover but anthropogenic activities have more influence (Meyer, 1995).

Inappropriate land cover change (like deforestation, overgrazing, and expansion of agricultural lands) leaves the land barren, which reduces the biomass (vegetation cover) and results in a decline in soil organic matter content, availability of nutrients and soil moisture. The lower organic matter content decreases the moisture holding capacity and nutrient availability in the soil. The soil bulk density increases as organic matter decreases, which affects the aggregate stability of the soil and the movement of water and nutrients through it. This also affects plant root penetration and biological activities in the soil (Gardner *et al*., 1999). But as soil organic matter increases, aggregate stability will be maintained by the increasing cohesion of aggregates, which reduces the loss of fine soil particles. With the increasing organic matter content, nitrogen mineralization also increases (Mao & Zeng, 2010). Organic matter may also maintain the soil pH. Soil pH manipulates the availability of essential soil nutrients which affects plant growth and soil quality as a whole (Wong, 2003). In acidic soil, as the pH lowers, the availability of micronutrients like aluminum and iron may be dominant and the toxicity of these nutrients may increase. In alkaline soils also, the availability of calcium and magnesium may increase, but as the pH increases, sodium toxicity

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may increase. The availability of phosphorus and other essential elements may be maintained when the soil is around a neutral pH condition. Soil degradation is one of the major factors that hinder agricultural land productivity. Due to the vegetation cover change which reduces organic matter and nutrients available to plants, the productivity of the land will decrease. Little or not much information is available on the effect of land cover change in this part of the country vis-a-vis the farming practice obtainable in the study location. It is against this backdrop that this study seeks to investigate the effects of land cover variations on the fertility status of soils in Umuhu, Ngor-Okpala area of Imo State.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Umuhu, Ngor-Okpala area of Imo State. Imo State is located in the Southeastern part of Nigeria. It has an area of about 561 km^2 and a population of about 159,932 as at the 2006 census. It lies within the humid tropical climate with an average annual temperature of 26ºC. The rainy season begins in April and lasts until October with annual rainfall varying from 1500 mm to 2200 mm (Akagha *et al*., 2021). The area has a gently undulating lowland topography whose height varies from a minimum of 40 m to a maximum of 122 m above sea level. The average height of the study area is about 71 m above sea level. Geologically, the study area lies within the deltaic depositional environment of Southern Nigeria (Uzoukwu, 2007). The uppermost formation of this environment is the Coastal Plain sands otherwise known as the Benin Formation which is the youngest in the Niger Delta Sedimentary Basin of Nigeria. The formation is underlain by the Agbada Formation which was laid down in paralic, brackish marine fluviatile, coastal and fluvio-marine environments and this formation consists of interbedded sands and shale. The Akata Formation is overlain by the Agbada Formation and this formation is shalier than the above two formations (Obianwu *et al*., 2011).

Soil Sampling

A reconnaissance survey of the entire area was first undertaken to enable the identification of areas having comparative advantages in terms of different land covers such as forest, cassava, plantain and palm oil, and also to get familiarized with the environment. A total of 12 sites (3 cassava farms, 3 plantain plantations, 3 oil palm plantations and 3 forests) were selected from Umuhu community, Ngor-Okpala. Random sampling was used for sample collection. Soil samples were collected at 0-15 cm depth, using soil auger. Three (3) samples were collected at the beginning, middle and at the end from each of the 12 sites, given a total of 36 samples. However, the samples collected from each of the sites were homogenized to get 12 composite samples for the study. Below is the map of the sampled location (Figure 1).

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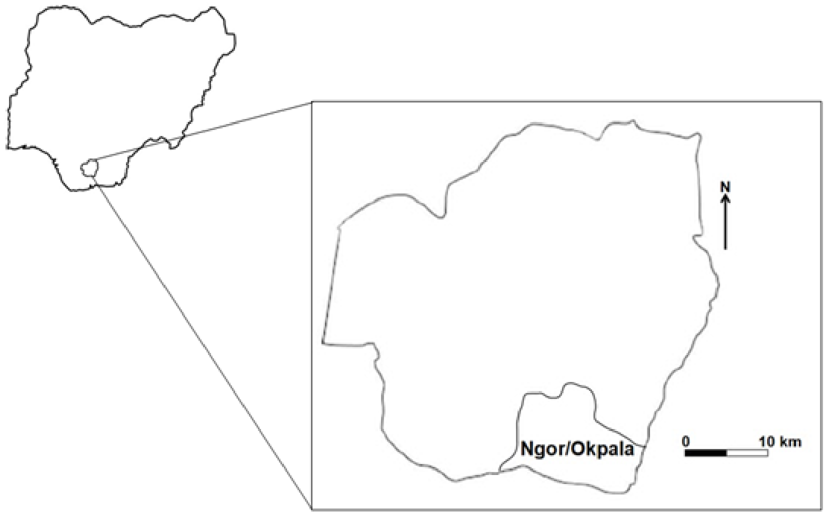

Figure 1: Map of Imo State showing the study location (**Credit:** This Study)

Laboratory Analysis

The composite soil samples collected were air dried, crushed and sieved through 2 mm sieve. The sieved soil samples were used to determine the physical and the chemical properties of the soil. Particle size distribution was determined by the hydrometer method (Gee & Or, 2002). Soil pH was measured using 1:2.5 soil-water ratio using a pH meter (Thomas, 1996). Organic carbon was measured using a modified Walker-Black wet digestion method (Nelson & Sommers, 1982). Total nitrogen was determined by MicroKjeldahl digestion technique (Bremner, 1996). Available phosphorus was extracted using Bray 2 method and the phosphorus was determined by the molybdenum method (Olsen & Sommers, 1982). Exchangeable acidity was obtained by the method described by McLean (1982). Exchangeable bases and CEC were determined by neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982).

Data Analysis

The data generated from the laboratory analysis were analyzed statistically using the completely randomized design of analysis of variance (ANOVA) at 5% level of probability. The mean variation in soil fertility characteristics among the land covers were compared by using Tukey's HSD test at $P < 0.05$.

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RESULTS AND DISCUSSION

The particle size distribution of the soils under different land covers were presented in Table 1. The textural class of all the land cover types considered fall within loamy sand. The sand content under the different land cover showed no significant (P < 0.05) difference. The percentage sand ranged from 82.0-86.0% for soil under cassava cultivated farm (CCF), 80.0-84.0% for soil under oil palm plantation (OPP), 80.0-82.0% for soil under plantain plantation (PP) and 82.0-86.0 % for soil under forest land (FL). The silt fraction had no significant (P < 0.05) effect among the four different land covers. The mean percentage silt ranged from 5.67% to 7.67% with the PP (7.67%) having the highest % silt mean value. The clay fraction was also not significantly influenced by the different land covers, with its highest mean value in OPP (11.67%) and the lowest mean value in CCF (9.67%). Despite the no significant difference in particle size distribution, the soils under the different land covers in this study have high sand particles compared to other fine earth fractions. This is because of the predominance of sand fraction in the study area. This is similar to the findings of Onyekanne *et al*. (2012) that the soils of the coastal plain sand are coarse grained and are devoid of cementing agents such as organic and inorganic colloids. The silt-clay ratios also gave no significant difference among the four different land covers evaluated in this study. The mean values were 0.65, 0.48, 0.73 and 0.52 in CCF, OPP, PP and FL respectively. According to FAO (1990), a silt-clay ratio of less than 0.20 signifies a low degree of weathering. However, Ayolagha (2001) stated that old parent materials usually have a SCR below 0.15 while SCR above 0.15 is indicative of young parent materials. Interestingly, the results of this study showed that all the soils had silt-clay ratios above 0.2 and 0.15 indicating a high potential degree of weathering in all the soils.

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Table 1: The results of the physical properties of the soil under different land covers

Covers	Sites	Sand	Silt	Clay	SCR	Texture
			(%)			
Cassava	1	84.0	7.0	9.0	0.77	Loamy Sand
Cultivated	2	86.0	5.0	9.0	0.55	Loamy Sand
Farm (CCF)	3	82.0	7.0	11.0	0.64	Loamy Sand
Mean		84.0[a]	6.33[a]	9.67[a]	0.65[a]	
Oil Palm	1	84.0	5.0	11.0	0.45	Loamy Sand
Plantation	2	80.0	7.0	13.0	0.54	Loamy Sand
(OPP)	3	84.0	5.0	11.0	0.45	Loamy Sand
Mean		82.67[a]	5.67[a]	11.67[a]	0.48[a]	
Plantain	1	80.0	7.0	13.0	0.54	Loamy Sand
Plantation (PP)	2	82.0	7.0	11.0	0.64	Loamy Sand
	3	82.0	9.0	9.0	1.0	Loamy Sand
Mean		81.33[a]	7.67[a]	11.0[a]	0.73[a]	
Forest Land	1	82.0	5.0	13.0	0.38	Loamy Sand
(FL)	2	82.0	7.0	11.0	0.64	Loamy Sand
	3	86.0	5.0	9.0	0.55	Loamy Sand
Mean		83.33[a]	5.67[a]	11.0[a]	0.52[a]	

Note: The distinct alphabet in a column displayed statistical difference ($P < 0.05$).

The variation in the land cover had a significant impact on the soil pH (Table 2). The results of the soil pH of the land cover types were generally acidic, according to the rating of Singer and Munns (1999). The mean values showed that CCF (5.70), OPP (5.73) and FL (5.27) were moderately acidic while PP (6.13) was weakly acidic. The results from Table 2 showed that there is a change in total nitrogen (TN) level in the four different land covers under evaluation. The TN ranges from 0.168-0.229% with the highest mean value from the PP (0.229 %) and the lowest from FL (0.168%). This work was not in agreement with the work of Yimer *et al*. (2007), who found that the N content is significantly lower in cropland in comparison with forest lands. This might be as a result of shifting cultivation farming practices being carried out by the farmers in the study location. The famers in the study location allow their farms to fallow for four years before cultivating on the said farm again. The lower N contents in the cropland which is represented by CCF in this study comparable to PP may be due to tillage, since soil tilling enhances susceptibility to erosion (Funderbury, 2016).

The land cover type showed no significant difference with soil organic matter content (Table 2). Soil organic matter (SOM) ranges from 3.647-4.70% which is generally higher than the

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critical level of 3% as specified by Akinrinde & Obigbeson (2000). Despite not been significant the higher amount of SOM found in soils under PP cover is as a result of litters and organic ash deposition. It might also be due to low mineralization (Osujieke *et al.*, 2017). Available P has mean values of 18.96, 5.60, 27.05 and 9.64 mg kg^{-1} in CCF, OPP, PP and FL respectively. The phosphorus content in PP is high (> 20 mg kg^{-1}) according to the rating of Enwezor (1990). Uzoho & Oti (2004) stated that an increase in soil acidity (pH < 5.0) reduces phosphorus availability in the soil as P is fixed more in highly acidic soils. Nevertheless, the studied soils of PP had pH > 5.5 which is well within the ideal pH (5.5-7.0) for optimal crop growth and sustainability.

Table 2: The results of soil pH, organic matter (OM), total nitrogen (TN) and available phosphorus (Av. P) under different land covers

Covers	Sites	Soil pH (H_2O)	Total Nitrogen (TN)	Soil Organic Matter (SOM)	Available Phosphorus
			(%)		mg kg^{-1}
Cassava	1	5.6	0.196	4.391	10.26
Cultivated Farm	2	5.9	0.182	4.083	38.24
(CCF)	3	5.6	0.196	4.391	8.39
Mean		5.70^{a}	0.191^{ab}	4.288^{a}	18.96^{b}
Oil Palm	1	5.5	0.238	5.085	5.6
Plantation	2	5.8	0.14	2.774	4.66
(OPP)	3	5.9	0.168	3.082	6.53
Mean		5.73^{a}	0.182^{ab}	3.647^{a}	5.60^{d}
Plantain	1	6.1	0.252	5.393	27.98
Plantation	2	5.9	0.224	4.546	13.99
(PP)	3	6.4	0.21	4.16	39.17
Mean		6.13^{a}	0.229^{a}	4.700^{a}	27.05^{a}
Forest Land	1	5.0	0.168	4.083	5.6
(FL)	2	5.5	0.182	3.775	6.53
	3	5.3	0.154	3.698	16.79
Mean		5.27^{b}	0.168^{b}	3.852^{a}	9.64^{c}

Note: The distinct alphabet in a column displayed statistical difference (P < 0.05).

Table 3 shows the mean values of Exchangeable Ca, Mg, K and Na (2.550, 1.971, 0.619 and 0.045 cmolc kg^{-1} respectively for soils under CCF cover; 3.130, 1.739, 0.468 and 0.053 cmolc kg^{-1} respectively for soils under OPP cover; 6.492, 3.942, 0.953 and 0.060 cmolc kg^{-1} respectively for soils under PP cover; and 2.550, 2.203, 0.334 and 0.047 cmolc kg^{-1}

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respectively for soils under FL cover. There were significant ($P < 0.05$) variations in all the basic cations evaluated on the different land covers except that found in K. However, critical values of basic cations as reported by Esu (1991) showed that soils under this study have medium to high basic cations for various land cover types. Ca was medium in all the land covers except that found under PP while Mg and K were high in all the land cover types. Exchangeable Na was found to be at the lower range for all the land covers evaluated in this study. Despite K not showing significant variation, PP had the highest mean K value of K (0.953 cmolc kg^{-1}). This could be attributed to the common practice by farmers in the study location, where the use of ash especially ash from palm produce serves as a means of fertilizing their plantain plantation (PP).

Aluminum had the highest value record at FL (1.20 cmolc kg^{-1}) and lowest at PP (< 0.001 cmolc kg^{-1}) land covers respectively. Elevated aluminum toxicity is prevalent on most soils suffering acidity problems (FAO, 2002). However, the pH value obtained in this study indicates a moderate to weakly acidic pH value for the different land covers evaluated, implying no aluminum toxicity. Hydrogen had its highest value on PP cover (1.2 cmolc kg^{-1}) with its lowest on OPP cover (0.3 cmolc kg^{-1}), a function strongly controlled by pH.

Cation exchange capacity (CEC) of the different land covers has the highest value at PP (28.4 cmolc kg^{-1}) while the lowest was on OPP (26.4 cmolc kg^{-1}). The soil CEC under the different land covers were generally high (>12 cmolc kg^{-1}) when compared with the ranking of (Esu, 1991). However, CEC showed no significant variation among soils under the studied land cover types. The lower CEC obtained from OPP might be a function of the soil's pH level (Okunsami & Oyediran, 1985).

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Table 3: The results of Exchangeable Ca, Mg, K, Na, Al, H and Cation exchange capacity (CEC) under different land covers

Covers	Sites	Ca	Mg	K	Na	Al^{3+}	H^{+}	CEC
		(cmolc kg^{-1})						
Cassava	1	2.435	1.739	0.803	0.046	0.6	1.4	27.2
Cultivated	2	3.130	1.391	0.452	0.045	0.4	0.2	26.4
Farm (CCF)	3	2.087	2.782	0.602	0.044	1.2	0.2	28.0
Mean		2.550^{b}	1.971^{b}	0.619^{a}	0.045^{b}	0.7^{a}	0.6^{ab}	27.2^{a}
Oil Palm	1	3.478	0.696	0.452	0.052	1.2	0.2	27.6
Plantation	2	2.782	1.739	0.401	0.053	0.8	0.4	25.2
(OPP)	3	3.130	2.782	0.552	0.055	0.6	0.4	26.4
Mean		3.130^{b}	1.739^{b}	0.468^{a}	0.053^{ab}	0.9^{a}	0.3^{b}	26.4^{a}
Plantain	1	7.652	4.869	0.502	0.055	0.0	1.0	32.4
Plantation	2	5.217	3.478	0.301	0.049	0.0	1.4	24.8
(PP)	3	6.608	3.478	2.057	0.076	0.0	1.2	28.0
Mean		6.492^{a}	3.942^{a}	0.953^{a}	0.060^{a}	0.0^{b}	1.2^{a}	28.4^{a}
Forest Land	1	2.087	2.087	0.301	0.047	1.6	0.4	32.0
(FL)	2	2.782	2.087	0.301	0.048	1.0	0.4	25.6
	3	2.782	2.435	0.401	0.047	1.0	0.4	26.0
Mean		2.550^{b}	2.203^{b}	0.334^{a}	0.047^{ab}	1.2^{a}	0.4^{b}	27.9^{a}

Note: The distinct alphabet in a column displayed statistical difference ($P < 0.05$).

CONCLUSION

It was observed that the different land cover types influenced the soil properties after due examination of the sampled soils. However, soils under PP recorded a high level of pH, SOM, total nitrogen, available P, Ca, Mg, K, Na and CEC over soils under CCF, OPP and FL. The soils under CCF did not show much degeneration due to the shifting cultivation being practiced in the study location. However, PP had more soil fertility attributes than the other land covers which resulted from a high content of organic materials, a dense vegetative cover which mitigates erosion effects, and the addition of ash as a means of fertilizing the soils under plantain plantation.

However, the use of ash as a management practice for sustainable agriculture should be encouraged. This strategy could help to promote the physicochemical properties. Finally, the above suggested agricultural practices should be complemented with strong land use policies as part of the strategy for sustainable agricultural development in the study area.

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