Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 23 (2019) 1-12 EISSN 2543-5426

Physicochemical Properties of Soils derived from Sandstone Parent Materials under Selected Land use types at Agoi-Ibami in Central Cross River State, Nigeria

M. O. Eyong[a] and **E. A. Akpa**[b]

Department of Soil Science, University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria

[a,b]E-mail address: michaeleyong87@yahoo.com , enyaanari@gmail.com

ABSTRACT

Three profiles were sited on the major landscape elements of crest, middle slope and lower slope on three land uses; Forest (FS), Rubber (RS) and arable cropping (AS) at Agoi-Ibami in Central Cross River State, Nigeria. For study purposes, soil samples were collected from the morphogenetic horizons for the analysis of physical and chemical properties. Results showed that the surface horizon textures were mostly sandy loams with little sandy clay loam, while subsurface textures were mostly sandy clay loams with few silt clay loams and clays. The bulk densities were below the ranges of 1.46 to 1.63 $g\ cm^{-3}$ for silts and clays and 1.75 $g\ cm^{-3}$ for sands. This imposes stresses such as mechanical resistance to root penetration, decrease in cultivation and organic matter. The surface and subsurface pH values vary from 4.9–4.5 in FS, 4.9-4.6 in RS and 4.9 in AS, indicating that the soils are very strongly acidic. The Organic carbon contents was low with mean values of 4.33 and 0.6 % in surface and subsurface for FS, 2.10 and 0.50 % for surface and subsurface for RS, while surface and subsurface values proved to be 0.57 and 0.31 % for AS. The nitrogen contents was also low, mean values of 0.16 and 0.06 % for surface and subsurface for FS, 0.23 and 0.08 % for surface and subsurface for RS, and 0.19 and 0.10 % for surface and subsurface for AS. The content and available phosphorus are equally low, except for AS, with surface mean values ranging from 11.52 $mg\ kg^{-1}$ to 13.87 $mg\ kg^{-1}$. The exchangeable cations, Ca, Mg, K, and Na were very low, while exchangeable H^+ and Al^{3+} were high. Base saturation was also low in FS and AS (< 50%) in surface soils, but higher in AS in the surface and in RS in the subsurface soils. The mean values of organic matter were 4.33 and 0.16 %. The land use should, therefore, be adjusted by application of recommended inorganic fertilizers and organic matter so as to support growth of crops such as maize, yams, cassava etc.

***Keywords*:** Physicochemical properties, Sandstone, land use types

(Received 20 December 2018; Accepted 10 January 2019; Date of Publication 22 January 2019)

1. INTRODUCTION

The problem of land use types is the way land is put into use. Land is an important aspect of production which is put into different uses by land users. Land use is defined as the total of arrangements, activities and inputs that people undertake in a certain land cover type as put by Ameztegul *et al*. [2]. It involves the management of natural environment into built environment such as settlements and semi-natural habitat such as arable fields, pastures and managed woods. Land use practices have a major impact on natural resources including water, soil, nutrients, plants and animals. Forest, rubber and arable lands are excellent for production of crops and can increase the growth and yield of crops if properly managed. The nature and properties of soils vary with their environmental factors particularly their climate and vegetation as put by Ameztegul *et al*. [2].

Soil physical and chemical properties are important characteristics used to determine the texture and the fertility content of any soil which are of extreme important for crop production, project planning and design because they form the basis for many of the more costly operations that are required in project development. Soil physical conditions are measured and managed to provide favorable environment like water, air, temperature and adequate soil protection against water or wind [8]. Their importance is predicted on their control of water infiltration, percolation drainage water retention, root-extension, soil inherent resistance to erosion, aeration and gas exchange, temperature regulation, workability or ease of tillage of the soil and stability in the case of building site [11]. Soil deficient in nutrients reserve results to low fertility status for plant growth and yield and its chemical properties are important aspect to be considered in land uses in agriculture. The parent materials giving rise to soils in Central Cross River State include basalt, basement complex (granite, gneiss, quartzite and schist), sandstone-shale intercalation and alluvium [5]. Sandstones are mechanically formed sedimentary rocks and produce soils known as acid sands which are acid in nature with multiple nutrients deficiency but possessing some desirable physical properties [7]. Three land use types: forest, rubber and arable cropping were defined as major land uses in Agoi-Ibami and Nko as observed by Eyong *et al*. [6]. The soils are acid sands developed from sandstones predominantly in the study area but of agricultural significance. Despite their extensive occurrence and influence on agriculture, their physical and chemical properties were seldom investigated. This study therefore will report a fundamental knowledge of the physicochemical properties of the soils based on the land use types in the study area.

2. MATERIALS AND METHODS

2. 1. Location

The study area is located at Agoi-ibami in Central Cross River State. It lies between latitude 5º47.56' N and longitude 8º11.30' E (Fig. 1). The mean annual rainfall ranges from 1700 - 2250 mm while its distribution is bimodal with a dry spell of 4 months between November and March [4]. The means daily minimum and maximum temperatures vary from 21 – 24 ºC and 2 – 32 ºC respectively and the relative humidity varies from 82 – 97 % [4]. The area is underlain by cretaceous deposit of sandstones as put by Eyong *et al*. [6]. The vegetation consists of mosaic farmlands cultivated to arable crops like maize, cocoyam, okra etc., forest and permanent tree crops such as rubber and oil palm.

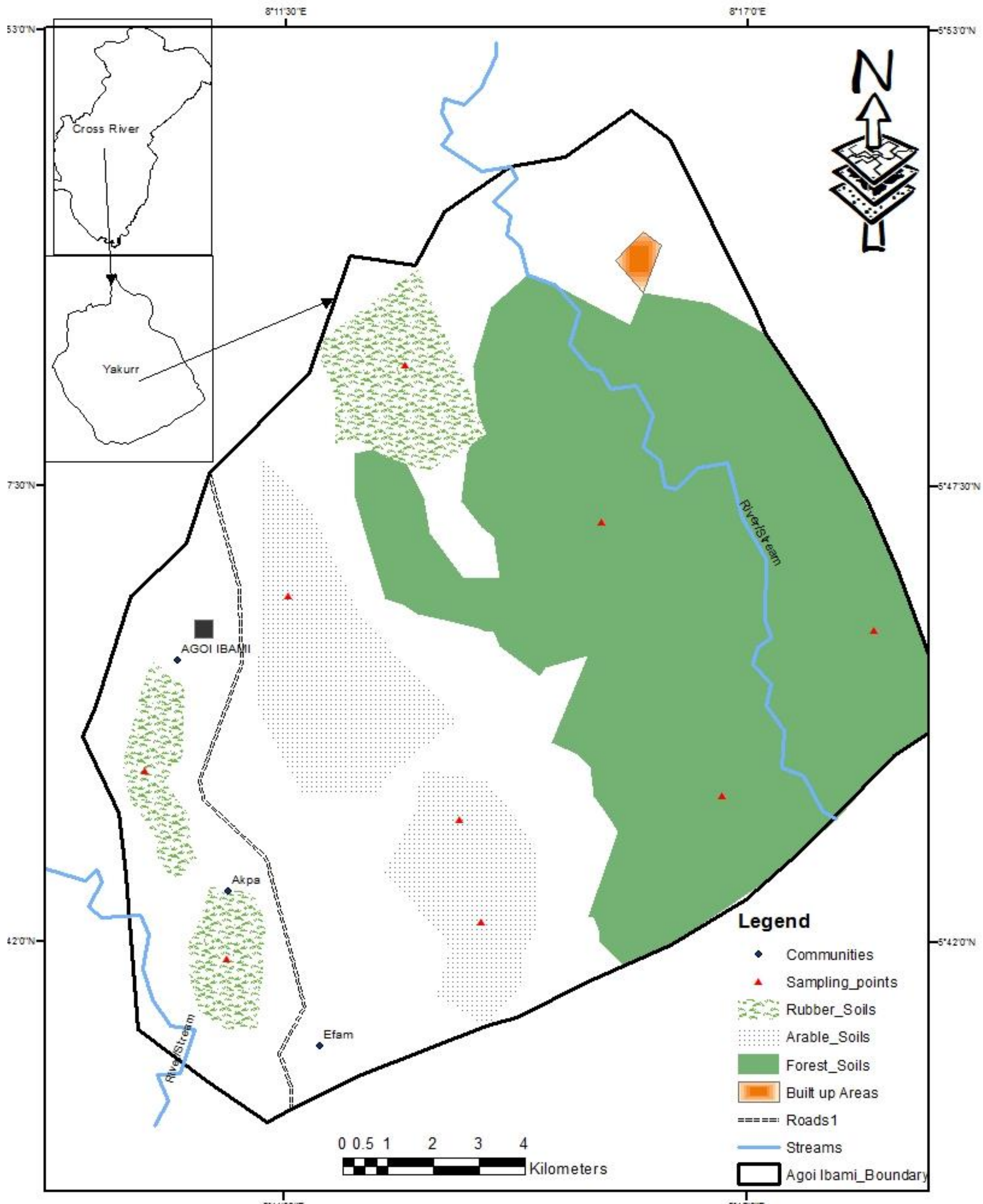

Fig. 1. Map showing the study area

Source: Geographic Information System (GIS) Laboratory, Department of Geography and Environmental Science, University of Calabar

2. 2. Field study

Three profiles were sited on major landscape elements of crest, middle slope and lower slope in each of the land use types: forest (FS) rubber (RS) and arable cropping (AS) to account for differences in soil properties and elimination of catenaries difference. Profiles were dug 1.5 m × 2.0 m × 2.0 m deep to impenetrable layer or water table or whichever was shallower. Thereafter soil samples were collected from the morphogenetic horizons into well labeled sample bags and taken to the laboratory for analysis. Samples from forest profiles were designated FS1, FS2 and FS3, rubber were designated RS1, RS2 and RS3 while arable were designated AS1, AS2 and AS3.

2. 3. Laboratory analyses

Soil samples collected from the site were air-dried, gently crushed with pestle and mortar and sieved through a 2.00 mm sieve to obtain the fine earth fraction for the analysis. Particle size analysis was determined by Bouyoucos hydrometer methods using sodium hexametaphosphate(VII) as dispersant [10]. Bulk density was determined using 100 cm^3 metallic cores to collect undisturbed soil samples from various horizons of each profile pit, oven-dried at 105 ºC to constant weight and the bulk densities were calculated. The pH was determined potentiometrically with a glass electrode pH meter in water at 1:2.5 soil: water ratio. Organic Carbon was determined following the Walkley and Black wet oxidation method as described by Srikanth *et al.* [13]. Total nitrogen was determined by the micro-kjeldhal method. Available phosphorus was determined by extraction with Bray P-I extractant and phosphorus in the solution described by Srikanth *et al.* [13]. Exchangeable acidity was determined by successive leaching of soil with neutral unbuffered 1N KCl using 1:10 Soil: Liquid ratio. The amount of H^+ and Al^{3+} in the leachate was determined by the titration method described by Srikanth *et al.* [13]. Exchangeable cations were determined with 1N ammonium acetate (pH 7.0) using 1:10 Soil: Water ratio. Ca^{2+} and Mg^{2+} in the filtrate were determined with an atomic adsorption spectrophotometer (AAS) while Na^+ and K^+ were determined with a flame photometer described by Srikanth *et al.* [13]. Cation exchange capacity (CEC) was determined by the neutral ammonium acetate (pH 7.0) method. While effective cation exchange capacity was calculated by summing up exchangeable H^+ and Al^{3+} and exchangeable cations. Base saturation was determined the summation of exchangeable bases (Ca, Mg, K and Na) by the total exchangeable bases and acidity and multiply by 100 percent.

2. 4. Data analysis

Data collected in each of the land use types in the study location was subjected to statistical analysis of variance and descriptive statistics with the help of SSPS software.

3. RESULTS AND DISCUSSION

3. 1. Physical properties - Particle size distribution

The results of the physical properties of forest, rubber and arable soils are presented in Table 1, 2 and 3. In surface horizon, the mean values of sand, silt and clay were 75.7, 13 and 11.3 % for forest and 52.7, 39 and 8.7 % for rubber and 70, 23 and 7 % for arable land uses while in sub surface horizon the mean values of sand, silt and clay were 67.3, 10 and 22.7 for forest and 28.6, 25 and 46 for rubber and 55, 12.8 and 32% for arable land uses. This showed that all the mean values increased with depth. The surface horizon textures were predominantly mostly by sandy loams while subsurface textures were mostly by Sandy clay loams. The dominant particle size fraction was sand and reflects the sandstone parent material from which the soils were derived. The sand fraction decreased with depth while there was argilluviation of clay leading to a clay bulge as a result of removal of finer materials which are transported vertically and laterally down the slope by subsurface drainage and runoff [1] respectively. Silt fraction was the least and was not uniformly distributed.

3. 2. Bulk density

The results of the bulk density for the forest, rubber and arable land uses are shown in Tables 1, 2 and 3 respectively. In Forest soils, the mean values were 1.18 and 1.37 g/cm^3 for surface and sub surface. For rubber, the mean values were 1.26 and 1.5 g/cm^3 for surface and sub surface and arable land uses, the mean values were 1.16 and 1.3 g/cm^3 for surface and sub surface respectively. They all increased with depth as a result of decrease in cultivation and organic matter as depth increases as observed by Eyong *et al.* [6]. The bulk densities values showed mechanical resistance to root penetration, decrease in air filled porosity and permeability.

Table 1. Physical properties of soils under forest at Agoi-Ibami.

Elev. (m)	Profile NO:	Horizon	Depth (cm)	PSD			TC	BD
				Sand	Silt	Clay		g/cm^3
				←	%	→		
141	FS1	A	0-20	66	20	14	SL	1.25
		Bt	20-68	75	7	18	SL	1.36
		C	68-105	70	8	22	SL	1.38
121	FS2	A	0-15	77	13	10	SL	1.3
		BA	15-56	70	13	17	SL	1.45
		Bt	56-103	65	12	23	SCL	1.46
		C	103-150	65	12	23	SCL	1.46
115	FS3	A	0-20	84	6	10	LS	0.98
		Bt	20-51	64	6	30	SCL	1.2
		Btg	51-89	62	12	26	SCL	1.25
	Surface	**Mean**		**75.7**	**13**	**11.3**		**1.18**

		Min.		**66**	**6**	**10**		**0.98**
		Max.		**84**	**20**	**14**		**1.3**
	Subsurf	**Mean**		**67.3**	**10**	**22.7**		**1.37**
		Min.		**62**	**6**	**17**		**1.2**
		Max.		**75**	**13**	**30**		**1.46**

FS = Forest soils; PSD = Particle size distribution; TC = Textural class; BD = Bulk density; SL = Sandy loam; SCL = Sandy clay loam; LS = Loamy sand

Table 2. Physical properties of soils under rubber at Agoi-Ibami.

Elev. (m)	Profile NO:	Horizon	Depth (cm)	PSD			TC	BD
				Sand	Silt	Clay		g/cm^3
				←	%	→		
135	FS1	Ap	0-30	57	32	11	SL	1.42
	Crest	BA	30-68	54	30	16	SL	1.47
		Bt	68-110	47	26	27	SCL	1.55
		C	110-150	17	28	55	C	1.56
86	RS2	AP	0-20	54	38	8	SL	1.3
	Mid. Sl.	Bt1	20-55	46	23	31	SCL	1.38
		Bt2	55-90	16	19	65	Si CL	1.39
		C	90=150	18	17	65	Si CL	1.45
52	RS3	Ap	0-25	47	46	7	SL	1.05
	Low.sl.	Bt	25-90	19	36	45	C	1.4
		Bt2	90-110	16	23	61	C	1.47
		Ct2	110-145	24	26	50	C	1.49
	Surface	**Mean**		**52.7**	**39**	**8.7**		**1.26**
		Min.		**47**	**32**	**7**		**1.05**

		Max.		**57**	**46**	**11**		**1.42**
	Subsurf	**Mean**		**28.6**	**2**	**46**		**1.5**
		Min.		**16**	**17**	**16**		**1.38**
		Max.		**54**	**36**	**65**		**1.57**

RS = Rubber soils; PSD = Particle size distribution; TC = Textural class; BD = Bulk density; SL = Sandy loam; SCL = Sandy clay loam; Si CL = Silty clay loam; C = clay

Table 3. Physical properties of soils under arable at Agoi-Ibami.

Elev. (m)	Profile NO:	Horizon	Depth (cm)	PSD			TC	BD
				Sand	Silt	Clay		g/cm^3
				←	%	→		
152	AS1	Ap	0-30	75	19	6	SL	1.15
	Crest	BA	30-49	65	10	25	SCL	1.26
		Bt	49-85	47	9	44	SC	1.3
		C	85-150	46	11	43	SL	1.35
157	AS2	Ap	0-18	68	24	8	SCL	1.3
	Mid. Sl.	BA	18-85	63	5	32	SC	1.35
		Bt	85-125	59	4	37	SC	1.35
		C	125=160	56	3	41	SL	1.4
52	AS3	Ap	0-20	67	26	7	SL	1.03
	Low.sl.	BA	20-45	58	33	9	SCL	1.15
		Bt	45-96	54	14	32	SCL	1.3
		C	96-150	51	26	23	SCL	1.45
	Surface	**Mean**		**70**	**23**	**7**		**1.16**
		Min.		**67**	**19**	**6**		**1.03**
		Max.		**75**	**24**	**7**		**1.3**
	Subsurf	**Mean**		**55**	**12.8**	**32**		**1.3**
		Min.		**46**	**3**	**9**		**1.15**
		Max.		**65**	**33**	**44**		**1.45**

AS = Arable soils; PSD = Particle size distribution; TC = Textural class; BD = Bulk density; SL = Sandy loam; SCL = Sandy clay loam; LS = Loamy sand

Table 4. Chemical properties of soils under forest at Agoi-Ibami.

Elev.	Profile NO	Horizon	Depth (cm)	pH	OC	TN	Av. P	EXC, Bases				Exc. A		ECEC	BS
								Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	H^{+}	Al^{3+}		
					%	%	Mg/kg	← Cmol/kg →							%
135	FS1	Ap	0-20	4.8	5.5	0.15	6	1	0.4	0.3	0.1	0.1	0.6	4.4	4.09
	Crest	Bt	20-68	4.6	0.75	0.07	4	0.6	0.25	0.2	0.1	0.1	0.8	5.45	21.1
		C	68-105	4.4	0.4	0.06	2	0.42	0.15	0.15	0.1	0.1	2.3	8.72	9.4
86	RS2	AP	0-15	4.9	3.5	0.1	4	0.7	0.25	0.2	0.2	0.2	0.8	5.65	23.9
	Mid. Sl.	BA	15-56	4.7	0.68	0.07	3	0.4	0.15	0.1	0.1	0.1	1.2	9.15	8.19
		Bt	56-103	4.5	0.45	0.05	3	0.4	0.15	0.1	0.1	0.1	5.3	18.05	4.1
		C	103-150	4.4	0.45	0.03	2	0.1	0.1	0.08	0.1	0.1	8.5	23.88	1.5
52	RS3	AP	0-20	4.9	4	0.25	8	1.3	0.75	0.15	0.2	0.2	0.75	3.9	61.5
		Bt	20-51	4.7	0.85	0.08	3	0.3	0.4	0.12	0.1	0.1	3.0	3.92	23.5
		Btg	51-89	4.5	0.65	0.05	2	0.2	0.3	0.1	0.1	0.1	2.5	5.9	11.9
	Surface	**Mean**		**4.9**	**4.33**	**0.16**	**6**	**1**	**0.47**	**0.22**	**0.17**	**0.17**	**0.72**	**4.65**	**42.1**
		Min.		**4.8**	**3.5**	**0.1**	**4**	**0.7**	**0.25**	**0.15**	**0.1**	**0.1**	**0.6**	**3.9**	**23.9**
		Max.		**4.9**	**5.5**	**0.24**	**8**	**1.3**	**0.75**	**0.3**	**0.2**	**0.2**	**0.8**	**5.65**	**61.5**
	Subsurf	**Mean**		**4.5**	**0.6**	**0.06**	**2.7**	**0.35**	**0.21**	**0.12**	**0.1**	**3.37**	**7**	**10.7**	**11.4**
		Min.		**4.4**	**0.4**	**0.03**	**2**	**0.1**	**0.1**	**0.08**	**0.1**	**0.8**	**2.7**	**3.9**	**1.5**
		Max.		**4.7**	**0.85**	**0.08**	**4**	**0.6**	**0.4**	**0.2**	**0.1**	**8.5**	**15**	**23.58**	**23.5**

FS = Forest soils; OC = Organic carbon; Total N = Total nitrogen; A.P = Available phosphorus; ECEC = Exchangeable cation exchange capacity; BS = Base saturation

Table 5. Chemical properties of soils under rubber at Agoi-Ibami

Elev.	Profile NO	Horizon	Depth (cm)	pH	OC	TN	Av. P	EXC, Bases				Exc. A		ECEC	BS
								Ca^{2+}	Mg^{2+}	K^+	Na^+	H^+	Al^{3+}		
					%	%	Mg/kg	←		Cmol/kg			→		%
135	RS1	AP	0-30	4.9	1.93	0.2	3.25	0.75	0.25	0.33	0.1	0.5	3	4.93	29.0
	Crest	BA	30-68	4.8	0.8	0.16	0.4	0.55	0.33	0.25	0.1	1.6	7	9.83	12.5
		Bt	68-110	4.7	0.75	0.09	0.2	0.42	0.4	0.12	0.1	3.4	8.4	12.84	8.09
86	RS2	C	110-150	4.6	0.7	0.06	0.12	2.2	0.45	0.1	0.1	4.5	13	18.75	15.2
	Mid. Sl.	AP	0-20	4.8	1.75	0.21	2.5	0.45	0.15	0.2	0.2	1.4	4.5	6.9	14.5
		Bt1	20-55	4.7	0.63	0.15	0.45	0.3	0.12	0.15	0.1	2	7	9.67	6.93
		Bt2	55-90	4.6	0.33	0.07	0.32	0.25	0.18	0.1	0.1	2.5	8.5	11.55	4.76
52	RS3	C	90-150	4.6	0.27	0.04	0.2	0.25	0.2	0.1	0.1	9.5	12	21.65	3.0
	Low. sl.	AP	0-25	4.9	2.75	0.27	2.55	0.85	0.2	0.35	0.2	0.6	4	6.6	24.2
		Bt1	25-90	4.7	0.5	0.07	1.2	0.64	0.25	0.25	0.1	2.3	8.3	11.84	10.4
		Bt2	90-110	4.6	0.29	0.05	0.6	0.56	0.36	0.15	0.1	2.1	15	18.57	6.3
		Ctg	110-150	4.5	0.21	0.03	0.45	0.37	0.36	0.12	0.1	7.6	12	20.95	4.5
	Surface	**Mean**		**4.9**	**2.1**	**0.23**	**2.8**	**0.68**	**0.2**	**0.29**	**0.17**	**0.83**	**3.8**	**6.1**	**22.6**
		Min.		**4.8**	**1.75**	**0.2**	**2.5**	**0.55**	**0.2**	**0.2**	**0.1**	**0.5**	**3**	**4.93**	**14.5**
		Max.		**4.9**	**2.75**	**0.27**	**3.25**	**0.85**	**0.25**	**0.35**	**0.2**	**1.4**	**4.5**	**6.9**	**29.0**
	Subsurf.	**Mean**		**4.6**	**0.5**	**0.08**	**0.4**	**0.6**	**0.3**	**0.15**	**0.1**	**3.9**	**10**	**15.1**	**8.0**
		Min.		**4.5**	**0.21**	**0.03**	**0.12**	**0.25**	**0.12**	**0.1**	**0.1**	**1.6**	**7**	**9.67**	**3.0**
		Max.		**4.8**	**1.2**	**0.16**	**1.2**	**2.2**	**0.45**	**0.25**	**0.1**	**9.5**	**15**	**21.65**	**15.2**

FS = Forest soils; OC = Organic carbon; Total N = Total nitrogen; A.P = Available phosphorus; ECEC = Exchangeable cation exchange capacity; BS = Base saturation

Table 6. Chemical properties of soils under arable at Agoi-Ibami.

Elev.	Profile NO	Horizon	Depth (cm)	pH	OC	TN	Av. P	EXC, Bases				Exc. A		ECEC	BS
								Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	H^{+}	Al^{3+}		
					%	%	Mg/kg	← Cmol/kg →							%
152	AS1	AP	0-30	5	0.72	0.24	11.52	2	1.6	0.1	0.1	0.12	0.5	4.46	85.2
	Crest	AB	30-49	4.9	0.52	0.16	4.32	1	0.9	0.19	0.05	0.54	0.8	3.51	60.9
		Bt	49-85	4.8	0.44	0.12	5.75	2.6	0.5	0.16	0.05	0.72	1.0	4.98	66.8
157	AS2	C	85-150	4.8	0.32	0.06	1.25	2.8	2	0.14	0.04	0.88	1.7	7.51	66.3
	Mid.	AP	0-18	4.9	0.16	0.04	11.62	2.4	1.4	0.12	0.06	0.15	0.2	4.33	91.9
	Slope	AB	18-85	4.9	0.32	0.06	6.5	0.8	1.6	0.24	0.06	0.23	0.3	3.23	83.6
		Bt	85-125	4.8	0.18	0.02	1.75	1.4	1.8	0.14	0.05	0.45	0.5	4.34	78.1
52	AS3	C	125-160	4.8	0.08	0.01	2.75	1.6	2	0.11	0.05	0.56	1.5	5.82	64.6
	Lower	AP	0-20	4.8	0.84	0.3	13.87	3.4	1.5	0.3	0.1	0.24	0.4	5.89	89.9
	Slope	BA	20-45	5.1	0.44	0.17	8.75	1.4	1.8	0.2	0.1	0.29	0.5	4.24	82.5
		Bt	45-96	4.8	0.24	0.07	4.75	1.4	1.6	0.15	0.1	0.6	0.7	4.55	71.4
		C	96-150	4.8	0.24	0.05	4.25	1.6	1.8	0.15	0.1	0.85	1.9	6.35	57.5
	Surface	**Mean**		**4.9**	**0.57**	**0.19**	**12.34**	**2.6**	**1.5**	**0.173**	**0.09**	**0.17**	**0.4**	**4.89**	**89.0**
		Min		**4.8**	**0.16**	**0.04**	**11.52**	**2**	**1.4**	**0.1**	**0.06**	**0.12**	**0.2**	**4.34**	**85.2**
		Max.		**5.1**	**0.84**	**0.3**	**13.87**	**3.4**	**1.6**	**0.3**	**0.1**	**0.24**	**0.5**	**5.89**	**91.2**
	Subsurf.	**Mean**		**4.9**	**0.31**	**0.1**	**4.45**	**1.6**	**1.6**	**0.2**	**0.1**	**0.6**	**0.1**	**4.1**	**7.0.1**
		Min.		**4.8**	**0.08**	**0.01**	**1.25**	**0.8**	**0.5**	**0.11**	**0.04**	**0.23**	**0.3**	**3.23**	**57.5**
		Max.		**5.1**	**0.52**	**0.17**	**8.75**	**2.8**	**2**	**0.24**	**0.1**	**0.88**	**1.9**	**7.51**	**83.6**

AS = Arable soils; OC = Organic carbon; Total N = Total nitrogen; A.P = Available phosphorus; ECEC = Exchangeable cation exchange capacity; BS = Base saturation

3. 3. Chemical characteristics

The pH is presented in Table 4, 5 and 6. Their mean values of the surface and subsurface varies from 4.9-4.5 for FS, RS 4.9-4.6 and AS 4.9 indicating that the soils are very strongly acidic [10]. Organic carbon and nitrogen contents are low with FS having the highest mean value of 4.33 % organic carbon in surface horizon while RS had the highest mean nitrogen value of 0.23 %. Low content of these nutrients might be attributed to the iso-hyperthermic temperatures from solar radiation and constant bush burning. This has direct relationship as both organic carbon and nitrogen decreases with depth in soils because litter fall is on the soil surface as observed by Manjoka *et al* [9].

Available phosphorus is equally low except for AS with surface mean values ranging from 4.45 - 12.34 mg kg^{-1}. Low values of available phosphorus result from fixation in the acidic soil medium while high values in AS are attributed to fertilizer application as observed by Eyong *et al.* [6].

The exchangeable cations, Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+} are very low while exchangeable H^{+} and Al^{3+} are high. This is attributed to high rainfall in the region. This agrees with the work of Edosomwan *et al*. [3] that all major soils in the high rainforest tropics are chemically impoverished even under virgin rainforest and that a number of the soils have extremely low contents of exchangeable cations which is usually associated with relatively high amounts of extractable aluminum. The ECEC was generally low. The low ECEC can be attributed to the fact that soils in this region are strongly weathered, have little or no content of weathered materials in sand and silt fractions and have predominantly kaolinite in their clay fraction. This is in line with Eyong, *et al*. [5] that stated that at ECEC < 15 cmol/kg, the soils will suffer from significant cation losses through leaching. Mean Base Saturation (BS) was 42.1 % for FS, RS 22.6 % RS and AS 89 % in surface horizons while subsurface horizons mean values were 11.4 % for FS, RS 8 % and AS 70.1 % respectively. Base saturation was low in FS and AS (< 50%) in surface soils but higher (> 50%) in AS in the surface and RS in subsurface soils. This might be attributed the virtually devoid of soluble minerals, rocks and rapid weather of the soils due to isohyperthemic temperatures and abundant moisture and torrential rains which have washed away nutrients from the soils hence the low base status state in FS and RS and AS reported by Osedeke *et al.* [12].

4. CONCLUSION

From the result obtained in the study, it can be concluded that physicochemical properties of soils derived from sand stone parent materials under selected land use types are deep and well drained except for lower slopes. They are acidic with low CEC, base saturation and fertility levels and suffer from multiple nutrient deficiencies. The poor physical and chemical properties of the soils are due to the underlying parent material of loose, unconsolidated sandstones or sediments, rapid mineralization of organic matter under isohyperthermic soil temperature regimes, denitrification and volatilization processes involving nitrogen, high phosphate fixation capacity and extensive leaching of most nutrients resulting from prevailing high rainfall amounts. The soils can be made productive by application of recommended inorganic fertilizers and organic matter in order to support growth of crops such as maize, yams, cassava etc.

References

[1] Akamigbo, FOR. & Asadu, CLA. The influence of topography on some soil parameters in selected area of Anambra state, Nigeria. *Nigerian Journal of Soil Science.* 1986; 6: 35-46

[2] Ameztegul, A. Coll, L. Brotons, L. & Ninot, JM. Land use legacies rather than climate change are driving the recent upward shift of the mountains tree line in Pyrenees. *Global Ecology and Biogeography*. Volume 25, Issue 3 March 2016 Pages 263-273. https://doi.org/10.1111/geb.12407

[3] Edosomwan, NI, Nwachukwu, AA & Osemweta LO. A comparative study of selected soil properties of an alfisol in various land utilization types in central southern Nigeria. *Journal of Agricultural Resources* 2001; 17: 3-12

[4] Effiong, J. Changing pattern of land use in the Calabar river catchment, Southern Nigeria. *Journal of sustainable development,* 2011; 41(1): 92-102

[5] Eshett, ET. The basaltic soils of SE Nigeria, Properties, Classification and Constraints to productivity. *Journal of Soil Science,* 1987; 38: 585-571

[6] Eyong, MO, Esu, JE & Ogbiji, PO. Classification and evaluation of soils under rubber (*Havea brazilliensi Muell argo*) plantation at Nko, Cross River State of Nigeria. *Global Journal of Pure and Applied Science* 2008; 141, 9-24

[7] Gobin, A, Campling P, Deckers, J. & Feyen, J. Quantifying soil morphology in tropical environments. Methods and application in soil classification, *Soil Science Society of America Journal.* 2000; 64: 1423=1433.

[8] Igwe, CA. & Stahr, K.. Water-stable aggregates of flooded Inceptisols from Southeastern Nigeria in relation to mineralogy and chemical properties. *Australian Journal of Soil Research* 2004; 42, 171-179

[9] Manjoka, J. Yerokun, OR, Lungu, OI & Munyinda, K. Changes in soil organic matter and soil aggregation of a Zambian Oxisols after applying lime. *International Journal of Soil Science* 2007; 2: 190-196

[10] Myers, RJ. One – Hundred years of pH . *Journal of Chemical Education* 2010; 87: 30 - 32

[11] Ogban, PI & Ekerette, IO. Physical and chemical properties of the coastal plain sands soils of South- Eastern Nigeria. *Nigerian Journal of Soil and Environmental Research*. 2001; 2: 6-14

[12] Osedeke, YE. Kamalu, OJ. & Omenihu, AA. Characterization and suitability evaluation of representative rubber growing Soils of Nigeria. *Journal of tropical Agriculture, Environment and Extension* 2002; 3 (1): 41-46.

[13] Srikanth, P., Somasekhar, SA. Kanthi, GK. & Raghu, BK. Analysis of heavy metals by using atomic absorption spectroscopy from the samples taken around Visakhapatnam. *International Journal of Environment, Ecology, Family and Urban Studies* 2013; 3(1): 127-132.