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Land degradation rating under different land use types

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Abstract

Soil degradation is a major challenge to agricultural production and often leads to low crop yield in most parts of the world. Hence, a field study was carried out in the University of Ibadan to assess soil physical and chemical properties, and their level of degradation under different land use types. Six land use types consisting of fallow land (FL), arable land (AL), Oil palm plantation (OP), Residential land (RL), paddock (P) and valley bottom (VB) were identified and examined in this study. Disturbed and undisturbed soil samples were obtained from 0-3cm depth and analyzed for their chemical and physical properties using standard procedures. Soil colloidal fractions (organic matter, clay and silt) were integrated to estimate the soil structural stability index (S), while soil degradation rating (SDR) was determined from selected soil physical (Particle size distribution, bulk density and saturated hydraulic conductivity) and chemical (pH, organic carbon, total nitrogen and available phosphorus) properties. Data were analyzed using descriptive statistics and analysis of variance at α0.05. The land use types were slightly acidic with pH range of 5.7 (FL) to 6.9 (RL). Soil organic carbon differed significantly and was in the order: RL (29.8 g kg-1) > VB (20.0 g kg-1) > P(19.1 g kg-1) > FL (12.3 g kg-1) > OP (11.9 g kg-1) > AL (10.7 g kg-1). Significant differences were recorded for soil bulk density among the land use types. The VB had the lowest value (1.43 Mg m-3), followed by FL (1.52 Mg m-3), OP (1.64 Mg m-3), P (1.66 Mg m-3), RL (1.71 Mg m-3), and highest in AL (1.83 Mg m-3). The S also differed significantly among the land use types and was highest under VB (32.4), while AL had the lowest (3.1). On the average, AL, FL, OP, P and RL appeared to be moderately degraded, while VB was slightly degraded. The soil degradation rating mirrored the adverse effect of agricultural land use types, especially arable land, paddock and oil palm plantation on soil quality. Thus, soil conservation measures such as the use of organic fertilizers and organic mulch should be put in place in order to rehabilitate these land use types.

Keywords: Land use; Degradation; Disturbed soil; Undisturbed soil

1 Introduction

Soil degradation is a major limiting factor in crop cultivation. It is the reduction of soil physical and chemical fertility to a threshold that limits maximization of agricultural productivity (Ezeaku and Davidson, 2008). Omotayo and Chukwuka (2009) reported that soil degradation had severe negative impact on agronomic productivity of crops, environmental quality, food security and the overall livelihood of human beings. Hence, the decline in soil fertility resulting to soil degradation has been considered a major constraint facing agricultural productivity in sub-Sahara Africa, including Nigeria (Onwudike *et al*., 2015). Zhang *et al*. (2011) demonstrated that soil degradation remains a serious problem in most developing countries due to the mining of soil fertility and the problem of soil erosion due to periodic change in land use.

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Land use affects soil nutrient dynamics and other soil processes, such as erosion, oxidation, mineralization, and leaching etc. (Celik, 2005; Liu *et al*., 2013). It results to considerable alterations in soil properties (Fu *et al*., 2000). Though land use types vary considerably across the world, Benti and Balemi (2015) reported that improper land use and poor soil management practices are a great challenge to attempts to increase food production to meet the growing demand for food. For instance, in non-cultivated land, the type of vegetative cover influences the soil organic carbon content while soil quality diminishes after the cultivation of previously untilled soils (Liu *et al*., 2013). Thus, land use types impact natural resources, including soils (Ameztegui *et al*., 2016), while land use changes directly affect soil physical, chemical and biological properties (Gregorich *et al*., 2017).

Several phenomena have been reported to be responsible for soil degradation. Soil degradation resulting from soil erosion (Obi and Salako, 1995; Babalola *et al*., 2007; Oshunsanya *et al*., 2014), and continuous cropping (Brams, 1971; Adepetu *et al*., 1979; Juo *et al*., 1995) have been reported in several studies, while little attention has been given to the study of the effects of land use types on soil degradation. Therefore, this study was conducted to provide background information that will enhance the knowledge of soil degradation under different land use types.

2 Material and methods

2.1 Description of the study area

The study was conducted in the University of Ibadan, Ibadan, Nigeria. Ibadan is located between latitude 7° 23' N of the equator at a distance of about 145 km North-east of Lagos and longitude 3° 54' E of the Greenwich meridian. It is 750 m above sea level and covers a land area of 130 km^2. The University of Ibadan is located in the northern part of Ibadan, and it lies between latitude 7° 26' N and longitude 3° 54' E at an altitude of 277 m above sea level The site is characterized by a tropical climate with distinct rainy and dry seasons. The rainy season begins in March and ends in October. There is usually a lull in August, while the dry season starts in November and ends in March the following year. The average maximum and minimum temperatures are 32°C and 22°C, respectively.

2.2 Experimental setup

Six land use types were identified and selected for this study. The coordinates of the sites were taken with a Garmin etrex 20 geographical positioning system (GPS). The land use types which consist of fallow land (FL), arable crop land (AL), oil palm plantation (OP), residential land (RL), paddock (PD) and valley bottom (VB) are described as follows:

2.2.1 Description of land use types

Fallow land (FL)

This land is located opposite the Dairy Farm beside the Fire Service Station in the University of Ibadan. It is situated between latitude 7° 27.428′ N and 003° 53.897′ E, with an altitude of 215 m above sea level (GPS stand point: 4 m). The land is called a tableland having a flat slope. It was previously used for pasture cultivation and as a grazing land. Currently, the land is under fallow. The vegetation was predominantly grasses such as *Pennisetum purpureum* and shrubs.

Arable crop land (AR)

This land is located in the Experimental Farm at Parry Road, University of Ibadan. It is situated between latitude 7° 27.118′ N and longitude 003° 53.411′ E, and has an altitude of 206 m above sea level (GPS stand point: 2 m). The land has a gentle sloping surface and has been subjected to the actions of farm machines including ploughing and harrowing. The land has been put to cultivation of arable crops since the early 1960s. It has undergone many cycles of fallow and cropping over the years. The major crop grown include cassava and maize. Currently, cassava is grown on the land.

Oil palm plantation (OP)

This land is located beside the Old Dam Site at the Teaching and Research Farm of the University of Ibadan. It is situated between latitude 7° 27.276′ N and longitude 003° 53.409′ E with an altitude of 198 m above sea level (GPS stand point: 3 m). The plantation has a fairly flat to gently undulating land form, constituting the valley bottom land. The land has been cultivated with oil palm since the early 1960s. The application of N:P:K 15:15:15 was used to improve the fertility status of the soil until 1997 when fertilizer application seized. Bushy perennial shrubs such as Christmas bush (*Alchovnea cordifolia* and *Alchovnea laxiflor*) and annual herbs like *Ipomoea triloba, Ipomoea vegans* (climber) are some of vegetative undergrowth found, with a thick layer of organic materials covering the soil surface.

Residential land (RL)

This land is situated in Parry Road, University of Ibadan. It lies between latitude 7° 27.053′ N and longitude 003° 53.491′ E with an altitude of 227 m above sea level (GPS stand point: 4 m). The land was used as a farmland before it was converted to a residential area in the early 1960s. The predominant vegetation includes shrubs and grasses, with some trees observed in the location.

Paddock

The paddock is located within the Dairy Farm premises in the University of Ibadan. It is situated between latitude 7° 27.413′ N and longitude 003° 54.015′ E with an altitude of 209 m above sea level (GPS stand point: 2 m). The land is gently sloped. It has been used as a paddock for more than forty years. Grasses like *Panicum maximum* and *Pennisetum purpureum* are the vegetation that dominate the land.

Valley bottom (VB)

This land is located opposite the Faculty of Natural Renewable Resources, University of Ibadan, Nigeria. It lies between latitude 7° 27.488′ N and longitude 003° 53.895′ E, and has an altitude of 190 m above sea level (GPS stand point: 2 m). The land has a gentle slope. Gully erosion and siltation are active around the land due to inadequate and inappropriate drainage system. The land has been in use since 1985 for the Practical Year Training Program (PYTP) of 400 level students in the Faculty of Agriculture and Forestry. Over the years, the land has been cultivated to cowpea, vegetables, maize etc., with the use of organic (manure) and inorganic (N.P.K and urea) fertilisers. The dominant vegetation types are grasses such as *Pennisetum purpureum, Chromolaena odorata*, shrubs such as *Delonix regia, Newbouldia leavis*etc, herbs such as *Gomphrena celosiodes, Phyllanthus amarus, Peperomia pelucida* etc., and trees such as *Naucleadi derichii, Albizia saman, Adansonia digitata*. Also, fruit trees like banana and plantain (*Musa spp*) are found at some edges of the land.

2.3 Soil sampling

Disturbed and undisturbed soil samples were randomly collected with the aid of a soil auger and 5 × 5 cm core samplers at 0-15 cm and 15-30 cm depths, respectively. This is because the layer that controls many critical and environmental processes, including seed germination and early seedling growth, surface crusting, infiltration and runoff falls within the 0-30 cm depth (Reynolds *et al*., 2009). The disturbed soil samples were bulked together to form composite samples before triplicate subsamples were extracted, while four undisturbed soil samples were also collected per land use type for laboratory analyses.

2.4 Laboratory analyses

Disturbed soil samples were air-dried, crushed with mortar and pestle and sieved using 2 mm and 0.5 mm mesh for physical and chemical analysis, respectively.

2.4.1 Determination of chemical properties

Soil pH

This was determined in a 1:1 soil and water mixture with the aid of a Glass electrode pH meter. Ten grams (10 g) of 2 mm air-dried soil was weighed into an extraction cup and 10 ml of distilled water was added. The suspension was allowed to stand for 30 minutes and was stirred occasionally with a glass rod. The electrode of the pH meter was inserted into the suspension and the reading was taken.

Exchangeable Acidity

The potassium chloride (KCl) extraction method was used to determine the exchangeable acidity of the soil. Two grams (2 g) of 2 mm sieved soil was weighed into an extraction cup. The soil suspension was shaken in a mechanical shaker for 30 minutes. Each solution was filtered using whatman filter paper and transferred into another cup. Two drops of phenolphthalein indicator were added to the solution and titrated with 0.01N NaOH until the attainment of the end point. The amount of base consumed is equal to the total amount of acidity in the aliquot taken. The soil exchangeable acidity was calculated as follows:

$$\text{Exchangeable Acidity (EA)} = \text{meq of base used} \times 50 \qquad (1)$$

Where 50 = factor for converting 2 g of soil to 100 g of soil.

$$\text{Meq} = \text{Normality of solution } \times \text{Volume of solution } \times \text{Dilution Factor} \qquad (2)$$

Organic carbon

The soil organic carbon was determined using the Walkey- Black procedure (1934). Half gram (0.5 g) of 0.5 mm sieved soil was weighed into a 500 ml conical flask before adding 10 ml of K_2CrO_7 to the flask by the means of a pipette. The mixture was swirled to mix and 20 ml of concentrated sulphuric acid was added to the flask by the means of graduated cylinder. The mixture was swirled gently for 1 minute and then allowed to stand for 30 minutes. The solution was diluted with 200 ml of distilled water and 3 drops of ortho-phenothroline indicator was added. Blank solution was prepared following the same procedure but without the soil sample. The two solutions were titrated with 0.5 N ferrous ammonium sulphate to a burgundy end point.

Exchangeable bases and metals

The Mehlich-3 extraction (1984) procedure was used to determine the soil exchangeable bases and metals. Two grams (2 g) of air-dried soil was weighed into extraction cups and 20 ml of mehlich-3 was added to it. The suspension was then shaken on the mechanical shaker for 20 minutes and later filtered with filter paper. The clear supernatant was taken to the flame spectrometer and atomic absoption spectrometer. The values of calcium (Ca), magnesium (Mg), potassium (K), manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) were determined using an atomic absorption spectrometer, while the value of sodium (Na) was determined using a flame photometer.

2.4.2 Available phosphorus

This was determined using the Mehlich-3 extraction procedure. Five milliliters (5 ml) of supernatant obtained from the mehlich-3 extractant for exchangeable bases was used and 5 ml of ascorbic reagent was added. The soil available phosphorus wad read with the aid of a spectrophotometer.

Total nitrogen

The macro Kjeldahl apparatus was used to determine the total nitrogen in the soil. Half gram (0.5 g) of 0.5 mm sieved soil sample was weighed into a digestion flask and 20 ml of distilled water was added. Two tablets of Na_2SO_4 and one tablet of selenium catalyst was added after which 5 ml of concentrated H_2SO_4 was added. The suspension was swirled gently and placed on the digestion plate in the fume chamber at a temperature of 370°C. The flask was allowed to cool and later washed into a 250 ml volumetric flask. Five milliliters (5 ml) of the aliquot was pipette into a conical flask. Distilled water, boric acid and indicator was added to the sample in the conical flask. The sample was distilled with 75 ml water and titrated with 0.01N HCl using EDTA indicator.

2.4.3 Determination of physical characteristics

Particle size distribution

This was determined using the hydrometer method (Bouyoucos, 1951). Fifty grams (50 g) of 2 mm sieved air-dried soil was weighed into a dispersion cup and 20 ml of calgon was added to the soil in the dispersion cup. The mixture was then mounted on a mechanical shaker and allowed to shake for 20 minutes for proper dispersion. The soil suspension in the dispersion cup was emptied into a sedimentation cylinder through a 0.2 mm sieve. The coarse sand fraction retained in the sieve was transferred into a petri-dish and oven-dried to constant weight at 105°C. The soil suspension in the sedimentation cylinder was made up to the 1000 ml mark. The sedimentation cylinder was shaken continuously from end to end for 60 times. The cylinder was quickly placed on the table and the temperature and hydrometer readings were taken simultaneously at 1 minute and 2 hours, respectively. The particle size distribution was then estimated as follows:

$$\text{Temperature Correction Factor (CF)} = 0.3\ (\text{Ti°C} - 20\text{°C}) \qquad (3)$$

Where Ti = Temperature of soil suspension at 1 minute or 2 hours, respectively.

$$\%\text{Silt} + \%\text{Clay} = \frac{1\text{ minute reading} \times \text{CF} \times 100}{\text{Weight of Sample}}$$

$$\%\text{Clay} = \frac{2\text{ hours reading} \times \text{CF} \times 100}{\text{Weight of Sample}} \qquad (4)\ (6)$$

$$\%\text{Silt} = (\%\text{Silt} + \%\text{Clay}) - \%\text{Clay} \qquad (5)$$

$$\%\text{Fine Sand} = 100 - (\%\text{Clay} + \%\text{Silt} + \%\text{Coarse Sand}) \qquad (7)$$

Bulk density

This was determined using the thermos gravimetric procedure. Upon obtaining the constant weight of the soil samples after oven-drying to constant weight at 105°C, bulk density was calculated as follows:

$$\rho\text{b} = \frac{\text{Ms}}{\text{Vb}} \qquad (8)$$

Where ρ_b is bulk density, M_s is mass of oven-dry soil and V_b is soil bulk volume.

Total porosity

This was computed from the measured bulk density (ρ_b) values as follows:

$$\text{Total porosity (TP)} = (1 - \rho_b/\rho_s)\ 100 \qquad (9)$$

Where particle density (ρ_s) = 2.65 Mg m^{-3}

Hydraulic conductivity

Saturated hydraulic conductivity (K_s) was determined in core samples using a constant head permeameter as described by Reynolds W.D. and Elrick D.E. (2002). The K_s was calculated as described by Hillel (2004) below:

$$\text{Ks} = \frac{\text{QL}}{\text{At}\Delta\text{H}} \qquad (10)$$

where: Q is volume of the water that flows through the soil column (cm^3); A is the cross-sectional area of flow (soil core) through the soil column (cm^2); t is time interval (h); L is the length of soil column (cm); ΔH is hydraulic head drop (cm), equals the sum of the pressure head and gravitational head drops.

The soil structural stability index (S) was estimated as described below:

$$\text{S} = \frac{\text{Organic matter content (\%)} \times 100}{\text{Clay (\%)} + \text{Silt (\%)}} \qquad (11)$$

S is the structural stability index, where the critical values of S distinguished for numerous savannah soils of West Africa by Pieri (1989) is presented in Table 1

2.5 Soil degradation rating (SDR) and vulnerability potential (Vp) assessment

Degradation and vulnerability ratings were estimated from soil physical (particle size distribution, bulk density and saturated hydraulic conductivity) and chemical (pH, organic carbon, total nitrogen, and available phosphorus) properties following the scheme described by Lal (1994) in Table 2 The physical and chemical properties were selected because they are considered as important measures of soil quality that determine soil productivity (Doran *et al.*, 1994). The critical levels of soil quality were weighted on a scale of 1 to 5. For SDR, the weighting sequence was as follows: 1 = no degradation, 2 = slightly degraded, 3 = moderately degraded, 4 = severely degraded, and 5 = extremely degraded. Thus, good soils have the lowest SDR and poor soils the highest value. However, the reverse of the weighting order was the case for vulnerability potential where 5 = no vulnerability, 4 = low vulnerability, 3 = moderate vulnerability, 2 = high vulnerability, and 1 = very high vulnerability. Determination of SDR of the selected soil parameters was based on the established critical levels of soil elements from various literatures (Adepetu *et al*., 1979; Enwezor *et al*., 1989; Lal, 1994; Isirimah *et al*., 2003).

Table 1 Critical values of soil structural stability index

S < 5	Severe physical degradation
5 < S < 7	High hazards of physical degradation
7 < S < 9	Low hazards of physical degradation
9 < S	No physical degradation

Source: Pieri. C. (1989)

Table 2 Rating scheme for soil degradation rating (SDR)

Limitation	RWF	pH	SOC (%)	TN (%)	Avail. P (mg kg^{-1})	ρ_b (Mg m^{-3})	K$_{sat}$ (cm hr^{-1})	Texture
None	1	7-8	5-10	>0.15	>19	<1.3	>2	Loam
Slight	2	6-7 or 8-9	3-5	0.10-0.15	15-19	1.3-1.4	0.2-2	Silt Loam, Silt Clay
Moderate	3	5.5-5.9 or 9-9.5	1-3	0.05-0.10	10-15	1.4-1.5	0.02-0.2	Clay loam, Sandy Loam
Severe	4	5.0-5.4 or >9.5	0.5-1	0.02-0.05	5-10	1.5-1.5	0.002-0.02	Silt Clay, Loamy Sand
Extreme	5	<5 and >9.5	<0.5	<0.02	<5	>1.6	<0.002	Clay, Sand

RWF: Relative weight factor; SOC: Soil organic carbon; TN: Total nitrogen; K$_{sat}$: Saturated hydraulic conductivity; (Source: Lal (1994))

2.6 Data analysis

Data obtained from the laboratory analyses of the soil samples were analyzed using the general linear model procedures (GLM Proc.) of GenStat Discovery (8th edition). Analysis of variance (ANOVA) test was performed on all the data, while means with significant differences were subjected to post-hoc analysis using Duncan Multiple Range Test (DMRT) at $p \leq 0.05$.

3 Results and discussion

3.1 Chemical characteristics of soil under different land use types

3.1.1 Soil pH

Soil pH differed significantly ($p \leq 0.05$) among the land use types and ranged from 5.7 (Fallow land) to 6.9 (Residential land) as shown in Table 3. The soil under the different land use types appeared to be slightly acidic and this could be due to intense weathering of parent materials resulting from rainfall intensity, hence resulting to leaching of basic nutrients. Busari *et al.* (2005) also reported that low pH values could be due to the amount of materials removed at previous harvests, and the amount and type of fertilizer used for crop cultivation. Similar observations were made by Abassi *et al*. (2014) who reported acidifying effect mineral fertilizer on soil.

3.1.2 Soil organic carbon (SOC)

There was significant ($p \leq 0.05$) difference in soil organic carbon among the land use types with Residential land recording the highest value of 29.8 g kg^{-1} (Table 3). This was followed by Valley bottom (20.0 g kg^{-1}), Paddock (19.1 g kg^{-1}), Fallow land (12.3 g kg^{-1}), Oil palm (11.9 g kg^{-1}), and least by Arable land (10.7 g kg^{-1}). The SOC under the different land use types ranged from severe to moderate according to Lal (1994). All the values were below the critical value of 40 g kg^{-1} as established by Adeoye and Agboola (1984). The SOC for Paddock land, Fallow land, Oil palm and Arable land were lower than the threshold (20 g kg^{-1}) reported by the Federal Ministry of Agriculture, Water Resources and Rural Development (1989).

3.1.3 Total Nitrogen (TN)

Soil TN was significantly ($p \leq 0.05$) influenced by the different land use types (Table 3). residential area had the highest TN (3.3 g kg^{-1}) followed by Valley bottom (2.2 g kg^{-1}), paddock land (2.1 g kg^{-1}), fallow land (1.4 g kg^{-1}), Oil palm (1.3 g kg^{-1}) and least by arable land (1.2 g kg^{-1}). This result is in line with the reports of Yihenew and Getachew (2013). The TN values under arable land, oil palm and fallow land were lower than the critical value (1.5 g kg^{-1}) reported for

Table 3 Soil chemical properties as influenced by land use types

Land use	pH	O.C.	TN	Avail P (mg kg^{-1})	K	Ca	Mg	Cu	Fe
		g kg^{-1}			mg kg^{-1}				
Arable	6.0bc	10.7b	1.2b	19.9	0.43ab	1.35c	0.97	3.97c	165.2ab
Fallow	5.7c	12.3ab	1.4ab	19.7	0.29bc	1.77c	1.29	3.31cd	125.3b
Oil Palm	6.7a	11.9ab	1.3ab	19.9	0.13c	0.85c	0.64	2.63d	218.2a
Paddock	6.4ab	19.1ab	2.1ab	20.0	0.43ab	2.06bc	1.10	3.01d	236.5a
Residential	6.9a	29.8a	3.3a	19.6	0.48a	4.35a	1.00	5.55a	179.8ab
Valley bottom	6.7a	20.0ab	2.2ab	19.4	0.51a	3.42ab	1.13	4.70b	204.2ab
S.E.D$_{0.05}$	0.239	2.190	0.847	Ns	0.080	0.696	ns	0.311	33.310

Means with the same letter(s) are not significantly different at p = 0.05; ns: not significantly different at p = 0.05; S.E.D: Standard error of differences of means

Table 3 shows significant difference ($p \leq 0.05$) in the soil chemical properties among the land use types. Soil pH ranged from 5.7 (Fallow Land) to 6.9 (Residential Land), Soil Organic Carbon ranged from 10.7 (Arable Land) to 29.8 (Residential Land), Total Nitrogen ranged from 1.2 (Arable Land) to 3.3 (Residential Land), Available Phosphorus ranged from 9.4 (Valley Bottom) to 20.0 (Paddock Land). For Potassium, Calcium, Magnesium, and copper, Oil palm Land has the lowest range 0.13, 0.85, 0.64, 2.63 respectively and Iron ranged from 125.2 (Fallow land) to 236.5 (Paddock Land).

3.2 Available phosphorous (AP)

The soil AP among the various land use types did not differ significantly ($p \leq 0.05$) and ranged from 19.4 mg kg^{-1} (valley bottom) to 20.0 mg kg^{-1}) paddock land (Table 3). The AP values recorded among the land use types exceeded the critical range (10-15 mg kg^{-1}) reported by Adeoye and Agboola (1984).

3.2.1 Potassium

There were significant ($p \leq 0.05$) differences in potassium content among the land use types (Table 3). The soil potassium was in the order of valley bottom (0.51 mg kg^{-1}) > residential land (0.48 mg kg^{-1}) > paddock land (0.43 mg kg^{-1}) = arable land (0.43 mg kg^{-1}) > fallow land (0.29 mg kg^{-1}) > oil palm (0.13 mg kg^{-1}). With the exception of oil palm land, the soil potassium under the different land use types was higher than the critical range (0.18-0.20 mg kg^{-1}) reported by Adeoye and Agboola (1984).

3.2.2 Calcium (Ca)

The Ca content among the various land use types differed significantly ($p \leq 0.05$) and ranged from 0.85 mg kg^{-1} (oil palm) to 4.35 mg kg^{-1} (residential land) (Table 3). The Ca content of oil palm, arable land and fallow land were below the critical value of 2.0 mg kg^{-1} reported by Adeoye and Agboola (1984).

3.2.3 Magnesium (Mg)

The Mg concentration of soil samples obtained from the different land use types did not differ significantly ($p \leq 0.05$) as shown in Table 3. However, Mg was in the order: fallow land (1.29 mg kg^{-1}) > valley bottom (1.13 mg kg^{-1}) > paddock land (1.10 mg kg^{-1}) > residential land (1.00 mg kg^{-1}) > arable land (0.97 mg kg^{-1}) > oil palm (0.64 mg kg^{-1}). The Mg concentration of the soil under the land use types were observed to be lower than the critical value (1.9 mg kg^{-1}) reported by Adeoye and Agboola (1984).

3.2.4 Copper (Cu)

There were significant ($p \leq 0.05$) differences in Cu concentration among soil samples obtained from the various land use types (Table 3). Copper concentration ranged from 2.63 mg kg^{-1} (oil palm) to 5.55 mg kg^{-1} (residential land). With the exception of residential land, the Cu concentration of other land use types were below the critical value of 5.00 mg kg^{-1} Adeoye and Agboola (1984).

3.2.5 Iron (Fe)

Significant ($p \leq 0.05$) differences were observed in the Fe content under the different land use types (Table 3). Paddock land had the highest Fe content (236.5 mg kg^{-1}). This was followed by oil palm (218.2 mg kg^{-1}), valley bottom (204.2 mg kg^{-1}), residential land (179.8 mg kg^{-1}), arable land (165.2 mg kg^{-1}), and least y fallow land (125.3 mg kg^{-1}). The Fe content under the different land use types were higher than the critical value of 5.0 mg kg^{-1} Adeoye and Agboola (1984).

3.3 Soil physical characteristics under different land use types

3.3.1 Bulk density (ρ_b)

The soil ρb under different land use types is presented in Table 4. There was significant ($p \leq 0.05$) difference in soil ρb which was highest under arable land (1.83 Mg m-3). This was statistically similar to residential land (1.71 Mg m-3), paddock (1.66 Mg m-3) and oil palm (1.64 Mg m-3), while fallow land had a low value of 1.52 Mg m-3, and the least was valley bottom (1.43 Mg m-3). The high bulk density recorded for arable land could be due to the frequent rate of vehicular trafficking resulting from the use of tractors or other forms of trafficking on the land. Increase in soil bulk density implies that there is high soil compaction which adversely affects root growth. This result corroborates the findings of Scalenge et al. (2004) who observed crusting and compaction of surface soil due to crop cultivation.

3.3.2 Total porosity (TP)

The TP of soil under different land use types is presented in Table 4. The soil TP differed significantly ($p \leq 0.05$) and was in the order of valley bottom (45.8%) > fallow land (42.5%) > oil palm (38.0%) > paddock (37.2%) > residential land (35.5%) > arable land (31.2%). This can be

Table 4 Land use effect on some soil physical properties

Land use	ρ_b (Mg m^{-3})	Total porosity (%)	K_{sat} (cm hr^{-1})	S
Arable	1.83a	31.2b	3.8b	3.1d
Fallow	1.52b	42.5ab	10.6ab	4.2d
Oil Palm	1.64ab	38.0ab	9.1ab	11.8b
Paddock	1.66ab	37.2ab	14.9a	6.3c
Residential	1.71ab	35.5ab	15.8a	5.5c
Valley bottom	1.43b	45.8a	7.6ab	32.4a
S.E.D$_{0.05}$	0.123	5.310	3.840	12.850

Table 4 shows significant difference in the soil physical characteristics under different land use types. Bulk density ranged from 1.43 (Valley Bottom) to 1.83 (Arable Land), Total porosity from 31.2 (Arable land) to 45.8 (Valley Bottom), Hydraulic conductivity from 3.8 (Arable land) to 15.8 (Residential) and Structural stability index ranged from 3.1 (Arable land) to 32.4 (Valley Bottom).

Means with the same letter(s) are not significantly different at p = 0.05; ρ_b: Bulk density; K_{sat}: Saturated hydraulic conductivity; S: Structural stability index; S.E.D: Standard error of differences of means attributed to the inverse relationship between soil ρ_b and TP, hence, the differences in soil compaction among the various land use types would have resulted to the variations in their available pore spaces. Similar observations were made by Guidi *et al.* (1984) who reported that the decrease in bulk density is directly related to increased porosity, which is also related to improved soil aggregation.

3.3.3 *Hydraulic conductivity (K_{sat})*

Table 4. presents the results of saturated hydraulic conductivity of soil under different land use types. Significant ($p \leq 0.05$) differences were observed in soil K_{sat} among the land use types which ranged from 3.8 cm hr^{-1} (arable land) to 15.8 cm hr^{-1} (residential land). The high K_{sat} under residential area suggests high water flow under this land use types relative to arable land. This could have been due to the high ρ_b, which is a measure of soil compaction under the arable land. Ezeaku and Anikwe (2005) reported that high saturated hydraulic conductivity could be due to increases in bioturbation which results to higher bio-pores and cross-sectional areas that contribute to hydraulic flow in soils.

3.3.4 *Structural stability index (S)*

This is the measure of integrity of the soil structure. The soil S differed significantly ($p \leq 0.05$) among the land use types and was in the order: valley bottom (32.4) > oil palm (11.8) > paddock (6.3) > residential land (5.5) > fallow land (4.2) > arable land (3.1) as presented in Table 4. The higher the value of structural stability index, the more stable the soil structure is and this implies that valley bottom land is more stable than the other land use types. The low soil S recorded for arable land could be due to low organic carbon content as high structural stability index has been attributed to high organic matter content Valentin, 1994).

3.4 Soil degradation rating (SDR)

The SDR of the land use types considered in this study is presented in Table 5. In terms of soil pH, fallow land (SDR = 3) was moderately degraded, while other land use types (SDR = 2) were slightly degraded. The soil organic carbon showed that all the land use types (SDR = 3) were moderately degraded, while the total nitrogen content depicted slightly degraded (SDR = 2) conditions for arable land, fallow and oil palm, and no degradation (SDR = 1) for paddock, residential land and valley bottom. The available phosphorus for showed that the land use types were not degraded (SDR = 1). For soil ρ_b showed that extreme degradation (SDR = 5) for arable land, oil palm, paddock, and residential land, respectively, while fallow land was severely degraded (SDR = 4), and valley bottom was moderately degraded (SDR = 3). The soil K_{sat} was showed that the land use types were not degraded (SDR = 1), while the soil texture showed that the land use types were extremely deraded (SDR = 5). On the average, the mean relative weight factor suggests that only valley bottom was slightly degraded, while the other land use types were moderately degraded. Similar observation was noted by Akpan-Idiok (2012) and Ezeaku (2013) for SDR of different soils in Southern Nigeria.

Table 5 Soil degradation ratings (SDR) of selected soil properties of six land use types

Land use	**pH**	**SOC**	**TN**	**Avail. P**	**ρ_b**	**K_{sat}**	**Texture**	**Mean RWF**	**SDR**
Arable	2	3	2	1	5	1	5	3	Moderate
Fallow	3	3	2	1	4	1	5	3	Moderate
Oil Palm	2	3	2	1	5	1	5	3	Moderate
Paddock	2	3	1	1	5	1	5	3	Moderate
Residential	2	3	1	1	5	1	5	3	Moderate
Valley bottom	2	3	1	1	3	1	5	2	Slight

SOC: Soil organic carbon; TN: Total nitrogen; ρ_b: Bulk density; K_{sat}: Saturated hydraulic conductivity; RWF: Relative weight factor; SDR: Soil degradation rating

4 Conclusion

This study was conducted to evaluate the influence of land use types on soil physical and chemical properties, and also to assess the level of degradation of soil under the different land use types within the University of Ibadan, Nigeria. Arable land, paddock, oil palm, fallow land, residential land and valley bottom were the land use types considered in this study. Though land use types were slightly acidic, arable land had the lowest organic carbon and total nitrogen content, while residential land had superior organic carbon and total nitrogen content. However, residential area was similar to valley bottom in organic carbon and total nitrogen content. The valley bottom appeared to have better soil bulk density and total porosity than other land use types, with arable land having the least quality of both physical parameters. This was also mirrored in the structural stability index which was highest for valley bottom and lowest for arable land. The soil degradation rating assessed using soil chemical (pH, C, N, and P) and physical (texture, bulk density and saturated hydraulic conductivity) indices of the land use types showed that the valley bottom was slightly degraded while the other land use types were moderately degraded. Thus, soil conservation measures such as the use of organic fertilizers and organic mulch should be put in place in order to rehabilitate the other land use types, especially arable land, in order to prevent further degradation of soil under those land use types.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflict of interest.

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