Soil Physicochemical Properties as Influenced by Land Use Practices in Ifite Ogwari, Anambra State

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ABSTRACT

Land use remains one of the major factors that can degrade soil properties with consequences on the provision of ecosystem services. This study was conducted at the faculty of Agriculture, Ifite Ogwari annex of Nnamdi Azikiwe University to investigate the influence of land use practices on selected physicochemical properties of soil. Three land use types (cassava farm, rice farm, grassland) with different histories were selected for the study. Soil samples were taken from each of the land use types in three replicates at 0-20cm and 20-40cm depths. To determine the physicochemical properties of soil under the land use types, samples were subjected to laboratory analysis. Data generated were subjected to statistical analysis and Duncan's multiple range test was used to separate significant means at 5% probability level. The results showed a predominant clay textural class under the land use types. Highest soil bulk density and lowest total porosity was obtained under cassava farm with values of 1.94 g/cm^3 and 30.31% respectively at 20-40cm depth. Soil hydraulic conductivity under the land use types ranged from 0.01- 0.03cm/hr. Aggregate stability of soils ranged from 0.32-0.56 across the depths. The silt clay ratio under land use types was generally low and showed a highly weathered soil. The soil pH was generally acidic. Soil organic carbon was generally low and ranged from 0.40-1.32% across the depths. The total nitrogen ranged from 0.01- 0.11% which was generally low across the depths. Available phosphorus was highest under cassava farm with a value of 8.33mg/kg at 0-20cm depth while grassland had the lowest available phosphorus content with a value of 0.86 mg/kg at 20-40cm depth. The cation exchange capacity under land use types ranged from 5.89 -8.65 cmol/kg at 0-20cm depth and 3.68 -7.55 cmol/kg at 20-40cm depth. It was generally observed that soil nutrients decreased as the depth increased. The studied land use types influenced the selected soil properties and this calls for soil conservation practices that could improve soil productivity.

INTRODUCTION

Soil is the basis of agriculture and natural plant communities and according to Ogunkunle (2015) it remains the root of food shortage, food insecurity or undernourishment which has assumed global dimension in the last three decades. The inherent quality of Nigerian soils is generally low, hence they are easily degraded in terms of physical, chemical and biological properties as soon as the land is opened up for cultivation and other kinds of uses. According to the report of Terr Africa in 2006 about 20% of the world's agricultural lands have been irreversibly damaged due to accelerated land degradation and intensive land use, leading to a reduction of about 15-30% of their productivity. Furthermore, land resources have been altered by rapid land use accelerated by changeable socio-economic factors including high population growth, rapid urbanization (Fabiyi, 2006) as well as agricultural intensification and government policies. Human activities exert tremendous effects on land cover through a variety of land uses and have altered the structure and functioning of the ecosystem (Turner *et al.*, 1994). Most soils in southeastern Nigeria are formed from sandy parent materials and occur mainly in the high rainfall areas hence they are fragile, highly leached, acidic and subject to water erosion (Udom *et al.,* 2013) and this calls for special attention for their proper management to ensure sustainable agricultural productivity and environmental quality. There is a growing need for information relating to soil conditions, their current status, changes due to land use types and management practices and appropriate conservation measures to ensure sustainable land utilization. Therefore, exploring ways and means to optimize sustainable land use, management and recovery suitable to develop strategies against low productivity and to enhance the provision of ecosystem services is important.

MATERIALS AND METHODS

The study was conducted at the Faculty of Agriculture, Ifite- Ogwari annex of Nnamdi Azikwe University situated in Ayamelum Local Government Area of Anambra State. The area lies within latitude 6^{0}14'28" N and 6^{0}14'51"N and longitude 7^{0}6'46" E and 7^{0}6'47" E. The soils are of Imo shale geologic formation (FDALR, 1990). According to Chukwu (2007), the vegetation of Ifite Ogwari is derived savanna with some patches of rainforest. The natural vegetation consists of grasses and trees. It experiences two major seasons of rainy season and dry season. The rainy season starts at the end of the month of March and lasts till October, while the dry season starts from the month of November and ends in the month of February. Data from Nigeria meteorological Agency for the year 2022 showed that Ifite ogwari had an annual rainfall of 2737.4mm and relative humidity of about 70%. The inhabitants of this region are predominantly farmers having rice, cassava, plantain and okra as their major food crops.

Description of land use practices in the study area

Three land use types namely; cassava farmland, grassland and rice farm were selected for the study**.** The selection of these land use types were based on the common farming practices within the study area**.** The grassland had been under grass cover for over three (3) years having spear grass, bahamas grass (*cynodon dactylon*), *panicum maximum, Elusine indica,* as well as *mimosa pudica* as dominant species. The rice farm had been under continous rice cultivation for over 5years while the cassava farm had been under continuous cultivation of cassava which sometimes is intercropped with maize and yam for more than 6 years. These farmlands (cassava and rice farms) are usually rainfed and cleared of weeds using herbicides.

Soil Sampling and Handling

Disturbed and undisturbed soil samples were collected with the aid of auger and core samplers from each of the land use types in three replicates at 0-20cm and 20-40 cm depths. The collected soil samples were bagged, properly labelled, air dried, and taken to the laboratory for analysis of selected physicochemical properties of soil.

Laboratory Analysis

The following physical and chemical properties of soil were carried out in the laboratory.

i. Particle size Distribution: The hydrometer method as described by Gee and Or (2002) was used to determine the particle size distribution of the samples, while the soil textures were determined using the USDA Textural triangle.

ii. Bulk Density: The bulk density was determined by core method as described by Grossman and Reinsch (2002)

iii. Soil Total Porosity: This was calculated from the bulk density as shown in this equation:

$$\text{Total porosity (\%)} = (1 - \frac{\text{Bd}}{\text{pd}}) \times 100$$

Where Bd =Bulk density
Pd =particle density (2.65g/cm^3)

iv. Saturated Hydraulic conductivity (k_{sat}): Saturated hydraulic conductivity was determined by the constant head permeability procedure according to Young (2001). Darcy's equation for vertical flow of liquid was used for the computation of K as shown in the equation:

$$K_{sat} = \frac{QL}{AT\triangle H}$$

Where Q is water discharge (cm), L is length of soil column, A is the interior cross-sectional area of the volume of soil not occupied by soil column (cm), H is the head pressure difference causing the flow and it is dimensionless, T is the time of flow measured in seconds.

v. Gravimetric Moisture Content: Moisture content of the soil was determined by oven drying at a temperature of 1050C and percentage of moisture in soil calculated mathematically as follows:

$$GMC = \frac{W2-W3}{W3-W1} \times 100$$

Where W_1=Weight of the can
W_2=Weight of wet sample + can
W_3=Weight of oven dried sample + can

vi. Soil pH was measured electrometrically by glass electrode in pH meter in both KCI (1 N) and distilled water suspension using a soil: liquid ratio of 1: 2.5 (International Institute for Tropical Agriculture, 1979)

vii. Soil organic carbon was determined using the wet dichromate oxidation method of Walkley and Black (1934). Organic matter was calculated by multiplying the value of organic carbon by a factor of 1.724 (Van Bemmelen factor).

viii. Total Nitrogen (TN): This was determined by the Kjeldahl digestion method according to Jackson (1965).

ix. Exchangeable Basic Cations (calcium, magnesium, potassium and sodium): These were extracted in 1N, NH_4OAC at pH 7 and was followed by Calcium and Magnesium determination using Atomic Absorption Spectrophotometer and Potassium, Sodium determination using flame photometer.

x. Exchangeable acidic cations: Hydrogen and Aluminum was estimated titrimetrically.

xii. Available phosphorus: Bray II method was used according to Olsen and Sommer (1990).

xii. Base Saturation: This was calculated on a percentage basis by dividing total exchangeable bases (Ca^{2+}, mg^{+}, K^{+}, Na^{+}) by cation exchange capacity multiplied by 100%.

$$BS = \frac{TEB}{CEC} \times 100$$

xiii. Cation Exchange Capacity (CEC): This was computed as the sum of the exchangeable bases and the exchange acidity.

CEC= TEB+ TEA

xiv. Exchangeable Sodium Percentage (ESP): This was calculated by dividing the exchangeable sodium by available CEC as shown in the equation:

$$ESP = \frac{\text{Exchangeable Na value}}{CEC} \times 100$$

Where TEB=Total Exchangeable Bases
CEC=Cation Exchange Capacity

Statistical Analysis

Data collected were subjected to analysis of Variance using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Significant difference between the means were separated using Duncan's multiple range test at 5% probability level.

RESULTS AND DISCUSSION

Physical properties of soil in relation to land use types

The results in table 1 showed that the soils under rice farm had the highest sand content of 388 g/kg at 20-40cm depth while the soils under grass cover had the lowest sand content of 306 g/kg at 0-20 cm depth. Cassava farm had the highest and lowest mean clay contents of 495g/kg and 392 g/kg at 20-40 cm and 0-20 cm depths respectively. Highest silt content with a value of 280 g/kg was obtained under cassava farm at 0-20cm depth while grassland had the lowest silt content of 173g/kg at 20-40cm depth. The soils under the studied land use types were predominantly of clay textural class with the exception of cassava farm with clay loam texture. Soil bulk density was highest under cassava farm having a value of 1.94 g/cm^3 at 20-40cm depth and lowest under grassland and rice farm with values of 1.60g/cm^3 respectively at 0-20cm depth. Soil bulk density under land use types were not significantly different however the highest bulk density obtained under cassava farm could be attributed to the activities and management practices during the cultivation process. The study observed that soil bulk density increased with an increasing depth and could be as a result of low organic matter content as well as pore space distribution which corroborates with the findings of Singh *et al*., (2015). Grassland and rice farm recorded the highest total porosity with equal values of 39.81% respectively at 0-20cm while cassava farm recorded the lowest total porosity having a value of 30.81% at 20-40cm depth. Soil moisture content was highest under grassland with a value of 10.99% at 0-20cm depth while cassava farm had the lowest moisture content having a value of 5.84% at 20-40cm depth. Soil moisture content was significantly higher under grassland when compared with rice farm at 0-20cm depth. The hydraulic conductivity of soils under land use types were generally low and ranged from 0.01 - 0.03cm/hr. Aggregate stability of soils under the land use types were generally low and ranged from 0.32-0.56 across the depths; the low values of soil aggregate stability obtained revealed a less stable aggregates which could be as a result of exposure of the studied land use types to water erosion. However, the aggregate stability of soil under grassland was significantly higher than the rice farm at 0-20cm depth. The silt clay ratio under the studied land use types were generally low; it decreased as the depth increased. The lower the silt clay ratio the more weathered the soils become.

Table 1: Physical Properties of Soils as influenced by land Use types at 0-20cm and 20-40cm depths.

LAND USE	Depth (cm)	Bulk density (g/cm)^3	Total porosity (%)	Ksat (cm/hr)	Moisture Content (%)	Aggregate Stability	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural Class	SCR
Cassava farm (CM)	0-20	1.68bc	36.73a	0.02b	9.17ab	0.52ab	321a	280a	392a	Clay loam	0.80a
	20-40	1.94ab	30.81a	0.03b	5.84ab	0.47abc	314a	215a	495a	Clay	0.80a
Grassland (GL)	0-20	1.60c	39.81a	0.02b	10.99a	0.56a	306a	206a	486a	Clay	0.70a
	20-40	1.82abc	31.31ab	0.02b	7.17ab	0.49abc	326a	173a	473a	Clay	0.41a
Rice Farm (RF)	0-20	1.60c	39.81a	0.01b	6.13b	0.32c	325a	246a	428a	Clay	0.73a
	20-40	1.82abc	31.31ab	0.01b	8.81ab	0.37bc	388a	193a	405a	Clay	0.56a

Note: same alphabets represent non-significant difference while different alphabet represents significant difference. SCR- Silt clay ratio

Chemical Properties of soil in relation to land use types.

From the results obtained as shown in table 2, soil pH under the studied land use types ranged from 5.68-5.77 at the 0-20cm depth and 4.84-5.87 at 20-40cm depth. The pH of soil under land use types within the 0-20cm depth was moderately acidic and ranged from very strongly acidic to moderately acidic at 20-40cm depth across the land use types. Cassava farm had the highest soil organic carbon content with a value of 1.32% at 0-20cm depth while grassland had the lowest soil organic carbon content with a value of 0.40% at 20-40cm depth. The total nitrogen in soils of the studied land use types ranged from 0.01- 0.11% which was generally low across the depths. Available phosphorus was highest under cassava farm having a value of 8.33 mg/kg at 0-20cm depth while grassland had the lowest available phosphorus content of 0.86 mg/kg at 20-40cm depth. The total exchangeable cations (ca^{2+}, mg^{2+}, $k^{+,}$ Na^+) obtained in soils under land use types and across the depths varied from moderate, low to very low based on FDALR (1990) classification. Calcium content ranged from 1.80 -4.07 cmol/kg (very low to low), magnesium content ranged from 1.20-2.40cmol/kg (moderate), potassium content ranged from 0.17 -0.34cmol/kg (very low to low) while sodium content ranged from 0.08-0.22cmol/kg (very low to low). Total exchangeable acidity was highest with a value of 1.67 cmol/kg under cassava farm at 0-20cm depth while it was lowest with a value of 0.80 cmol/kg under grassland at 20-40cm depth. The cation exchange capacity of soils under land use types studied ranged from 5.89 -8.65 cmol/kg at 0-20cm depth and 3.68 -7.55cmol/kg at 20-40cm depth. The cation exchange capacity of soils under cassava farm was significantly higher compared to other land use types. The cation exchange capacity of soils under the land use types studied were generally low and could be a reflection of the soil's inability to retain nutrients as reported by Nwosu *et al*. (2020). Highest exchangeable sodium percentage was obtained in cassava farm with a value of 3.21% at 20-40cm depth while the lowest was obtained under rice farm at 0-20cm depth having a value of 1.52%. Exchangeable sodium percentage identifies the degree to which the exchange complex of a soil is saturated with Na^+. A soil is considered sodic (high level of Na^+) when the ESP is 6 or greater; however the results obtained in this study were less than 6 and could imply a non-sodic soil. The soil base saturation under the land use types ranged from 78.20-82.23% which decreased as the depth increased. The percentage base saturation is often considered to be an indication of soil fertility. This study showed that the soil base saturation under the land use types was high based on Landon (1991) classification who classified soil with percentage base saturation of <20% to be low, 20-60% to be medium and >60% to be high in fertility. The general decrease in nutrients as the depths increased in this study could be attributed to the vertical loss of nutrients from the soil surface to the sub surface.

Table 2: Chemical Properties of Soils as influenced by land use types at 0-20cm and 20-40cm depths.

Land use	Depth (cm)	pH	SOC (%)	SOM (%)	TN (%)	AvP (Mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	H^+	TEA	CEC	ESP (%)	BS (%)
							←		Cmol/Kg					→		
CF	0-20	5.77a	1.32a	2.27a	0.11a	8.33a	4.07a	2.40a	0.34a	0.18ab	1.03a	0.63a	1.67a	8.65a	2.03bc	82.23ab
	20-40	5.87a	1.25a	2.14ab	0.10a	6.81a	3.46abc	2.07ab	0.30abc	0.22a	0.83ab	0.40bcd	1.26abc	7.12ab	3.21ab	82.03ab
GL	0-20	5.71a	0.49bcd	1.26bcd	0.06ab	3.54ab	2.67abc	1.60ab	0.32ab	0.18ab	0.86ab	0.27cd	1.13bcd	5.89ab	2.90ab	79.70ab
	20-40	4.84b	0.40cd	0.71cd	0.01bc	0.86ab	1.80c	1.20b	0.17d	0.08c	0.50cd	0.23d	0.80ed	3.68bc	2.23abc	78.20ab
RF	0-20	5.68a	1.21a	2.09ab	0.10a	6.67a	3.46abc	1.80ab	0.19cd	0.10bc	0.93ab	0.45bc	1.38abc	6.92ab	1.52c	79.77ab
	20-40	5.61a	1.04ab	1.79ab	0.09a	5.95ab	3.67ab	2.00ab	0.21bcd	0.17abc	1.00ab	0.50ab	1.50ab	7.55ab	2.28abc	78.20b

Note: same alphabets represent non-significant difference while different alphabet represents significant difference; CM= Cassava Farm, GL=Grassland, RF= Rice Farm

CONCLUSION

The study observed that the studied land use practices influenced majority of the soil properties hence the low values obtained; this showed that land use and management practices usually cause changes to soil characteristics and oftentimes degrade the soils. For optimum soil productivity, appropriate conservation practices and measures are required to ensure sustainable land utilization which in turn improves the soil physicochemical properties.

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