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Full Length Research Paper

Effect of different land use types and their implications on land degradation and productivity in Ogun State, Nigeria

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This study was designed to assess the extent to which land use types influence soil nutrients and productivity in Ogun State. Soils under four land uses were sampled for physical, chemical and biological analyses. The land use types studied were arable cropping (land use 1); oil palm (land use 2), secondary forest (land use 3) and building sites (land use 4). The results showed that soil nutrients vary from one land use type to another with respect to morphological properties such as colour, texture, structure and consistency. This soils have very high sand content (>90%), this decreases with depth thereby enhancing porosity, uptill a point of high clay content where permeability is hampered. Exchangeable bases, and acidity and silt: Clay ratios were generally low. Ca and Mg dominate the exchange complex, organic matter content, total nitrogen and effective cation exchange capacity were high in the surface soils compared to sub-surface. The reverse is the trend for available P. Extractable Zn and Cu relative to the critical levels established down the profile were very high and erratic. Soil nutrients depletion followed this order: Secondary forest < Oil palm < Arable cropping < Building sites. Soil depletion and degradation were very prominent under building sites and arable cropping. It was observed that the land use types employed on the study sites were not very compatible with the characteristics of the soil. However, since soil nutrients depletion were very high in all land uses, therefore, there must be a careful choice of appropriate use of land in order to reduce soil nutrients depletion and enhances soil productivity. In addition to the above, plausible land use approach, multiple cropping, organic mulching, contour ridge and cultivation of cover crops are recommended in order to minimize soil nutrients depletion which mostly accounted for major degradation in these plots.

Key words: Soil nutrients depletion, land uses, nutrients dynamic, land degradation, productivity.

INTRODUCTION

In all parts of Nigeria, there is noticeable evidence of land degradation. This varies from place to place in terms of the types, duration, severity, and socio-economic impact (Aruleba, 2004; Senjobi, 2007). A survey in 1990 by the United Nations suggested that a quarter of the world's total crop land is affected by degradation severely enough to restrict its productivity, 15.6% of this compromised agricultural land is strongly degraded land whose original biotic functions including nutrient cycling are largely destroyed. This has resulted in production loss of about 17% on degraded lands. Accelerated land degradation processes have been attributed not only to rapid human population growth, but also to concomitant intensification of land use. In the last 50 years alone, 20% of the world's agricultural land has been irreversibly damaged, and if the process of destruction continues at this pace, agriculture could lose 15 to 30% of its productivity (FAO, 1984). During 1945 to 1990, human induced land degradation in Africa exceeded 494 millions hectares, and only 22% of the total land area constitutes the producing biomass United Nations environmental programme (UNEP) and international soil reference and

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information centre (ISRIC), 1990 (cited from global assessment of soil degradation (GLASOD), 1998. According to Dudal (1982) and Lal (1990), annual estimate of land lost to land degradation was expected to rise from 5 to 7 million hectares in 1981 to 10 million hectares in year 2000. In an assessment of soil under different covers in Nigeria, it was observed that the average soil loss under bare fallow management was 5.5 kg/m^2 with average rainfall of 177 mm a month. Comparative loss in the same plot in the preceeding year which was 3.5 kg/m^2 corresponding to 55 and 50 tons/ha soil loss respectively (Senjobi, 2007). In view of the land degradation processes in South Western Nigeria due to human interference on the natural ecosystems, it then becomes pertinent to study the effect of this degradation on nutrients dynamic and their implications on soil productivity.

MATERIALS AND METHODS

Description of the studied area

The study was carried out at the Teaching and Research Farm of Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria in November/December, 2004. The area is located between latitude 6°55´ and 7°00´N and between longitudes 3°45´ and 4°05´E. The area falls within the rain forest region of South Western Nigeria with two main alternating wet and dry seasons which can be sub-divided into the long wet season from mid March to July, the short dry season in the month of August, the short wet season from September to early November and the long dry season from early November to mid March during which the local harmattan period commence between December to February. The area has an annual rainfall of about 1150 mm. The mean relative humidity of the area is generally high (about 80%) with the peak between May and October. The diurnal temperature ranges from highest in November to May and the lowest from June to October, the annual mean temperature is 27°C (Senjobi, 2007).

The dominant vegetable type of the area is secondary forest, tree species found in the study area include *Pentaclethra macrophylla, Bosqueia angolensis, Piptadeniastrum africanum, Antiaris toxicaria var africana, Cola spp., Guarea spp. and Mimusop spp* among others. There is also the widespread of *Elaeis guineensis* and the dominance of *Chlomolaena odorata*; a perennial weed in fallow lands.

Most of the soils in the survey area are developed from undifferentiated igneous and metamorphic, pre-cambrian basement complex rocks such as granite, biotite, gneiss, biotite schist, quartz schist and quartzite (Senjobi, 2007). The major land use types in the study area are arable crop production, cash crop production and non-agricultural uses such as residential, commercial and roads construction.

Field work

Four land use types namely: Arable cropping (land use 1), Oil palm (land use 2), Secondary forest (land use 3), and Building sites (land use 4) were studied. At each of the chosen land use type, an area of 50 hectares was identified with the aid of tape measurement. Bulk samples consisting of ten core samples from two depths (0 to15 cm and 15 to 30 cm) were collected randomly for physical, chemical and biological analyses. Profile pits (2 x 1 x 2 m) were dug at the three predominant different land types or slopes segment encountered at each of the chosen land use type. These were crest, middle slope, and valley bottom. The general site descriptions, such as climate, vegetable, land use, gradient of slope, drainage type, soil surface form, type and degree of erosion, field texture, micro-relief and depths to ground water table were recorded.

The profile pits were also described morphologically after FAO (2006), sampled and then followed by placing them in labelled bags and then transported to the laboratory for air-drying. After being air-dried for 72 h and the samples were crushed to pass through sieved using a 2 mm screens.

Soil samples were analyzed for the following parameters: Soil pH was determined in both water and 0.01 M potassium chloride solution (1:1) using glass electrode pH meter (Mclean, 1965). Total nitrogen was determined by the macro-kjeldahl digestion method of Jackson (1962). Bray-1 P was determined by molybdenum blue colorimetry (Bray and Kurtz, 1945) exchangeable cations were extracted with 1 M NH_4OAC (pH 7.0), K and Na were determined using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer (Sparks, 1996). Exchangeable acidity was determined by the KCl extraction method (Mclean, 1965) and organic carbon was after dichromate wet oxidation method (Walkey and Black, 1934). The organic matter content was got by multiplying a factor of percent organic carbon by 1.72. Cation Exchange Capacity (CEC) was calculated from the sum of all exchangeable cations. Available micronutrients were extracted with 1N NH_4Cl solutions and determined by Atomic Absorption Spectrophotmeter (AAS) (Water and Sammer, 1948) cited from Aruleba (2004). Particle size analysis was by the Bouyoucos (1951) method. Saturated hydraulic conductivity was determined using a constant head method, bulk density by core method, soil porosity was estimated from the bulk density data at an assumed particle density of 2650 kgm^{-3}. Water retention at 15 bar was determined in order to calculate available water holding capacities of the soil profile horizons (Mbagwu, 1985).

Statistical analysis

Multiple linear step-wise regression analysis (forward elimination method)

The significance of this analysis is to estimate the relative contribution of each factor (land use types, land type and suitability) to land degradation for each site. To achieve this objective, a step-down model which adds one variable to the regression equation at a time was used (SAS Inst. 1990). As each variable is entered, the model incorporates a check on the variance test. The process of adding variables in turn continued until the contribution of the most recently entered variable is not significant at ($P < 0.05$) by the partial F-value. Any variable which provides a non-significant contribution is removed from the model.

RESULTS AND DISCUSSION

Results

Morphological properties

The details of the morphological properties of the soils of land use types are shown in Table 1. The basic differences between pedons at different land use types locations were in colour, texture, structure and

Table 1. Morphological properties of the pedons and soils under the different land uses.

Profile no.	Parent material	Land use	Horizon designation	Depth (cm)	Colour		Boundary	Textural class	Structure	Consistency	Quartz	Concretions	Roots	Drainage	Mottles
					Moist	Dry									
Slope (10%)															
		Fallow/cassava	Ap	0-46	10YR 6/4	10YR 5/6	cl	SCL	Sg – sbk	ss, sp, vfr, lo	-	c	vf, f	pd	-
P1 (VB)	Basement complex		Bc	46-76	10YR 5/6	–	gs	SCL	P	ns, np, lo	f	vm	vf, vf	pd	5YR 5/4
			Bt	76-126	10YR 5/6	–	cl	SCL	Co	s, p, h	f	f	vf, vf	pd	5YR 4/2
Slope (5%)															
		Cassava/plantain	Apc	0-18	7.5YR 3/2	–	ab, s	SC	G	ns, np, lo	f	vm	vf, f	wd	-
P2 (MS)	”		Btc	18-57	5YR 5/4	–	cl, w	SC	Ab	s, p, fr	-	vm	vf, vf	wd	-
			Bt	57-118	5YR 5/6	–	ir	SCL	Sg	st, sp, fr	-	c	vf, vf	wd	-
Slope (1%)															
		Cassava/maize	Apc	0-14	5YR 6/8	–	di, s	SCL	Ab	s, sp, f	f	vm	vf, vf	wd	-
P3 (C)	”		Bt	14-23	5YR 5/8	–	di, s	SCL	Ab	s, sp, f	f	vm	vf, vf	wd	-
			Btc	23-53	7.5YR 6/6	–	ab, s	SCL	G	vs, p, f	-	vm	vf, vf	wd	-
			Bt	53-112	2.5YR 4/8	–	cl	CL	M	vs, vp, vh	-	f	vf, vf	wd	-
Slope (6%)															
P4 (VB)	”	Oil palm	Ap	0-30	5YR 4/3		ab, s	SL	Sg	ns, ns, lo, vf	-	vm	c – m	wd	-
			Btc	30-110	5YR 6/6	5YR5/8	s	SCL	g/m	s, p, fr	-	vm	vf, vf		
Slope (3%)															
P5 (MS)	Basement complex	Oil palm	Ap	0-34	5YR 2/2	5YR4/2	ab, s	S	Sg	ns, np, vfr		f	m, me-co	wd	-
			AB	34-69	5YR 4/4	5YR6/3	cl, ir	LS	sg	ns, np	-	c	c, me	wd	-
			B	69-113	7.5YR 5/6	7.5YR5/8	g, ir	LS	g	ns, np	-	vm	f,m-c0	wd	-
			BC	113-137	7.5YR 5/6	10YR6/6	di	LS	g-cr	ns, np	f	vm	vf,vf	wd	5YR 3/2

+ Boundary: ab = abrupt, cl = clear, g = gradual, di = diffuse, s = smooth, w = wavy, ir = irregular, [1]Textural class: LS = loamy sand, s = sand, SL = Sandy loam, SC = Sandy clay, SCL = Sandy clay loam, [2]Structure: sbk = Subangular blocky, ab = angular blocky, sg = single grain, m = massive, co = coarse, p = prismatic, cr = crumb, g = granular, [3]Consistency: ns = non-sticky, np = non-pastic, lo = loose, s = sticky, p – plastic, f = firm, h = hard VS = very sticky, vp – very plastic, vh = very hard, fr = friable, vfr = very friable, sp = slightly plastic, ss = slightly sticky, [4]Quartz: f = few, - = Absent, [5]Concretions: f = few, c = common, m = high, vm = higher, [6]Roots: vf = very few, f = few, c = common, m = many (concentration) vf = very fine, f = fine, me = medium, co = coarse (size), [7]Drainage: wd = well drained, pd = poorly drained, [8]VB=Valley-Bottom, MS = Middle Slow and C = Crest.

Table 1. Morphological properties of the pedons and soils under the different land uses (continued).

Profile no.	Parent material	Land use	Horizon designation	Depth (cm)	Colour		Boundary	Textural class	Structure	Consistency	Quartz	Concretions	Roots	Drainage	Mottles
					Moist	Dry									
P_5 (MS)	Basement complex	Oil palm	Ap	0-34	5YR 2/2	5YR4/2	ab, s	S	Sg	ns, np, vfr		f	m, me-co	wd	-
			AB	34-69	5YR 4/4	5YR6/3	cl, ir	LS	sg	ns, np	-	c	c, me	wd	-
			B	69-113	7.5YR 5/6	7.5YR5/8	g, ir	LS	g	ns, np	-	vm	f, m-c0	wd	-
			BC	113-137	7.5YR 5/6	10YR6/6	di	LS	g-cr	ns, np	f	vm	vf,vf	wd	5YR 3/2
Slope (0.5%)															
P_6 (C)	”	Oil palm	Ap	0-33	7.5YR 3/2	7.5YR4/4	cl, s	S	sbk –gb	ns, np	f	c	m, f-co	wd	-
			BC	33-65	7.5YR 5/6	7.5YR6/4	cl, w	SC	ab	ns, np, lo	f	vm	f, f–me	wd	-
			Bt	65-112	10YR 5/8	7.5YR5/8	di, s	SC	m	vs, p, fr	-	vm	vf, vf	wd	-
Slope (4%)															
P_7 (VB)	”	Secondary forest	Apc	0-31	7.5YR 5/8	-	ab, s	SL	g	vs, fr	f	f	f, vf	wd	-
			Btc	31-108	2.5YR 4/8	–	di, ir	SL	sg	Vs	-	f	vf, vf	wd	-
Slope (2%)															
P_8 (MS)	”	Secondary forest	Ap	0-30	7.5YR 5/8	–	ab, s	LS	sg	ns, lo	-	f	f, f-me	wd	-
			B	30-62	7.5YR 5/6	–	g, w	LS	sg	ns, lo	-	f	vf, vf	wd	-
			Btc	62-112	7.5YR 7/8	–	di	SL	g	vs, vf	f	vm	c,me-co	wd	-
Slope (1%)															
P_9 (C)	„	Secondary forest	Ap	0-50	7.5YR 6/8	–	cl, w	LS	sbk	vs, f	f	f	f, vf	wd	-
			Bt	50-86	7.5YR 5/8	–	di,	SCL	m	vs, vp, vf	-	f	vf, vf	wd	-
			Btc	86-128	7.5YR 5/6	–	g, w	LS	sg	ns, lo	-	vm	vf, vf	wd	-
Slope (6%)															
P_{10} (VB)	Sand stones	Building site	Ap	0-30	5YR 5/4	-	ab, s	SL	sg	ns, np, lo	-	m	m, vf-f	pd	-
			B	30-52	7.5YR 5/4	–	cl, w	SL	sg	ns, np, lo	-	f	co, vf-f	pd	5YR 3/2
			Btc	52-82	7.5YR 6/6	–	w	LS	m	s, p, f	f	f	vf –vf	pd	-
Slope (2%)															
P_{11} (MS)	Basement complex	Building site	Ap	0-45	7.5YR 5/4	–	cl, s	LS	sg	ns, np, lo	-	f	m, vf-co	wd	-
			Bc_1	45-72	7.5YR 5/6	–	g, w	LS	g	ns, np, lo	f	vm	f, vf -f	wd	-
			Bc_2	72-104	7.5YR 5/6	–	ir	SL	m	ns, np, lo	f	f	vf –vf	wd	-

Table 1. Morphological properties of the pedons and soils under the different land uses (continued).

Slope (4%)															
P_{12} (C)	Basement complex	Building site	Ap	0-26	7.5YR 3/2	–	ab, s	SL	sg	ns, np, lo	-	f	m, f-co	wd	-
			AB	26-57	7.5YR 5/2	–	di, s	LS	sg	ns, np, lo	-	f	co, f-co	wd	-
			Bt	57-102	7.5YR 6/8	–	s	SL	m	s, p, f	-	f	vf –vf	wd	-

+ Boundary: ab = abrupt, cl = clear, g = gradual, di = diffuse, s = smooth, w = wavy, ir = irregular, [1] Textural class: LS = loamy sand, s = sand, SL = sandy loam, SC = Sandy clay, SCL = sandy clay loam, [2] structure: sbk = subangular blocky, ab = angular blocky, sg = single grain, m = massive, co = coarse, p = prismatic, cr = crumb, g = granular, [3] consistency: ns = non-sticky, np = non-pastic, lo = loose, s = sticky, p – plastic, f = firm, h = hard VS = very sticky, vp – very plastic, vh = very hard, fr = friable, vfr = very friable, sp = slightly plastic, ss = slightly sticky, [4] Quartz: f = few, - = Absent, [5] concretions: f = few, c = common, m = high, vm = higher, [6] Roots: vf = very few, f = few, c = common, m = many (concentration) vf = very fine, f = fine, me = medium, co = coarse (size), [7] Drainage: wd = well drained, pd = poorly drained, [8] VB = Valley-Bottom, MS = Middle Slow and C = crest.

Table 2. Physical properties of the soil under cassava.

Profile no.	Horizon designation	Depth (cm)	Gravel	Sand (g/kg)	Silt (g/kg)	Clay	Silt: Clay ratio	Porosity (%)	Textural Class	WHC (%)	BD (g/cm^3)	HC (cm/h)	Permeability (cm/h)
	Ap	0-46	226	508	202	290	0.70	50.6	SCL	24.1	1.31	1.68	13.6
P_1 (VB)	Bc	46-76	775	642	148	210	0.70	47.4	SCL	28.3	1.40	1.53	12.5
	Bt	76-126	102	522	118	360	0.33	44.2	SC	28.5	1.41	1.55	12.2
	Apc	0-18	687	472	158	370	0.43	51.9	SC	34.8	1.28	2.82	23.8
P_2 (MS)	Btc	18-57	663	508	142	350	0.41	55.8	SC	31.6	1.17	0.54	3.24
	Bt	57-118	201	468	202	330	0.61	43.4	SCL	35.0	1.50	1.08	4.43
	Apc	0-14	808	492	220	288	0.76	41.7	SCL	33.3	1.55	1.32	12.1
P_3	Bt	14-23	593	672	120	208	0.58	45.9	SCL	38.9	1.44	0.99	7.4
(C)	Btc	23-53	487	532	188	280	0.67	43.5	SCL	38.8	1.43	0.10	6.8
	Bt	53-112	135	418	202	380	0.53	42.6	CL	47.5	1.42	0.10	6.7

P = ploughed, c = concretion, t = illuvial accumulation of clay, LS = loamy sand, s = sand, SL = sandy loam, SC = sandy clay, SCL = sandy clay loam, VB = valley-bottom, MS = middle slow and C = crest, WHC = water holding capacity (%), BD = bulk density (g/cm^3), HC = hydraulic conductivity (cm/hr).

consistency. The soils of the land use types were characterized by brown (5YR 5/4 – 10YR 6/4), sandy loam / loamy sand, topsoil over reddish brown (2.5YR 4/8 – 7.5YR 6/8) sandy clay loam to sandy clay subsoil. The soils are deep and well drained. The structure is single grain at the top to sub-angular blocky and massive atthe sub-horizons.

Physical properties

The main physical properties of the soils are presented in Tables 2 to 5. The particle size distribution data showed that the pedons have very high sand content (> 90%) and this decreases with depth, except in some cases, particularly at the sub-soil horizon (>50 in depths) where they have very high percentage of it. Sand dominates at all the depth of the profiles. The clay content in the soils ranged from 4.8 to 37% in the

Table 3. Physical properties of the soil under oil palm.

Profile no.	Horizon designation	Depth (cm)	Gravel	Sand (g/kg)	Silt (g/kg)	Clay	Silt: Clay ratio	Porosity (%)	Textural class	WHC (%)	BD (g/cm^3)	HC (cm/hr)	Permeability (cm/hr)
P_4 (VB)	Ap	0-30	893	612	320	68	4.71	53.2	SL	43.8	1.24	0.57	5.01
	Btc	30-110	705	558	142	300	0.47	49.9	SCL	55.4	1.07	0.40	3.12
P_5 (MS)	Ap	0-34	174	912	40	48	0.83	30.6	S	18.6	1.84	0.84	6.12
	AB	34-69	253	872	80	48	1.67	37.4	LS	23.5	1.66	0.75	5.16
	B	69-113	631	872	40	88	0.45	41.0	LS	29.8	1.57	0.78	5.43
	Bc	113-137	612	812	140	48	2.92	42.8	LS	23.5	1.52	0.48	2.85
P_6 (C)	Ap	0-33	251	912	40	48	0.83	42.5	S	28.7	1.53	0.54	3.39
	Bc	33-65	627	508	142	350	0.41	35.1	SC	25.7	1.72	1.13	9.90
	Bt	65-112	899	532	120	348	0.34	53.4	SC	38.7	1.24	0.85	7.90

Table 4. Physical properties of the soil under secondary forest.

Profile no.	Horizon designation	Depth (cm)	Gravel	Sand (g/kg)	Silt (g/kg)	Clay	Silt: Clay ratio	Porosity (%)	Textural class	WHC (%)	BD (g/cm^3)	HC (cm/hr)	Permeability (cm/hr)
P_7 (VB)	Apc	0-31	133	712	160	128	1.25	42.5	SL	23.8	1.53	1.05	7.89
	Btc	31-108	99	752	120	128	0.94	43.8	SL	23.1	1.49	2.22	18.48
P_8 (MS)	Ap	0-30	60	812	140	48	2.92	54.2	LS	35.5	1.22	1.74	14.01
	B	30-62	157	812	120	68	1.76	38.9	LS	26.1	1.62	2.40	20.13
	Btc	62-112	444	672	140	188	0.74	31.2	SL	21.9	1.83	1.11	8.43
P_9 (C)	Ap	0-50	143	872	80	48	1.67	44.0	LS	53.2	1.49	0.69	1.77
	Bt	50-86	95	672	120	208	0.58	40.5	SCL	43.2	1.57	0.57	3.81
	Btc	86-128	495	872	80	48	1.67	45.5	LS	34.0	1.45	0.30	1.38

surface layer and 4.8 to 38% in the subsurface and the clay content increased down the profile. The silt content in the soil was generally low and there was no definite sequence in its distribution within the profile. The silt: clay ratios were generally low

The water holding capacity of the soils increases with increase in clay content of the soils. The porosity of the land use soils was directly proportional to percentage of sand and gravel concentration, whereas the permeability was inversely proportional to the clay content. The bulk density and hydraulic conductivity were generally low with no definite sequence in their distribution within the profile.

Chemical properties

The data on the chemical properties of the soils are given in Tables 6 to 9. The pH values of the

Table 5. Physical properties of the soil under building site.

Profile no.	Horizon designation	Depth (cm)	Gravel	Sand g/kg)	Silt (g/kg)	Clay	Silt: Clay ratio	Porosity (%)	Textural class	WHC (%)	BD (g/cm^3)	HC (cm/h)	Permeability (cm/h)
	Ap	0-30	229	812	140	88	1.59	39.6	SL	29.1	1.61	0.60	3.54
P_{10} (VB)	B	30-52	101	712	200	88	2.27	37.6	SL	24.0	1.66	1.05	7.89
	Btc	52-82	124	772	80	108	0.74	36.4	LS	30.2	1.58	1.02	6.84
	Ap	0-45	78	852	80	68	1.18	48.3	LS	42.2	1.37	2.28	19.02
P_{11} (MS)	Bc_1	45-72	504	812	100	88	1.14	47.4	LS	19.9	1.58	0.84	6.12
	Bc_2	72-104	152	712	120	168	0.71	43.2	SL	52.1	1.51	1.29	10.08
	Ap	0-26	61	772	140	88	1.59	47.8	SL	37.0	1.32	3.39	28.56
P_{12} (C)	AB	26-57	30	792	140	68	2.06	46.8	LS	46.0	1.41	2.67	22.3
	Bt	57-102	103	672	180	148	1.22	37.4	SL	28.0	1.66	0.51	3.27

P = Ploughed, c = concretion, t = illuvial accumulation of clay, LS = loamy sand, s = sand, SL = sandy loam, SC = sandy clay, SCL = Sandy Clay loam, VB=Valley-Bottom, MS=Middle Slow and C = crest, WHC = water holding capacity (%), BD = bulk density (g/cm^3), HC = hydraulic conductivity (cm/hr).

Table 6. Chemical properties of soils under cassava/maize/plantain/banana.

Profile no.	Horizon designation	Depth (cm)	pH H_2O	pH KCl	cmol.kg^{-1} Exchange bases Na	K	Ca	Mg	Ex AC	ECEC (soil)	B. Sat (%)	C (%)	Total N (%)	P (mg.kg^{-1})	Zn	Cu
	Ap	0-46	7.20	5.10	0.34	0.21	1.04	2.06	0.05	3.70	98.65	0.32	0.02	4.71	5.70	5.60
P_1 (VB)	Bc	46-76	7.15	4.75	0.48	0.30	1.18	1.60	0.05	3.64	98.63	0.38	0.04	1.88	5.40	5.30
	Bt	76-126	7.05	5.65	0.29	0.19	0.86	1.73	0.05	3.12	98.40	0.29	0.02	5.18	6.90	5.10
	Apc	0-18	7.00	6.15	0.39	0.43	1.15	1.73	0.06	3.76	98.40	1.54	0.13	2.82	6.20	5.60
P_2 (MS)	Btc	18-57	7.25	6.10	0.30	0.36	0.78	1.87	0.05	3.36	98.51	0.29	0.03	13.65	5.80	3.70
	Bt	57-118	6.05	5.10	0.25	0.24	1.14	1.21	0.11	2.95	96.27	1.22	0.13	10.35	4.60	5.20
	Apc	0-14	6.35	5.20	0.36	0.41	1.10	2.00	0.09	3.96	97.73	1.66	0.16	1.88	5.00	5.60
P_3 (C)	Bt	14-23	5.95	5.20	0.27	0.21	1.16	1.19	0.11	2.94	96.26	0.40	0.03	10.35	7.00	6.10
	Btc	23-53	6.15	5.05	0.24	0.15	1.23	1.50	0.10	3.22	96.89	1.10	0.10	6.12	6.10	5.60
	Bt	53-112	6.05	4.95	0.23	0.14	1.18	1.65	0.11	3.31	96.68	1.13	0.11	7.06	6.40	4.80

P = ploughed, c = concretion, t = illuvial accumulation of clay, VB=Valley-Bottom, MS=Middle Slope and C=Crest.

Table 7. Chemical properties of soils under oil palm.

Profile no.	Horizon designation	Depth (cm)	pH H_2O	pH KCl	cmol.kg^{-1} Exchange bases Na	K	Ca	Mg	Ex AC	ECEC (soil)	B. Sat (%)	C (%)	Total N (%)	P (mg.kg^{-1})	Zn	Cu
	Ap	0-30	7.10	6.15	0.25	0.21	1.05	1.56	0.05	3.12	98.40	1.57	0.16	11.76	5.30	5.90
P_4 (VB)	Btc	30-110	6.65	5.05	0.47	0.29	1.15	1.83	0.08	3.82	97.91	0.43	0.05	3.29	5.00	5.20
	Ap	0-34	6.70	5.65	0.20	0.12	1.14	1.38	0.08	2.92	97.26	1.01	0.10	14.12	6.20	5.70
	AB	34-69	6.60	5.75	0.21	0.10	1.25	1.44	0.08	3.08	97.40	1.31	0.13	7.06	5.80	6.50
P_5 (MS)	B	69-113	6.70	5.90	0.28	0.14	0.90	1.71	0.08	3.11	97.43	0.16	0.01	10.35	4.80	3.90
	Bc	113-137	6.95	5.90	0.24	0.14	0.89	1.89	0.06	3.22	98.14	0.38	0.04	10.00	4.90	4.50
	Ap	0-33	7.50	6.20	0.31	0.30	1.04	1.75	0.04	3.44	98.84	0.99	0.10	5.18	6.00	4.90
P_6 (C)	Bc	33-65	6.90	6.00	0.26	0.13	0.96	1.79	0.06	3.20	98.13	0.48	0.05	8.47	6.20	4.70
	Bt	65-112	6.80	5.90	0.26	0.15	0.99	1.19	0.07	2.66	97.37	0.50	0.06	6.59	6.00	6.50

Table 8. Chemical properties of soils under secondary forest.

Profile no.	Horizon designation	Depth (cm)	pH H_2O	pH KCl	cmol.kg^{-1} Exchange bases Na	K	Ca	Mg	Ex AC	ECEC (soil)	B. Sat (%)	C (%)	Total N (%)	P (mg.kg^{-1})	Zn	Cu
P7	Apc	0-31	6.70	5.45	0.28	0.18	1.08	1.48	0.08	3.10	97.42	1.33	0.13	8.94	6.20	5.60
(VB)	Btc	31-108	6.40	5.65	0.23	0.13	1.03	1.38	0.09	2.86	96.85	0.67	0.07	5.18	6.00	5.40
	Ap	0-30	6.90	6.45	0.32	0.50	1.08	1.93	0.06	3.89	98.46	0.27	0.03	3.76	5.70	5.30
P8 (MS)	B	30-62	6.80	5.80	0.23	0.15	1.06	1.98	0.07	3.49	97.99	0.32	0.03	1.14	4.80	4.70
	Btc	62-112	6.65	5.75	0.33	0.28	0.90	1.87	0.08	3.46	97.69	0.21	0.02	0.94	4.80	4.50
P9	Ap	0-50	6.80	5.60	0.28	0.24	1.01	1.93	0.07	3.40	97.50	0.54	0.05	8.47	5.10	4.10
(C)	Bt	50-86	6.75	5.80	0.26	0.29	0.91	1.93	0.08	3.47	97.69	0.66	0.06	13.17	5.30	4.40
	Btc	86-128	6.30	5.30	0.36	0.21	0.99	1.73	0.09	3.38	97.34	0.61	0.06	1.14	5.40	4.40

land use soils ranged from 6.35 to 7.5 and KCl (5.10 and 6.30) in the surface layer. These values had no definite sequence in their distribution down the profile. The exchangeable bases (K, Ca, Mg and Na) in all the pedons were generally low and the exchange complex of all pedons were dominated by Ca and Mg. The Exchangeable Acidity (EA) was also low (0.04 – 1.10) cmol.kg^{-1} and fluctuated irregularly with depth in most of

Table 9. Chemical properties of soils under building site.

Profile no.	Horizon designation	Depth (cm)	pH H_2O	pH KCl	cmol.kg^{-1} Exchange bases Na	K	Ca	Mg	Ex AC	ECEC (soil)	B. Sat %	C (%)	Total N (%)	P (mg.kg^{-1})	Zn	Cu
P10 (VB)	Ap	0-30	6.85	5.70	0.29	0.18	1.09	1.89	0.07	3.52	98.01	0.64	0.06	0.94	4.10	5.10
	B	30-52	6.65	5.40	0.26	0.15	1.11	1.46	0.08	3.06	97.39	0.26	0.03	0.94	4.70	4.80
	Btc	52-82	7.10	5.50	0.32	0.26	1.11	1.95	0.05	3.69	98.64	0.21	0.02	16.47	5.60	5.30
P11 (MS)	Ap	0-45	6.85	5.50	0.25	0.24	0.80	1.67	0.07	3.03	97.69	0.32	0.02	2.35	4.90	5.30
	Bc_1	45-72	7.10	5.85	0.35	0.26	1.15	1.80	0.05	3.61	98.61	0.41	0.05	15.06	4.50	5.10
	Bc_2	72-104	7.00	5.85	0.30	0.32	0.88	1.56	0.06	3.12	98.08	0.32	0.03	2.82	4.60	5.20
P12 (C)	Ap	0-26	6.90	5.60	0.30	0.20	1.25	1.58	0.06	3.39	98.23	0.72	0.07	5.65	5.70	5.90
	AB	26-57	6.90	5.15	0.29	0.10	1.19	1.87	0.06	3.51	98.29	0.18	0.02	1.88	6.00	5.00
	Bt	57-102	6.50	5.05	0.31	0.10	1.13	1.48	0.08	3.10	97.42	0.12	0.01	7.87	4.80	5.40

P = Ploughed, c = concretion, t = illuvial accumulation of clay, VB = Valley-Bottom, MS = middle slope and C = crest.

the pedons. The Effective Cation Exchange Capacity (ECEC) was high and followed the same trend with exchangeable acidity with the highest values being recorded in most pedons at the surface horizon, the values of ECEC ranged from 2.92 – 3.96 cmol.kg^{-1} on the surface and 2.66 – 3.82 cmol.kg^{-1} at sub-surface. The base saturation by ECEC values were very high both in the surface and lower horizons in all the profiles of the land use types examined. While the distribution down the profiles decreases in some, in the others they were very erratic.

The organic carbon fluctuated irregularly with depth in nearly all the pedons, indicating deposition material particularly from soils of sand stones origin. The value of organic carbon ranged from 0.27 to 1.66% in the surface layers, with the highest concentration on the surface soils in most pedons. The total N was relatively low but high in most of the top soils where the range was between 0.02 and 0.16% and it fluctuated irregularly with depth following the same trend as organic carbon. Available P (Bray P1) in all the pedons was generally high and fluctuated irregularly with depth with high concentration at the sub-surface horizons in most pedons. This may be due to application of phosphate fertilizer. Extractable Zn and Cu relative to the critical levels established down the profile were very high and erratic.

The result of multiple linear stepwise regressions of land use type, land type and suitability with land degradation (physical, chemical and biological) is shown in Table 9 for all the land use types. The significance of the contribution of each factor was determined at 5% significance level ($P < 0.05$).

At the land use 1, suitability (oil palm) contributed significantly (24.22%) of degradation due to potassium content. There was no contribution and regression model at land use 2 because of the uniformity of independent variables of degradation indicators examined. At land use 3, land type contributed significantly 29.3% and suitability (cassava/maize) contributed significantly 35.1% due to nitrogen degradation. For degradation (organic matter content), suitability (in terms of cassava/maize) contributed 39.7. For degradation due to permeability in land use 4, land type significantly contributed 22.2% (Table 10).

DISCUSSION

The morphological, physical and chemical properties of the soils studied varied from one land type to another in all the four land use types especially as regard colour, texture, structure, consistency, exchangeable bases, organic carbon, total nitrogen etc. The major differences observed were in structure, texture, colour, drainage and soil consistence. It was observed

Table 10. Stepwise multiple linear regression analysis of land use types, land types, land suitability and land degradation.

Degradation indicator	Independent variable	Land use 1		Land use 2		Land use 3		Land use 4	
		Contribution	Cumulative	Contribution	Cumulative	Contribution	Cumulative	Contribution	Cumulative
BD	Suitability (Oil palm) (s)	-	-	-	-	-	-	-	-
Permeability	Land type	-	-	-	-	-	-	22.2	22.2
	Suitability (Oil palm) (s)	-	-	-	-	-	-	-	-
N	Land type	-	-	-	-	29.3	29.3	-	-
	Suitability (Cassava/Maize) (s)	-	-	-	-	85.1	64.4	-	-
K	Suitability (Cassava/Maize) (s)	24.2	24.2	-	-	-	-	23.6	45.8
Organic matter content	Suitability (Cassava/Maize) (s)	-	-	-	-	39.7	39.7	-	-

Model for land degradation: Land use 1, Potassium, $Y = 0.38 + 0.49S_1$, $-0.08LUT – 0.16LT – 0.13S_2$; Land use 3, Nitrogen, $Y = 4.50 – 0.50S_1 - 0.25S_2 – 0.03LT$, humus content, $Y = 4.65 – 0.40S_1 – 0.14S_2 – 0.17LT$; Land use 4, Permeability, $Y = 2.93 – 0.15S_1 – 0.28LT$, Potassium, $Y = 0.53 + 0.30S_1 + 0.60LT$. Note: LUT – Land use type, LT – Land type, S_1 – Cassava/Maize, S_2 – Oil palm.

from the study that the pedons at the crest and middle slope were well drained, while the pedons at the valley bottom were poorly drained. This is due to the differences in clay contents and regional water table, with valley bottom section having higher clay content at the surface than the other land types which invariably reduces infiltration rate of the water (Ahn, 1970; McKeague, Day and Shields, 1970; Philipson and Drosdoff. 1972; Banin and Amiel, 1969; Smyth and Montgomery, 1962; Senjobi, 2007). The colour difference showed that pedons on the crest and middle slopes were more reddish to brownish but greyish at the valley bottom. This variation in soil colour was due to the obvious sequences of drainage (Senjobi, 2007).

Besides, the influence of drainage on soil colour variation, it has been reported by Majlis (1967) that soil colour has been expressed too as a function of iron and organic matter contents, pH and type of clay mineral in the soil.

The fluctuating water table in the lower slope and valley bottom soils also resulted in the occurrence of hydromorphic mottles in these areas.

The gravel content was very high ranging from 6.0 to 95.9% in nearly all the pedons except in pedons number 12 at building site location. The pedons are composed of concretions, ferruginous nodules, quartz gravel and stones, which concentrate as stone lines or stone layers (Sharpe, 1938; Nye, 1954). The erosion exposes a sheet of gravel mantle, which is subsequently buried by the sedimentation of fine textured materials. Stonelines interfere considerably with manual soil tillage and thereby limits the aggregate size of farmland that a farmer can put under cultivation. According to Babalola and Lal (1987), this type of physical feature is permanent and difficult to change.

The high percentage of soil texture (41.8 – 91.2%) in all the land use types which is sandy is a good indication of the observable high infiltration rate and low water holding capacity of the soils, thereby resulting into moisture stress as reported by Fagbami and Udoh (1982) andSenjobi (2007). In addition to the above, this scenario encourages rapid leaching of nutrients from the soils beyond the rooting zones of the planted crops – a situation that threatens increase in food productivity and food security.

The poor water holding capacity of the soils is as a result of coarse texture nature of the studied soils. This in turn enhances erodibility of the soil on exposure either through cultivation or construction of buildings and roads. As a result of this, topsoil is washed away leading to loss of nutrients and organic matter content of the soil and possibly soil compaction. These erosion problems can be checked to the barest minimal level through appropriate land use practices which are not only environmental friendly and acceptable by land users, but which also ensure the maintenance and continuous vegetable cover over the soil surface.

The organic carbon fluctuates irregularly with depth for most of the pedons and this is an indication of continuous deposition of organic material. The low organic carbon values in some pedons may be partly due to the high temperature and high relative humidity, which favour rapid mineralization. Organic matter has been reported to have positive influence on the CEC, base saturation, structure, pH, buffering capacity, soil colour, and water holding capacity (Majlis, 1967; Ahn, 1970; Senjobi, 2007; Senjobi et al., 2010a). The organic matter content of the surface horizons in all the land use types is acceptable. This may be due to the fact that most of the organic residues in both cultivated and virgin soils are incorporated or deposited on the surface. The organic matter content of soils under secondary forest and oil palm cultivation are higher than those of building site and arable cultivation. This may be because the soils under those land use systems were always covered and they had not been subjected to intense cultivation and use as in arable and building land use types (Senjobi and Ogunkunle, 2010b). The incorporation of organic residues into the soils through tillage practices at the arable land use type have contributed to the relatively higher level of organic matter in this site than that of building site.

The total nitrogen content in all the soils of land use types was generally low (0.01 – 0.19%) compared with the critical value of 0.15% (Agboola and Carey, 1973). The intense cultivation of the soils normally increases the rate of mineralization of the organic matter (Senjobi, 2007; Senjobi and Ogunkunle, 2010b), thus negatively affect the level of total N content in the soil. The available P was generally moderate in most of the pedons and high in the remaining pedons compared with the critical level of 10 – 16 ppm (Adeoye and Agboola, 1985).

The exchangeable cations Ca, Mg, K and Na were generally low in all the pedons. This may be attributed to intense cultivation, leaching of nutrients and weathering consequently leading to the inherent low fertility status of the soil.

According to FAO (1978), the decrease in organic matter status of the soils when the biomass or the crop residues are insufficient to replace the humus could be attributed to the rapid biological degradation of the soils. For most low activity clays, of the tropical soils, the organic matter is the major exchange site for the basic nutrients cations in the soils. Organic matter had an influence on the cation exchange capacity and clay minerals of the tropical soils (McKague et al., 1970). Onasanya (1992) however, observed that organic matter had a more controlling effect on ECEC than clay minerals, especially in tropical soils. Therefore steps should be taken to increase the organic matter content of the soils, so as to increase the ECEC values of the soils and other soil chemical properties.

This can be achieved through the use of organic manure as a supplement to inorganic fertilizers. The use of mulching materials which will drastically reduce the effect of erosion at the same time enrich the soil is valuable. The use of organic refuse to conserve, maintain favourable soil temperature and supply nutrients through biological activities of earthworms are advisable (Senjobi, 2001, 2007; Senjobi et al., 2010a; Senjobi and Ogunkunle, 2010b).

The result of the multiple linear stepwise regression analysis above showed that factors contributing to different forms of degradation differ from one land use type to another. This analysis indicates that virtually most of the degradation forms are contributed to by suitability and land type nearly all the land use types. This could be attributed to the exploitative nature of the crops which are mainly cassava/maize and oil palm as well as exposure of land by the arable crops.

These results further showed that these crops were not planted to where they are best suited for. Again inappropriate allocations of agriculturally good lands to non-agricultural purposes constitute an immense factor to physical, chemical and biological degradation of the land.

Conclusion

It was observed from the study that soil nutrients vary and changes from one land use type to another. Soil nutrients depletion and degradation processes at all land use types were high, very high and prominent under building site and arable that is cassava and maize based cropping systems as reflected in their nutrients values.

It was also observed that the land use types employed on the study sites were not very compatible with the characteristics of the soil. Thus, it encourages various nutrients status which are always at the declining rate. This in turn affects soil productivity negatively leading to food insecurity at large.

To take adequate care of these deficiencies, and minimize soil nutrients depletion and degradation in the study sites, the following measures are recommended. These include plausible land use approach, multiple cropping, organic mulching, contour ridge and cultivation of cover crops among others.

In addition to the above measures, there is the need to understand the soil adequately through detailed soil survey and land evaluation. When this is carefully done, the soil can then be put to appropriate land use that is cultivate the crops that are most suitable for the land, having known its capability and constraints as well as use the land for the purposes it is best suited for, this will go a long way to improve the productivity of such lands.

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