

An Assessment of Degradation of Soil Properties in Kabba College of Agriculture, Kogi State, Nigeria

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ABSTRACT

Some soils in Kabba College of Agriculture, Kogi State, southern guinea savannah zone of Nigeria, were assessed to ascertain the levels of degradation of soil properties. The rigid grid soil survey method was used to identify seven soil units. Soils were sampled at 0-20 cm and 20-40 cm soil depth and analyzed for physical and chemical properties using standard methods. Levels of degradation were obtained by comparing laboratory data with the standard land/soil requirement (indicators/criteria) for grouping lands into different degradation classes of 1 to 4 (non to slightly, moderately, highly, and very highly degraded). Results showed that units D (sorghum) and E (citrus) were very highly degraded (Class 4) of exchangeable potassium; units C (yam), D and E were highly degraded (Class 3) of organic matter. Other units were moderately degraded (Class 2) of base saturation, bulk density and total nitrogen. There was no degradation of available phosphorus and exchangeable sodium percentage in all the units. Physical and chemical degradation took place in the study area with respect to bulk density, base saturation, total nitrogen, potassium, and organic matter. Sustainable management practices that will promote good bulk density and organic matter accumulation should be encouraged.

Keywords: Degradation, Assessments, Chemical, Physical, Indicators

1.0. Introduction

The threats to land by soil degradation have been the subject for intensive debate in the literature (Baumhardt *et al.*, 2015). In Africa, an estimated 500 million hectares of land have been affected by soil degradation including agricultural land (Wynants *et al.*, 2019). Its devastating effects have subjected local communities to high risks of loss of lives, properties and land resource that supports their livelihood.

In the world, there is practically no extensive area of land without limitation of one sort or another (Ibrahim and Idogba, 2013). Indiscriminate forest cleaning and burning, inappropriate land cultivation, over grazing, improper irrigation practice, urban development and high population density have no doubt contributed to changes in the landscape. More than 75 percent of Earth's land areas are substantially degraded, undermining the well-being of 3.2 billion people, according to the world's first comprehensive, evidence-based assessment (Leahy, 2018).

According to Idoga *et al.* (2007) land degradation is a universal set while soil degradation is derived from land degradation since soil is the most stable and most manipulated feature of the land. The major human activity that contributes to soil degradation is agriculture (Food and Agriculture Organization-FAO, 2005). Continuous and inappropriate land use systems have severely impaired the soil. It has been reported that every land use partly destroys the soil structure and reduces soil fertility (Altieri and Nicholis, 2003).

There have been many reports on implication of different land uses on soil properties and fertility, (Yusuf *et al.*, 2019; Yusuf *et al.*, 2015; Malgwi and Abu, 2011; Cobo *et al.*, 2010; Martensson, 2009) and other works on soil degradation assessment that examines the actual level, nature and forms in different agroecological zones of Nigeria (Adewuyi *et al.*, 2019; Senjobi *et al.*, 2013; Ibrahim and Idogba, 2013; Sotona, *et al.* 2013; Adewuyi 2011; Isirimah, 2005; Igwe, 2003). In Kabba College of Agriculture, Kabba, Kogi State the major land utilization type is agriculture involving intensive, continuous cropping and mechanization but there are no studies on soil degradation. Available report is on soil quality in relation to crop yield along toposquence (Babalola *et al.*, 2012); therefore, the need for this study arises. The objective of this study is to identify and document the actual level, nature and forms of soil degradation in the study area.

2.0. Materials and Method

2.1. Description of the study area

Kabba is located in Kogi State, Kabba/Bunu Local Government Area in the Southern Guinea Savannah Agro-ecological zone of Nigeria. Kabba College of Agriculture is located on latitude 7°51'N and longitude 6°04'E. It has climate that is typical of humid tropics with rainfall that spans the month of May to October. The dry season extends from November to April. The vegetation of the area is dominated by tall grasses and shrubs. Also, human activities have influenced the vegetation in the area (Babalola *et al.*, 2012). The area belongs to the basement complex geology of Nigeria (Obaje, 2009).

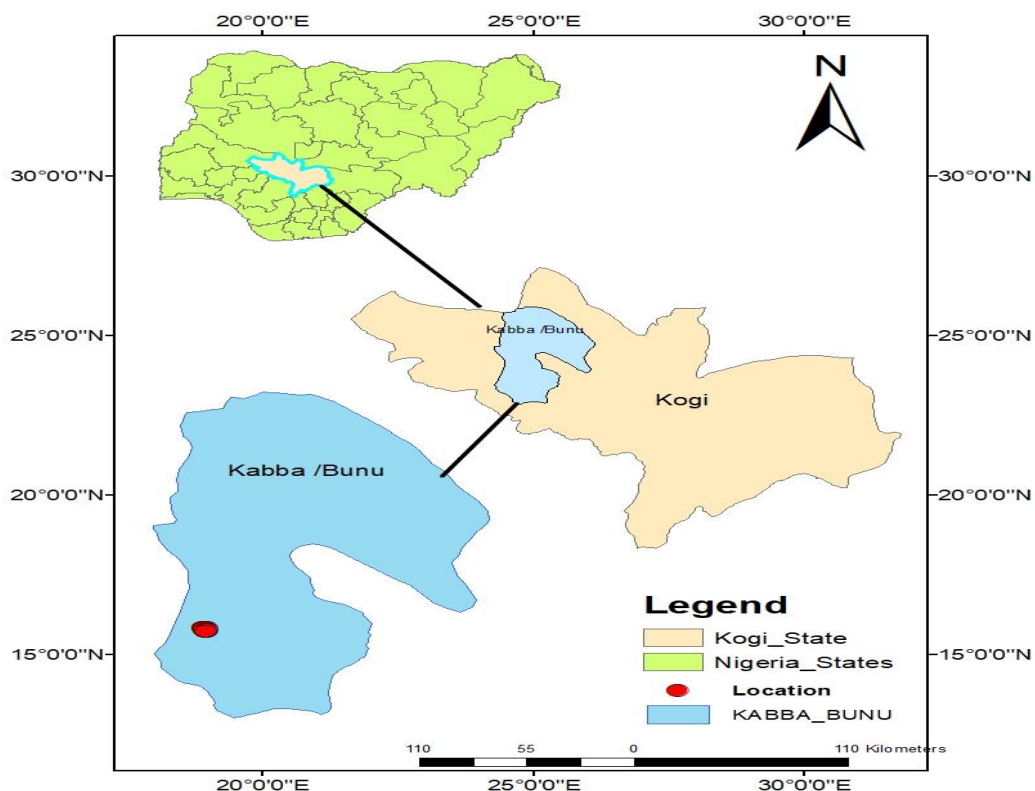


Figure 1: Map showing the location of the study within, Nigeria, Kogi State and Kabba/Bunu Local Government

2.2. Land use

The major land use type in the area is arable crop land involving cultivation of crops such as maize, sorghum, rice, cassava, yam, pepper and dry season vegetable production in the wetland portion of the area. Also, tree crops such as oil palm, banana, pineapple and citrus are cultivated in some part of the area. Tillage practices in the area involved the use of simple implements while ploughing, harrowing, and ridging is practiced in some part.

2.3 Field work and sampling

The rigid grid soil survey method following the guidelines of Soil Survey Staff, (2014) was used to sample the soils. Soils were probed at 100m within traverse and the colour, texture, consistence, and structure were determined. Areas with similar characteristics were identified as soil units and were labelled with the prominent agricultural land use within the unit (Figure 2) as follows: Cassava-A, Oil palm- B, Yam- C, Sorghum- D, Citrus- E, Maize- F and Pasture- G. Within each soil unit a representative area was selected and soil samples were collected at 0-20 cm and 20-40 cm soil depth using auger. Core sample were also collected for the determination of bulk density and saturated hydraulic conductivity.

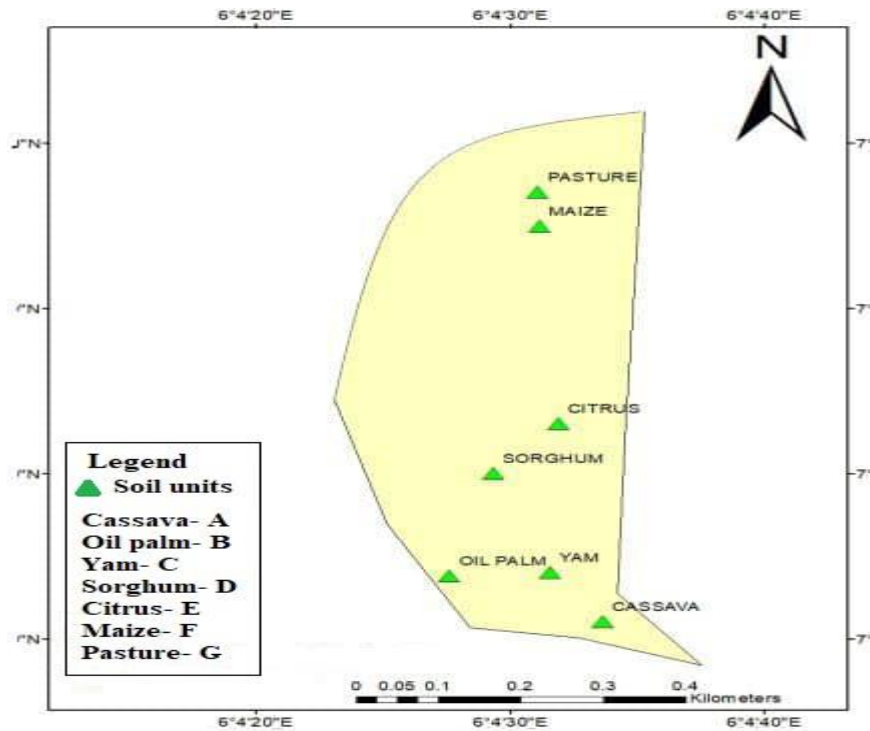


Figure 2: Map of the location showing the sampling points and agricultural land use of soil units

2.4. Soil analysis

The bulk samples were air dried, gently crushed and passed through a 2 mm sieve. Core samples were trimmed to the height of the core sampler for bulk density determination. Particle size distribution, pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases, and exchangeable acidity were determined following the International Institute for Tropical Agriculture IITA, (1979) guidelines. The effective cation exchanges capacity, base saturation, and exchange sodium percentages were calculated.

2.5 Land degradation assessment

The levels of degradation of the soil were assessed using the standard indicator and criteria for degradation assessment (Tables 1 – 3) (FAO, 1979; Snakin *et al.*, 1996; Senjobi *et al.*, 2013). Analytical data from each sample were placed in a degradation class by matching the soil characteristics with the land degradation indicator. The estimates of the degree of degradation were based on the measured physical and chemical parameters.

Table 1: Indicators and criteria of physical degradation of soil

Indicator	*Degree of degradation (%)				
	Initial Level	1	2	3	4
Soil bulk density (g/cm ³)	1.25 – 1.4	< 1.5	1.5 – 2.5	2.5 – 5	> 5
Permeability (cm/hr)	5 – 10	< 1.25	1.25 – 5	5 – 10	> 20

Sources: FAO (1979), Snakin *et al.* (1996), Senjobi *et al.* (2013)

*Where 1. Non to slightly degraded soil where productivity ranges from 75-100%

2. Moderately degraded soil where productivity ranges from 50 -75%

3. Highly degraded soil where productivity ranges from 25-50%

4. Very high degraded soil where productivity ranges from 0-25%

Table 2: Indicators and criteria of chemical degradation of soil

Indicator	*Degree of degradation (%)			
	1	2	3	4
Content of Nitrogen Element (Multiple decrease) N (%)	> 0.13	0.10 – 0.13	0.08 – 0.10	< 0.08
Content of Phosphorus Element (mg/kg)	> 8	7 – 8	6 – 7	< 6
Content of Potassium Element (cmol/kg)	> 0.16	0.14 – 0.16	0.12 – 0.14	< 0.12
Content of Exchangeable Sodium Percentage (ESP) (Increase by 1% of CEC)	< 10	10 – 25	25 – 50	> 50
Base Saturation (decrease of saturation in more than 50%)	< 2.5%	2.5 – 5%	5 – 10%	> 10%
Excess salt (Salinization) (Increase in conductivity (mmho/cm/yr)	< 2	2 – 3	3 – 5	> 5
Content of organic matter in soil (%)	> 2.5	2 – 2.5	1.0 – 2	< 1.0

Modified from: FAO (1979), Snakin *et al.* (1996), Senjobi *et al.* (2013)

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3.0. Results and Discussion

3.1. Soil properties

The physical and chemical properties of surface (0 – 20 cm) and subsurface (20 – 40 cm) of the studied area are presented in Table 3 and 4, respectively. All the seven (7) soil units show differences in the surface and subsurface horizons. Bulk density values were higher in units A, C, E, F, and G in the subsurface horizons (1.60, 1.65, 1.75, 1.67 and 1.50 g/cm³ respectively) than the surface horizons (1.58, 1.49, 1.50, 1.55 and 1.39 g/cm³ respectively) while the opposite exists for units B and D (1.55 and 1.49 g/cm³, 1.40 and 1.48 g/cm³ respectively). The trend of distribution of bulk density between the soils studied can be attributed to differences in clay and soil organic matter (Ibrahim and Idogba, 2013). Idoga *et al.* (2007) state that soil organic matter is light and tends to lower bulk density when present in high amount in the soil. The result of the total porosity mostly follows the same pattern as bulk density. Particle size analysis shows decrease in sand content and increase in clay content in most of the units from the surface to subsurface horizons; this is typical of soils developed on basement complex areas in Nigeria and in agreement with reports of Babalola *et al.* (2012) for some soils in Kabba, Kogi State.

There are differences between the surface and subsurface horizons of chemical properties of soils. Soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable cations, and Cation Exchange Capacity (CEC) are higher in the surface horizon of the soil units studied. These differences may be attributed to the production of humus in the surface horizon and cultivation practices.

Table 3: Physical properties of the soil units

Soil Unit/Land use	Depth (cm)	Bulk Density (g/cm ³)	Total Porosity	Permeability (K Sat) (Cm/hr)	Sand %	Silt %	Clay%	Textural Class
A (Cassava)	0 – 20	1.58	56	0.71	70	11	19	Sandy Loam
	20 – 40	1.60	45	0.65	71	09	20	Sandy Loam
B (Oil palm)	0 – 20	1.59	59	0.64	77	03	20	Sandy Loam
	20 – 40	1.55	50	0.52	71	13	16	Sandy Loam
C (Yam)	0 – 20	1.49	68	0.97	79	02	19	Sandy Loam
	20 – 40	1.65	51	1.01	39	08	53	Sandy Clay
D (Sorghum)	0 – 20	1.48	50	0.86	75	06	19	Sandy Loam
	20 – 40	1.40	35	3.09	62	08	30	Clay Loam
E (Citrus)	0 – 20	1.50	49	1.81	73	13	14	Sandy Loam
	20 – 40	1.75	37	1.71	60	08	32	Sandy Clay Loam
F (Maize)	0 – 20	1.55	65	2.71	35	26	39	Clay Loam
	20 – 40	1.67	55	1.91	46	19	35	Sandy Clay Loam
G (Pasture)	0 – 20	1.39	60	0.95	48	25	27	Loam
	20 – 40	1.50	41	0.88	57	21	22	Sandy Loam

Table 4: Chemical properties of the soil units

Soil Properties	Soil Units							
	Soil Depth (cm)	A	B	C	D	E	F	G
pH (H ₂ O)	0 – 20	5.95	6.14	5.67	5.51	6.22	5.97	4.97
	20-40	5.85	6.11	5.65	4.82	5.98	5.83	4.81
Organic Carbon (%)	0 – 20	1.68	1.85	1.12	1.24	0.89	2.53	2.70
	20-40	1.44	1.70	0.96	1.01	0.84	1.98	2.09
Organic Matter (%)	0 – 20	2.89	3.18	1.93	2.13	1.53	4.35	4.64
	20-40	2.48	2.92	1.65	1.74	1.45	3.41	3.60
Total Nitrogen (%)	0 – 20	0.121	0.114	0.116	0.170	0.162	0.180	0.179
	20-40	0.103	0.088	0.109	0.110	0.157	0.165	0.161
Available Phosphorus (mg/kg)	0 – 20	49.75	22.26	41.92	9.19	10.40	32.41	18.97
	20-40	40.18	19.15	39.11	7.82	9.69	30.97	17.65
Exchangeable Sodium (cmol/kg)	0–20	0.201	0.235	0.190	0.190	0.231	0.180	0.210
	20-40	0.196	0.213	0.189	0.169	0.207	0.179	0.198
Exchangeable Potassium (cmol/kg)	0 – 20	0.229	0.180	0.235	0.073	0.102	0.258	0.201
	20-40	0.229	0.175	0.221	0.064	0.097	0.237	0.199
Exchangeable Calcium (cmol/kg)	0 – 20	3.76	2.80	4.32	2.90	6.56	2.72	3.04
	20-40	3.28	2.72	4.16	2.86	6.40	2.56	2.98
Exchangeable Aluminum (cmol/kg)	0 – 20	0.01	0.01	0.01	0.02	0.01	0.02	0.01
	20-40	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Exchangeable Hydrogen (cmol/kg)	0–20	0.15	0.15	0.12	0.13	0.14	0.13	0.11
	20-40	0.13	0.14	0.12	0.11	0.12	0.13	0.11
Exchangeable Bases (cmol/kg)	0 – 20	5.830	5.005	6.115	5.083	7.693	4.118	5.761
	20-40	4.845	4.768	5.770	4.903	7.424	3.856	5.347
Cation Exchange Capacity (cmol/kg)	0 – 20	5.990	5.165	6.245	5.233	7.843	4.268	5.881
	20-40	4.985	4.918	5.900	5.023	7.554	4.006	5.467
Base Saturation (%)	0 – 20	97.33	96.90	97.92	97.13	98.09	96.49	97.96
	20-40	97.19	96.95	97.80	97.61	98.28	96.26	97.81
Exchangeable Sodium Percentage (%)	0 – 20	3.45	4.70	3.11	3.74	3.00	4.37	3.65
	20-40	4.05	4.47	3.28	3.45	2.79	4.64	3.70

3.2. Land degradation assessment

The land/soil requirement (indicators and criteria i.e. land qualities/soil properties) for grouping lands into different degradation classes are given in Table 1-2. The matching of the soil indicators/criteria are given in Table 5.

The land degradation assessment results show that in terms of bulk density, only unit D was none degraded at both horizons, units C and G are none degraded at the surface and moderately degraded at the subsurface. Units A, B, E, and F are all moderately degraded at both horizons.

With respect to permeability, at the surface horizon, units A, B, C, E, and G are none degraded, unit D is highly degraded while unit F is moderately degraded.

Result of chemical properties showed that base saturation is moderately degraded in all the units; base saturation is an indicator of level of leaching, therefore this result signifies that the soils are moderately leached of their exchangeable bases.

Degradation assessment for total nitrogen shows that units E, F, and G are none degraded; Units A and C are moderately degraded at both horizons. Unit B is moderately degraded at the surface horizon and highly degraded at the subsurface. Unit D is non-degraded at the surface and moderately degraded at the subsurface.

Assessment for available phosphorus showed that all the soil units are non-degraded.

With respect to exchangeable Potassium; units A, B, C, F, and G are non-degraded while units D and E are very highly degraded at both horizons.

In terms of Exchangeable Sodium Percentage; all the units are non-degraded, indicating that the soils are not sodic.

With respect to organic matter contents; units B, F, and G are non-degraded at the surface and subsurface. Unit A is non-degraded at the surface and moderately degraded at the subsurface. Unit D is moderately degraded at the surface and highly degraded at the subsurface. Units C and E are highly degraded in both horizons.

Physical and chemical degradation took place in the study area. Chemical degradation is as a result of loss of fertility from leaching and low organic matter. This might have occurred as a result of land use practices such as continuous cropping, improper handling of plant residues and bush burning. The soils can be ameliorated through improved and proper nutrient management practices (Eswaran and Dumanski, 1998; Senjobi *et al.*, 2013). Physical degradation of soil could be as a result of tillage practices and improper soil management and it requires a long time to meliorate (Hulugalle, 1994; Senjobi *et al.*, 2013).

Table 5: Land qualities/soil properties of the soil units

Soil Unit/Land use	Depth (cm)	Bulk Density (g/cm ³)	Permeability (cm/hr)	Base Saturation (%)	Total N (%)	Available P (ppm)	ExchK (cmol/kg)	ESP (%)	Organic Matter (%)
A (Cassava)	0-20	2	1	2	2	1	1	1	1
	20-40	2	1	2	2	1	1	1	2
B (Oil palm)	0-20	2	1	2	2	1	1	1	1
	20-40	2	1	2	3	1	1	1	1
C (Yam)	0-20	1	1	2	2	1	1	1	3
	20-40	2	1	2	2	1	1	1	3
D (Sorghum)	0-20	1	1	2	1	1	4	1	2
	20-40	1	3	2	2	1	4	1	3
E (Citrus)	0-20	2	1	2	1	1	4	1	3
	20-40	2	1	2	1	1	4	1	3
F (Maize)	0-20	2	2	2	1	1	1	1	1
	20-40	2	1	2	1	1	1	1	1
G (Pasture)	0-20	1	1	2	1	1	1	1	1
	20-40	2	1	2	1	1	1	1	1

N- Nitrogen, Exch. K- Exchange potassium, ESP- Exchangeable Sodium Percentage

**Where 1. Non to slightly degraded soil where productivity ranges from 75-100%*

2. Moderately degraded soil where productivity ranges from 50 -75%

3. Highly degraded soil where productivity ranges from 25-50%

4. Very high degraded soil where productivity ranges from 0-25%

4.0. Conclusions

It is concluded that physical and chemical degradation took place in the study area with respect to bulk density, base saturation, total nitrogen, potassium, and organic matter. This study is considered as a preliminary project for the quality soil degradation assessment to develop sustainable practices to support the reclamation process and to develop a soil health program for the study area. Sustainable management practices that will promote good bulk density and organic matter accumulation should be adopted.

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