




TEMPORAL VARIABILITY OF SOIL REACTION AMONG SURFACE AND NEAR-SURFACE HORIZONS OF SOILS OF DISSIMILAR LITHOLOGY IN A HUMID TROPICAL ENVIRONMENT

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Abstract

The study investigated changes in soil reaction among surface and near surface horizons of four soil groups as affected by wet and dry seasons in Southeastern Nigeria. A geological map of the area guided soil sampling. Free survey approach was used in locating soil profiles. Soil samples were collected based on horizon differentiation and samples were collected from the AB-horizon (near-surface) and the A-horizon (Surface). Routine laboratory analyses were conducted on these soil samples after sieving through a 2-mm sieve. Data were subjected to analysis of variance (ANOVA) using SAS Statistical Computer Package. There were significant ($p < 0.05$) changes in soil reaction in A- and AB-horizons in the dry seasons of 2016 and 2017. Similarly, in the wet season, soil pH varied significantly ($p < 0.05$) in 2016 and 2017. Soil reaction significantly ($p < 0.05$) differed in AB-horizons in both 2016 and 2017 irrespective of the season. All soil samples were acidic irrespective of lithologic material and season with pH values ranging from 4.20-5.60 and 3.31-5.42 in the A- and AB-horizons, respectively.

Keywords: Horizon, Soil reaction, Parent material, Lithology, Time

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Introduction

Soil pH is an important edaphic property influencing availability of plant nutrients as well as the quality of soil ecosystems. Soil pH tolerance limits differ among plants (Hao *et al.*, 2017). Soil pH changes among the soil horizons (Aznar *et al.*, 2013), influencing distribution of ions. Under low pH values, aluminum ions are readily released from the clay lattice and become established on the clay complex thereby increasing aluminum toxicity. Also at low pH, the phosphate ions combine with aluminum and iron to form compounds which are not readily available to plants. With the exception of molybdenum, all micronutrients become more available under acidic reactions. Soil pH at low status tends to reduce bacterial activity and this retards the process of nitrification due to toxicity effects. Antisari *et al.* (2013) reported that the toxicity of metal oxides is related to reactivity of soils which negatively influence microbial biomass and its abundance in soils.

At very high pH, signifying alkalinity and salinity, boron toxicity prevails in the soil system, while soil structural problems become prominent. In addition, phosphate is fixed by calcium and magnesium. These problems tend to influence soil nutrient availability and uptake, especially phosphorus, with the consequence being poor crop growth and yield.

Southeastern Nigeria is situated within the humid tropics: an agroecosystem characterized by 9 months of rainy season and 3 dry months (Okoli *et al.*, 2016 ; Okoli *et al.*, 2020). The soils are mainly derived from six major lithologic materials, namely; alluvium, coastal plain sands, falsebedded sandstone, upper coal measures, lower coal measures and shale (Onweremadu, 2006). The region is densely populated and farm lands are highly fragmented and communally owned in most cases. Land preparation follows the traditional and conventional approaches, which rarely conserve soil nutrients. Land is prepared by slash and burn and soil fertility is regenerated by bush fallow. Bush fallow lengths have drastically reduced due to population pressure and increasing use of soils for numerous non-agricultural ventures. Soils are not sustainably managed as a result of these practices. Therefore, there is pronounced soil degradation due to inappropriate land use practice coupled with increasing and extreme rainfall prevalence, resulting in leaching, denitrification and seepage which tend to wash basic cations away from root zones or zones of availability within the pedosphere. The situation heightens acidification of near-surface or epipedal horizons due to loss of basic cations such as calcium, magnesium and potassium beyond the root zone. Given the fact that soil reaction (soil pH) governs availability of plant nutrients and the need to sustain crop yields to meet the food and fibre needs of highly populated Southeastern Nigeria; it becomes imperative to investigate soil reactions of surface and near-surface horizons and how they vary among soils of varying parent materials and within the two major seasons of the area as agricultural production can be conducted in both rainy and dry seasons of the area to overcome heightening needs. Based on the above, the main objective of the study was to investigate seasonal changes

in soil reaction in surface and near surface horizons of some soils of dissimilar lithologic origin in southeastern Nigeria.

Materials and methods

Study area

The study was conducted in the southeastern, Nigeria, lying between Latitude 4°40' and 8°15' North and Longitude 6°40' and 8°15' East (FDALR, 1985). The soils were derived from coastal plain sands, alluvium, falsebedded sandstone, shale, lower coal measure and upper coal measure (Orajaka, 1975). The study area lies within the humid tropics characterized by annual rainfall of about 2400 mm with its pattern being bimodal, with peaks in the months of July and September while temperatures changes slightly throughout with mean annual temperature being 27°C (Okoli *et al.*, 2016). Average monthly evapotranspiration remains low during the rainy season with an average of 2.5 to 3.5 mm/day, and this increases from 4.0 to 4.5 mm/day during the dry season. The vegetation of the area is rain forest characterized by multiple plant species ranging from herbs to shrubs and trees. Oil palm trees (*Elaeisguineensis*) dominate other tree species in the area. Smallholder, agriculture is common in the area forming a major socioeconomic activity while land preparation is by slash-and-burn method followed by mound making and flat forms of tillage. Bush fallow is a fertility regeneration measure in the area but fallow length has been drastically reduced such that some areas practice continuous cultivation.

Soil sampling

The four parent materials locations where soil sampling was conducted included; Mbaise (Coasted plain sands), Okigwe (Falsebedded sandstones), Amuro (Imo clay shales) and Isuochi (Upper coal measure). The locations were chosen based on their uniqueness and geographical spread. Two dominant seasons in the area, rain (wet) July, and dry (March) seasons were chosen for the study. Secondary forest was used for the study. Two horizons, namely; A- (surface) and AB-(Near-surface) horizons were used for the study being genetic horizons housing arable crop roots. The A- and AB-horizons represented the surface and near-surface horizons. Mini pedons were dug in each of the sampling sites and pedons were georeferenced using handheld Global Positioning System (GPS) Receiver (Garmin Ltd, Kansas USA). Soil samples were collected from these horizons using soil hand trowel. Ten auger samples were bulked in each horizon and section. These soil samples were bagged and sealed using aluminum foil and sent to the laboratory. Soil samples were all-dried and sieved using a 2 mm sieve in preparation for routine analyses.

Table 1: Geographical Coordinates of the Sampled Sites

Site	PM	Latitude (N) (o)	Longitude (E) (o)	Elevation (M)
Mbaise	CPS	5°47' 58".047	7° 37' 10".040	90
Okigwe	FBS	5°56'35".513	7°44' 06".500	318
Amuro	ICS	5°59' 58".460	7°34' 37".610	292
Isuochi	UCM	5°55' 27".252	7°40' 42".820	348

PM = Parent material, CPS = Coastal plain sand, FBS = Falsebedded Sandstones, ICS = Imo Clay Shale, UCM = Upper Coal

Measure

Laboratory Studies

Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Soil pH was measured using glass electrode pH meter in 1:1 soil/water ratio (Thomas, 1996). Exchangeable calcium and magnesium were extracted using 1NNH₄OAc buffered at pH 7 and then measured by complexometric titration method (Thomas, 1982) while total nitrogen was determined by the Macro Kjeldahl method (Bremner and Mulvaney, 1996). Organic carbon was determined by chromic wet oxidation method (Nelson and Sommers, 1996).

Data analysis

Data were subjected to analysis of variance (ANOVA) using Statistical Computer Package of SAS (2002). Mean values were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results and discussion

Particle Size Distribution in the Soils

Particle size distribution results of the A-horizon are presented in Table 2. Sand-sized particles dominated other particle sizes irrespective of lithologic origin, depth and season (Table 2). Mean values of sand were 745 g kg⁻¹ and 777 g kg⁻¹ in the wet season of 2016 and 2017. Abundance of clay-sized particles showed mean values of 153 g kg⁻¹ and 175 g kg⁻¹ in the dry and wet seasons of 2016 (Table 2). Loamy sand and sandy loam predominated over sandy clay loam during the dry season irrespective of the lithologic origin in A-horizon while in the wet season, sandy loam was the dominant textural class in A-horizon (Table 2).

Table 3 shows particle size distribution of soils of the AB horizon. Similarly, irrespective the season and lithologic origin, sand was the dominant particle size with mean values being 749 g kg⁻¹ (dry season) and 747 g kg⁻¹ (wet season) while silt and clay had mean values 89 g kg⁻¹ and 162 g kg⁻¹ in the wet season of 2016. In 2017, sand content was 755 g kg⁻¹ (dry season) and 748 g kg⁻¹ (wet season). Silt value was higher in dry season of 2017 (80 g kg⁻¹) when compared with the value (69 g kg⁻¹) obtained in wet season of 2017. However, clay content varied from 165 g kg⁻¹ in the dry season of 2017 to 183 g kg⁻¹ in the wet season of 2017. Sandy loam textures dominated the soils irrespective of depth, season and parent material.

Table 2: Particle Size Distribution (g kg⁻¹) in the Soils (A-horizon)

PM	2016 (dry)				2017 (dry)			
	Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
CPS	820	40	140	Loamy sand	840	20	140	Loamy sand
FBS	780	60	160	Sandy loam	790	45	165	Sandy loam
ICS	560	190	250	Sandy clay loam	600	200	200	Sandy clay loam
UCM	880	60	60	Loamy sand	890	50	60	Loamy sand
Mean	760	87	153	Sandy loam	780	78	142	Sandy loam
PM	2016 (wet)				2017 (wet)			
	Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
CPS	800	38	162	Sandy loam	845	25	130	Loamy sand
FBS	770	55	175	Sandy loam	785	35	180	Sandy loam
ICS	550	180	270	Sandy clay loam	610	200	190	Sandy loam
UCM	860	50	90	Loamy sand	870	45	85	Loamy sand
Mean	745	80	175	Sandy loam	777	76	147	Loamy sand

.PM = Parent material, CPS = Coastal plain sand, FBS = Falsebedded sandstone, ICS = Imo clay shale, UCM = Upper coal measure

Table 3: Particle Size Distribution (g kg⁻¹) of the Soils (AB-horizon)

PM	2016 (Dry)				2017 (Dry)			
	Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
CPS	800	50	150	Sandy loam	805	40	155	Sandy loam
FBS	775	55	170	Sandy loam	780	40	180	Sandy loam
ICS	550	190	260	Sandy clay loam	560	180	260	Sandy clay loam
UCM	870	60	70	Loamy sand	875	62	63	Loamy sand
Mean	749	89	162	Sandy loam	755	80	165	Sandy loam
PM	2016 (Wet)				2017 (wet)			
	Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture

790	45	165	Sandy loam	790	40	170	Sandy loam
770	50	180	Sandy loam	772	42	186	Sandy loam
560	150	290	Sandy clay loam	564	153	283	Sandy clay loam
865	40	95	Loamy sand	867	40	93	Loamy sand
747	71	182	Sandy loam	748	69	183	Sandy loam

PM = Parent material, CPS = Coastal plain sand, FBS = Falsebedded sandstone, ICS = Imo clay shale, UCM = Upper coal measure

Soil pH Distribution in the Soils in 2016 and 2017

There were significant changes in soil reactions in both the horizons of 2016 as well as A-horizons of 2017 in the dry seasons (Table 4). Similar contrasts were recorded in AB- horizons of the soils in 2016 and 2017 dry seasons. In the wet season, soil pH significantly ($p>0.05$) differed among A-horizons of soils in 2016 and 2017. With the exceptions of soils formed over Upper Coal Measures (UCM), soil pH increased in wet season in 2016 while there was no clear trend in pH change in 2017 of the A-horizon. Similarly, soil pH changed significantly ($p>0.05$) in AB-horizon in both 2016 and 2017 irrespective of the season (Table 4). Among soils of the same lithologic origin, soil pH differed significantly ($p>0.05$) in the same season over time. The exception was soils formed over Imo Clay Shale (ICS) which although were numerically different (pH_{water} 5.20 in 2016 and 5.40 in 2017). Generally, all soils of the area irrespective of parent materials and season recorded pH values within the acidic range in A-horizon (4.20 – 5.60) and the AB-horizon (3.31 to 5.42), which could be due to the high rainfall intensity within the area which might have resulted to leaching out of soil basic cations resulting in dominance of acidic cations (Okoli *et al.*, 2019). Hence, this condition would limit crop performance.

Table 4: Soil pH Distribution in Soils in 2016/2017

PM	2016 (Dry) A	2017 (Dry) A	Combined	2016 (Dry) AB	2017 (Dry) AB	combined
CPS	4.20c	4.60b	4.40c	4.10c	4.35c	4.20c
FBS	4.42b	4.44c	4.42b	4.35b	4.50b	4.53b
ICS	5.20a	5.40a	5.43a	5.30a	5.40a	5.35a
UCM	4.32b	4.50bc	4.40c	4.34b	4.40c	4.30bc
SE±	0.02	0.06b	0.03	0.02	0.06	0.03
	2016 (Wet) A	2017 (Wet) A	combined	2016 (Wet) AB	2017 (Wet) AB	combined
CPS	4.30c	4.42b	4.35b	3.31b	4.53b	4.42b
FBS	4.52b	4.45b	4.37b	3.35b	4.57b	4.44b
ICS	5.40a	5.60a	5.50a	5.40a	5.42a	5.39a
UCM	4.23c	4.29c	4.30c	4.23c	4.37c	4.32c
SE±	0.02	0.06	0.03	0.02	0.06	0.03

Pm = Parent material, CPS = Coastal plain sand, FBS = Falsebedded sandstone, ICS = Imo clay shale, UCM = Upper coal measure; Note: Means with the same letter are statistically the same at 5% level of significance.

Organic Matter Distribution in the Soils in 2016/2017

Table 5 shows the distribution of organic matter in the horizons in 2016 and 2017. Mean values of soil organic matter were 18.35 g kg⁻¹ in the dry season of 2016 and 20.03 g kg⁻¹ in dry season of 2017 in the A-horizon, while within the AB-horizon, the mean organic matter content of soils were 11.7 g kg⁻¹ and 12.28 g kg⁻¹ in the dry seasons of 2016 and 2017, respectively. During the wet seasons of both years, organic matter in the A-horizon increased from 16.68 g kg⁻¹ in 2016 to 18.78 g kg⁻¹ in 2017, which could be due to higher litter accumulation during the wet season. Similar results were recorded in the AB-horizons during the wet seasons of both years (Table 5). There were numerical differences in organic matter distribution with A-horizons recording greater values than AB-horizons, which could be due to higher litter accumulation in the surface since the layer makes first contact with plant residues.

Table 5: Organic Matter Distribution in the soils (g kg⁻¹) in 2016 and 2017

PM	2016 (Dry)	2017 (Dry)	2016 (Dry)	2017 (Dry)
	A	A	AB	AB
CPS	12.7	13.6	9.6	10.2
FBS	13.8	14.4	10.2	10.6
ICS	33.8	38.2	18.6	19.4
UCM	13.1	13.9	8.4	8.8
Mean	18.35	20.02	11.7	12.28
	2016 (Wet)	2017 (Wet)	2016 (Wet)	2017 (Wet)
	A	A	AB	AB
CPS	11.6	12.8	8.4	9.2
FBS	13.1	13.9	8.8	9.6
ICS	29.2	35.2	12.6	15.2
UCM	12.8	13.2	7.8	8.2
Mean	16.68	18.78	9.4	10.55

PM = Parent material, CPS = Coastal Plain Sand, FBS = Falsebedded Sandstone, ICS = Imo Clay Shale, UCM = Upper Coal Measure

Total Nitrogen Distribution in the Soils in 2016 and 2017

Total nitrogen distribution in the soils was given in Table 6. At the A-horizon, there was increase in total nitrogen from 1.455 g kg⁻¹ in 2016 to 1.540 g kg⁻¹ in 2017 during the dry season. However, at the AB-horizon the mean values were similar during the dry season. But mean total nitrogen values of the A-horizon varied among the years, being 0.955 g kg⁻¹ in wet the seasons of 2016 and 1.298 g kg⁻¹ in the wet season of 2017. Similar trends were followed in AB-horizon for both years. However, total nitrogen content was higher in dry seasons of both years when compared with the wet seasons of 2016 and 2017 in both A and AB-horizons

(Table 6).The disparity in the results could be linked to high intensity of rainfall in the wet season which favours leaching losses of nitrogen. It could be also due to rapid mineralization that is prevalent in the area during the wet season. Hence, unstable inorganic nitrogen forms released during the mineralization process are easily lost through denitrification, volatilization and leaching process (Romanya *et al.*, 2012).

Table 6: Total Nitrogen Content (g kg⁻¹) of the Soils in 2016 and 2017

PM	2016 (Dry)	2017 (Dry)	2016 (Dry)	2017 (Dry)
	A	A	AB	AB
CPS	1.07	1.16	0.77	0.81
FBS	1.19	1.24	0.82	0.85
ICS	2.47	2.66	0.99	0.87
UCM	1.09	1.10	0.80	0.83
Mean	1.455	1.540	0.845	0.840
	2016 (Wet)	2017 (Wet)	2016 (Wet)	2017 (Wet)
	A	A	AB	AB
CPS	0.92	1.10	0.53	0.56
FBS	0.96	1.14	0.69	0.71
ICS	1.01	1.83	0.78	0.80
UCM	0.93	1.12	0.76	0.79
Mean	0.955	1.298	0.690	0.715

PM = Parent material, CPS = Coastal plain sands, FBS Falsebedded sandstone, ICS = Imo clay shale, UCM = Upper coal measures

Exchangeable Calcium and Magnesium Distribution in the Soils in 2016 and 2017

Exchangeable calcium and magnesium values are presented in Table 7. Exchangeable calcium varied in the dry season among A-horizons in 2016 and 2017 as well as among soil groups with highest value of 4.14 cmol kg⁻¹ observed in ICS soil in 2016 while the least value of 0.78 cmol kg⁻¹ was reported in soil of UCM in 2016. While exchangeable calcium increased in the A-horizon of 2017 for all soil groups compared to the previous year, it was observed that of soil exchangeable calcium values of soil from CPS decreased from 1.28 cmol kg⁻¹ in 2016 to 1.00 cmol kg⁻¹ in 2017. During the wet season of 2016, exchangeable calcium decreased to 1.12, 0.80, 3.96, and 0.52 cmol kg⁻¹ for CPS, FBS, ICS and UCM, respectively as opposed to 1.28, 0.96, 4.14 and 0.78 cmol kg⁻¹ obtained in the same soil groups during the dry season of 2016. The main determinants of cations in the soils are clay and organic matter because they carry negative electric charges strong enough to attract the positively charged cationic elements (Brady and Weil, 2010). But this role was minimal in the wet season relative to dry season due to lower organic matter level in the wet season which reduced the number of exchange sites for attraction of cations.

Table 7: Exchangeable Calcium and Magnesium Content (cmol kg⁻¹) of Soils

PM	2016			2017			2016			2017		
	(Dry)			(Dry)			(Dry)			(Dry)		
	A			A			AB			AB		
	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg
CPS	1.28	0.96	1.33	1.00	0.31	3.22	0.81	0.26	3.11	0.71	0.30	2.36
FBS	0.96	0.78	1.23	1.00	0.38	3.03	0.70	0.21	3.33	0.68	0.28	2.43
ICS	4.14	1.19	3.47	4.21	1.14	2.69	2.33	0.71	3.28	2.12	0.96	2.21
UCM	0.78	0.28	2.78	0.82	0.24	3.41	0.41	0.19	2.15	0.63	0.24	2.62
Mean	1.790	0.802	-	1.881	0.505	-	1.06	0.342	-	1.035	0.445	-
	2016			2017			2016			2017		
	(Wet)			(Wet)			(Wet)			(Wet)		
	A			A			AB			AB		
	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg	Ca	Mg	Ca:Mg
CPS	1.12	0.62	1.80	0.80	0.28	3.33	0.80	0.28	2.85	0.68	0.22	3.09
FBS	0.80	0.30	2.67	0.90	0.32	2.81	0.60	0.27	2.22	0.62	0.25	2.48
ICS	3.96	1.17	3.38	4.00	1.11	3.60	2.00	0.60	3.70	1.98	0.66	3.00
UCM	0.52	0.28	1.85	0.50	0.22	2.77	0.30	0.15	2.00	0.48	0.18	2.66
Mean	1.600	0.592	-	1.55	0.482	-	0.925	0.325	-	0.94	0.327	-

Ca = Calcium, Mg = Magnesium, Ca:Mg = Calcium/Magnesium ratio; CPS = Coastal plain sands, FBS False bedded sandstone,

ICS = Imo clay shale, UCM = Upper coal measure

Similarly, in the wet season of 2017, soil exchangeable calcium decreased in the A-horizon to 0.80, 0.90, 4.00 and 0.50 cmol kg⁻¹ compared with higher values of 1.00, 1.00, 4.21 and 0.82 cmol kg⁻¹ from CPS, FBS, ICS, and UCM soil groups obtained in A-horizon during the dry season. Similar trends were followed by exchangeable calcium distribution in AB-horizons of dry and wet seasons in 2016 and 2017 as the vital secondary macronutrient decreased towards the wet season irrespective of parent material. A comparison of A-and AB-horizons showed higher values of exchangeable calcium in the surface soils (epipedons).

Exchangeable magnesium values are shown in Table 7 with soils generally having higher values of the secondary macronutrient in A-horizon (surface mineral horizon) than in AB-horizon (subsurface mineral horizon). Higher values were also observed in the dry season when compared with wet season in both years (2016 and 2017). Similarly, higher values of exchangeable magnesium were recorded in A-horizons when compared with AB-horizons. Among the soil groups, ICS had higher value of 1.11 cmol kg⁻¹ and 1.14 cmol kg⁻¹ in 2016 and 2017 dry seasons respectively.

Calcium-magnesium ratios in dry season were observed to be higher in A-horizons of 2017 when compared with A-horizons of 2016 (Table 7). With the exception of soils developed on UCM, values of Ca:Mg were higher in AB-horizons of 2016 than those of 2017 during the dry season.

In the wet season, Ca:Mg ratio of soils were higher in 2017 than 2016 in the A-horizon. Similar trend was observed in the Ca:Mg of AB-horizons except in ICS. The Ca:Mg increased from 1.33 in dry season of 2016 in CPS to 1.80 in wet season of 2016 of A-horizon while in FBS, similar result was obtained with Ca:Mg rising from 1.23 (dry season) to 2.67 (wet) in A-horizon of 2016. However, decreases from 3.47 to 3.38 (ICS) and 2.78 to 1.85 (UCM) were recorded between A-horizon of dry and wet seasons of 2016. While increases in Ca:Mg ratio were obtained in soils of CPS and FBS from dry to wet seasons of 2017, decreases were observed in ICS and UCM in A-horizons. Decreases in Ca:Mg in all the soil groups in AB-horizon of 2016 between the dry spell and wet seasons except in ICS were observed, but in 2017, Ca:Mg ratio of all the soil groups increased in the wet season in AB-horizons. Calcium: Magnesium ratio is an indicator of soil fertility and soils with values less than 3.0 are said to be of low fertility (Landon, 1991).

Rate of Change of pH with Time and Depth

Figure 1 shows rate changes of soil pH with time and depth. Between 2016 and 2017 dry season, soil pH changed by 0.4%, 3.8% and 4.1% in CPS, FBS, ICS and UCM, respectively in the A-horizons while during the wet season of both years, soil pH of surface soils (A-horizons) changed by 3.0%, 1.3%, 3.7% and 1.4% for CPS, FBS, ICS and UCM soil groups, respectively. In the AB-horizons, changes in pH between dry season of 2016 and that of 2017 showed percent rate change of 6.0%, 5.7, 1.8 and 1.3 for CPS, FBS, ICS and UCM, respectively.

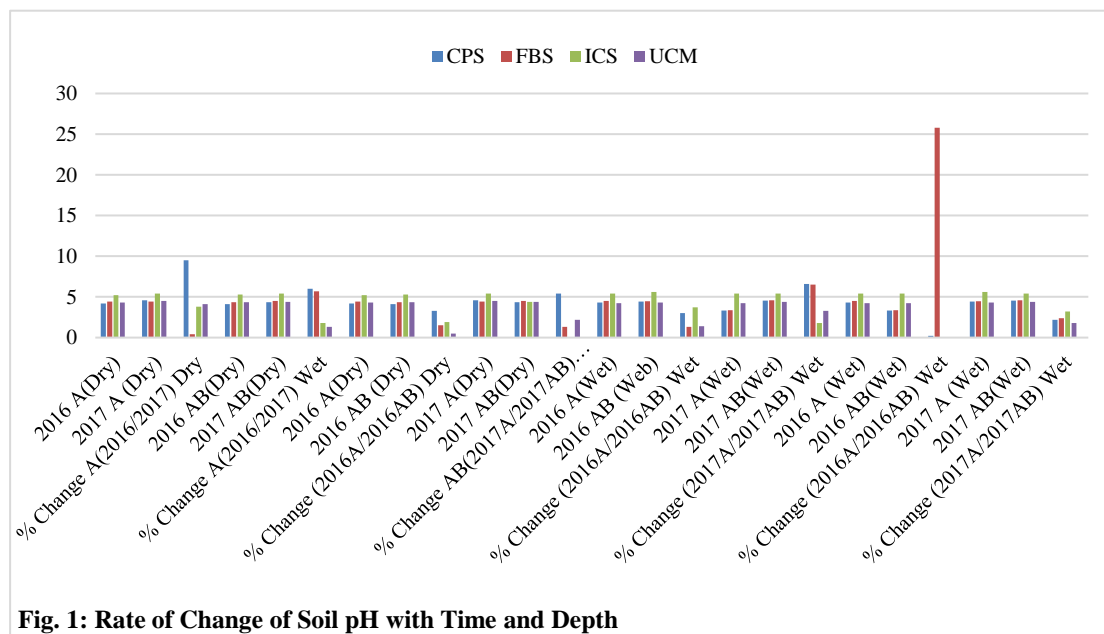


Fig. 1: Rate of Change of Soil pH with Time and Depth

Temporal Variability in Soil pH with Depth and Season

Results in Figure 2 indicate variability of soils reaction due to differences in lithologic origin, position of the horizon in the pedosphere and seasonal changes. Lithologic materials differ in their composition and reactivity. When lithologic materials undergo weathering, they release these constituents contained therein to the finest state resulting in larger surface area. Acidic lithologic materials like granite will form acidic soils

while basic lithologic materials such as basalt form basic or alkaline soils. Consequent upon this, acid sands which are more in UCM, CPS, and FBS parent materials had lower pH values when compared with ICS. Earlier, Ibanga (2006) observed that nature of parent materials influences characteristics of emerging soils. Soil reaction varied between surface (A-horizons) and near-surface (AB-horizons) of the soils irrespective of lithologic origin. There was no regular pattern in the change of reaction which could be due to a combination of pedogenic and anthropogenic activities inherent in the area. However, decreases in AB-horizons can be attributed to leaching losses since the area is characterized by abundant rainfall resulting in intermittent overlay of water on the soil surface before percolation into deeper horizons. Similar findings were made by Onyekanne *et al.* (2012) who opined that high intensity of rainfall leaches away basic cations in the humid tropics leading to the development of soil acidity.

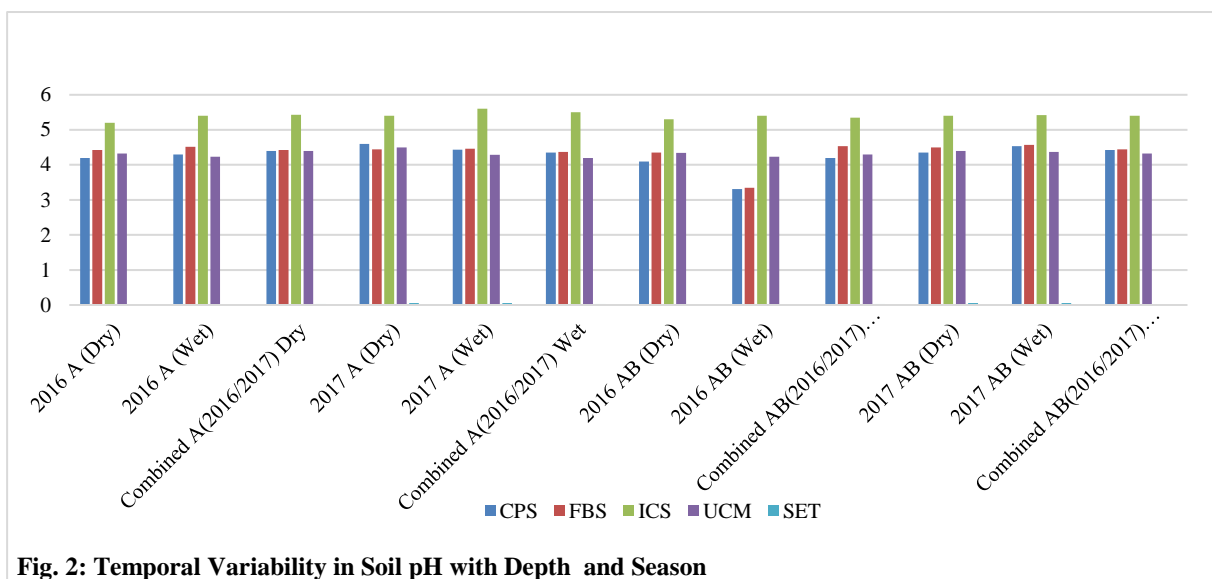


Fig. 2: Temporal Variability in Soil pH with Depth and Season

Conclusion

Soil reaction varied without a regular pattern temporally irrespective of the parent material from which soils were derived. This variability was affected by soil depth in all the locations being more prominent in A horizon. Soils of the area were acidic irrespective of the season, depth and parent material. The soils should be amended to raise the soil pH to neutral to near-neutral values to enhance optimal nutrient availability and plant uptake.

Conflict of interest

The authors declare no conflict of interest.

Author contribution statements

Emmanuel Onweremadu initiated the research. Bernadine Aririguzo designed the research. Nnaemeka Okoli and Isaiah Afangide jointly prepared the manuscript.

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References

- Antisari, L.V.I, Carbons, S., Gatti, A., Vianello, G. and Nanniperi, P., 2013. Toxicity of metal oxide (CeO₂, Fe₃O₄), SnO₂ engineered nanoparticles on soil microbial biomass and their distribution in soil. *Soil Biology and Biochemistry*, 60:87-94. <https://doi.org/10.1016/j.soilbio.2013.01.016>
- Aznar, J.M., Poch, R.M. and Badia, D., 2013. Soil catena along gypseous woodland in the middle Ebro basin: Soil properties and micromorphology relationships. *Spanish Journal of Soil Science*, 3 (1):28-44. DOI: 10.3232/SJSS.2013.V3.N1.02
- Bremner, J.M. and Mulvaney, C.S., 1992. Total-Nitrogen. In: *Methods of Soil analysis Part 2*. Ed by Page, A.L., Mille, R.H. and Keeney, D.R. American Society of Agronomy, Madison, WI, 595-624p.
- FDALR, (Federal Department of Agricultural Land Resources) 1985. The reconnaissance soil survey of the Imo State, Nigeria (1:250,000). Soil Report 133p.
- Gee, G.W. and Or. D., 2002. Particle Size Analysis. In: *Methods of Soil Analysis Part 4-Physical Methods*, ed by Dane, J.H. and Topp, G.C. Soil Science Society of America Book Series No. 5, Madison, WI, 255-293p.
- Ibanga, L.J. , 2006. *Soil Studies: The pedological approach*. MAESOT Printing and Computers, Calabar. 144 p.
- Landon, J.R., 1991. *Booker tropical soil manual: A handbook for soil survey and agricultural land evaluation in the tropics and subtropics*. Longman Scientific and Technical, Essex, England. 474p.
- Hao, J. H., Lv, S.S., Bhattacharya,S., and Fu, J.G., 2017. Germination Response of four alien congeneric *Amaranthus* species to environment factors. *Plos ONE* 12: e0170297. Doi: 10.1371/ journal. Pone. 0170297.
- Nelson, D.W. and Sommers, L.E., 1996. Total Carbon, Organic Carbon and Organic Matter. In: *Methods of Soil Analysis Part 3-Chemical Methods*, ed by Sparks, D.L. et al. Soil Science Society America Book Series No. 5, Madison, WI, 961-1010p.

- Okoli, N.H., Uzoho, B.U., Ihem, E.E. and Okon, M.A., 2019. Differential speciation and availability of copper in soils derived from different parent materials in Imo State, Southeastern Nigeria. *Agroscience*, 18(1):7-15.
- Okoli, N. H., Uzoho, B.U., Onweremadu, E. U., Nkwopara, U. N. and Irokwe, I. F., 2016. Zinc fractionation of soils of different materials and Their relationship with some soil properties. *Malaysian Journal of Soil Science. Volume*, 20: 49-66.
- Onweremadu, E.U., 2006. Application of Geographic Information Systems (GIS) on soils, land use and soil-related environmental problems in Southeastern Nigeria. A Ph.D Thesis of the Department of Soil Science, University of Nigeria, Nsukka. Nigeria. 330pp.
- Onyekanne, C.F., Akamigbo, F.O.R. and Nnaji, G.U., 2012. Characterization and classification of soils of Ideato North Local Government Area. *Nigerian Journal of Soil Science*, 22(1):11-17.
- Orajaka, S.O., 1975. Geology. In: Nigeria in Maps, ed by Ofomata, G.E.K.. Eastern States. Ethiopia Publishing House, Benin City, 5-7p.
- Thomas, G.W., 1996. Soil pH and soil acidity. In: Methods of Soil Analysis, Part 3. Chemical Methods, ed by Sparks, D.L, Page, A.L., Helmke, P.A., Loeppert, R.H., Soltanpour, P.N., Tabatabai, M.A., Johnson, C.T. and Summer, M.E. Soil Science Society of America, Inc, and American Society of Agronomy, Madison, WI, 475-490p.
- Thomas, G. W., 1982. Exchangeable Cations. In: Methods of Soil Analysis, Part 2-Chemical and Microbiological Properties, ed by Page, A.L., Miller, R.H. and Keeney, D.R. American Society of Agronomy, Madison, WI, 159-166p.
- Romanya, J., Arco, N., Sola-Morales, I., Armengot, L., and Sans, X., 2012. Carbon and Nitrogen Stocks and Nitrogen Mineralization in Organically Managed Soils Amended with Composted Manures. *Journal of Environmental Quality* 41 (4): 1337-1347. Doi:2134/jeq2011.0456.