INFLUENCE OF PARENT MATERIALS AND LAND USE ON SOIL CARBON SEQUESTRATION IN SOUTHERN NIGERIA

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INTRODUCTION

- Carbon sequestration and its effect on climate change and agric is a major concern globally.

- IPCC (2016) options for mitigation of atmospheric CO_2 concentrations by the agricultural sector:

  - ✓ Reduction of agriculture-related emissions,
  - ✓ Creation and strengthening of C sinks in the soil, and
  - ✓ Production of bio-fuels to replace fossil fuels.

OBJECTIVES OF THE STUDY

Specific objectives were to:

- determine the effects of parent materials and land use on selected soil physico-chemical properties.

- Determine the effect of parent materials and land use on soil organic C pool.

MATERIALS AND METHODS

- ❖ The study was conducted at:
- ✓ FRIN, Isieke
- ✓ NIHORT,Okigwe
- ✓ AIRBDA, Agbala
- ✓ NDBDA, Kpong and
- ✓ NDBDA, Isiokolo

- ❖ In the States of Abia, Imo, Rivers and Delta, Southeastern Nigeria.

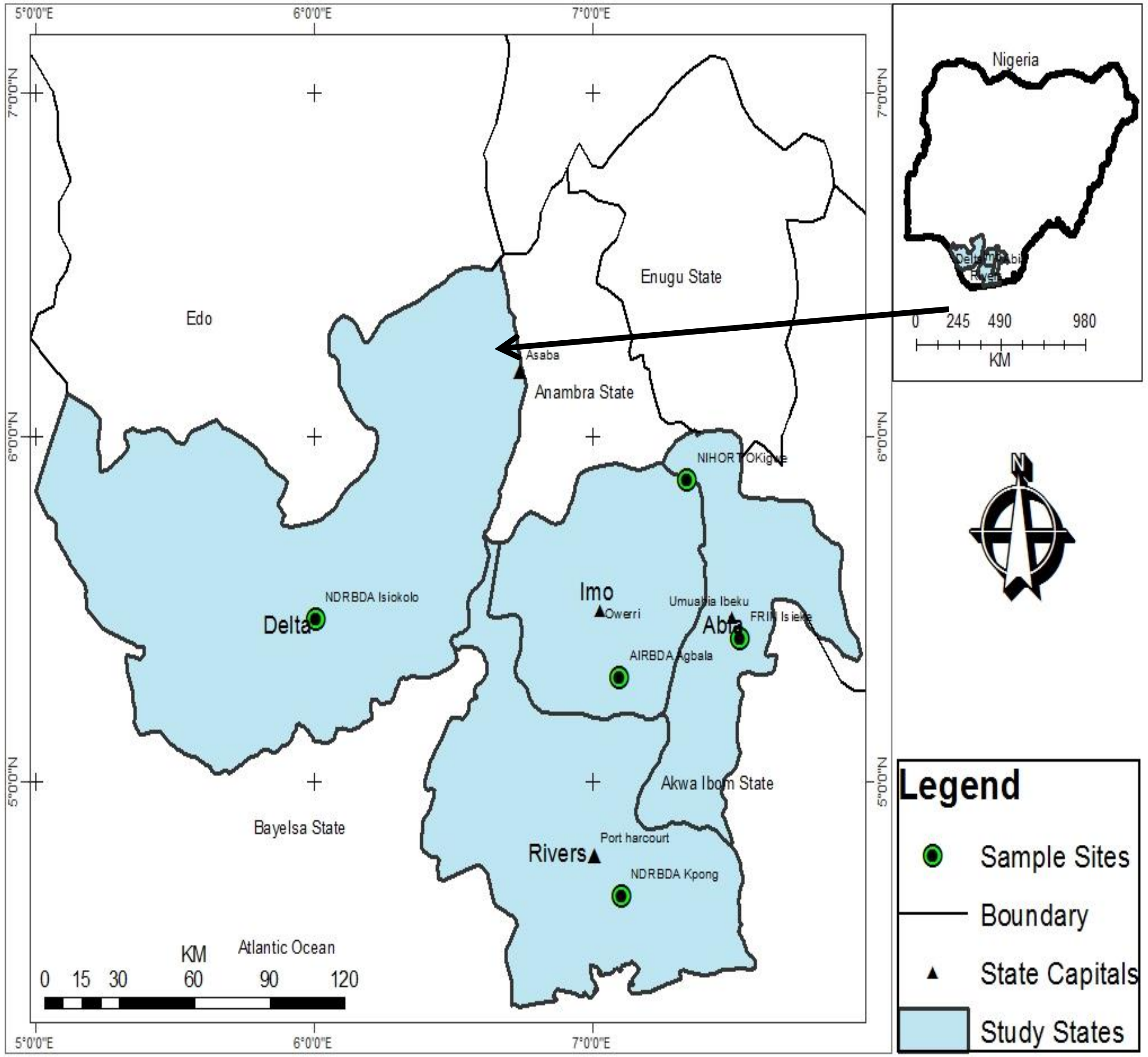


Figure 8: Georeferenced Map of the study area showing sampling locations

CLIMATE

- Average annual rainfall Southsouth-2500mm.
  Southeast -2350mm.
- Average annual maximum temperature-32^{0}C.
- Average annual minimum temperature- 21^{0}C and
- annual range- 11^{0}C.
- (NIMET,2008, NDBDA 2019, AIRBDA 2019).

Natural Vegetation, Land use and Cultural practices

- Vegetation is secondary tropical rainforests.
- Land utilization types were arable croplands, Horticultural croplands and managed forestry tree plantations.
- Cultural practices include: Mixed Cropping, Manual Weeding, Longer Stand Rotation, Mulching, Pruning, Monocropping, Crop Rotation.
- Application of Agrochemicals and Irrigation Systems.

LABORATORY ANALYSIS

Physical Analysis:

- Particle size distribution was determined by the hydrometer method (Gee and Bander, 1986).
- Bulk density was obtained by the cylindrical core method (Blacke and Hantge, 1986)

Chemical Analysis

- Soil pH was determined in distilled water and potassium chloride solution at ratio 1:1 and 1:2.5 soil/water suspension using pH meter (McLean, 1982).
- SOC content were quantified by Walkley and Black Method (Nelson and Sommers, 1982).
- TN content was determined by the Macrokjeldahl digestion method (Bremmer and Mulvaney, 1982).
- CEC was determined by the NH_4OAC (Ammonion acetate) pH 7 method (Thomas, 1982).

SOC POOL

SOC pool was calculated using the equation of Lal *et al*. (1998):

$$MgCha^{-1} = \frac{(\%\ C \times Pb \times d \times 10^{-4} m^2 ha^{-1})}{100}$$

Where:

$MgCha^{-1}$ = Megagram carbon per hectare (1 Mg = $10^{6g)}$

% C = Percentage of C given by laboratory results

Pb = Soil bulk density (Meggram per cubic meter)

d = Depth in meters)

STATISTICAL AND SPATIAL ANALYSES

- Descriptive statistics

- Experimental design was 2×5×3 factorial in RCBD.

- The factors were parent materials, land use and depths.

- Separation of treatment means for statistical

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL CHARACTERIZATION

- Sand particles are dominant size fraction in both LUTs, 49-85%, followed by clay with 9-40%.

- Textural class ranged from loamy sand to sandy loam at the surface and sandy clay loam to sandy clay at the subsurface horizons.

- The soils were extremely acid to strongly acid (pH 4.4-5.5) in soils under MTC, but very strongly acid to moderately acid (pH 4.5-5.6) in soils under CCC. This supports the findings of Osodeke (2017) and Sullerman et al. (2019).

- Available phosphorus across the major LUTs ranged from moderate to high (9.63-28.07 $mgKg^{-1}$ and varied down the profile. This

Table 1: Mean values of physico-chemical properties of soil under managed tree croplands (MTC)

Parent material	Land use	Depth (cm)	%			Textural Class	BD (g/cm^3)	pH (H_2O)	%		$cmolkg^{-1}$		P (mgKg-1)	SOC Pool
			Sand	Silt	Clay				SOC	TN	K	CEC		
CPS-FRIN-ISIEKE	PPF-PCP	0-19	75	9	16	SL	1.48	5.50	3.63	0.51	0.04	18.01	15.25	133.40
		20-39	71	11	18	SL	1.58	4.90	3.28	0.38	0.02	16.11	19.75	107.60
		40-100	69	3	28	SCL	1.78	4.60	3.28	0.38	0.02	16.11	13.80	33.80
SHL-NIHORT-OKIGWE	MTC-IWP	0-19	75	14	11	SL	1.62	5.0	2.11	0.10	0.05	25.00	18.33	104.10
		20-39	65	22	13	SL	1.81	5.5	3.10	0.20	0.06	22.00	18.33	104.10
		40-100	49	11	40	SC	1.84	5.5	3.06	0.31	0.20	22.00	19.26	326.80
ICS-AIRBDA-AGBALA	MTC-OPP	0-19	75	12	13	LS	1.50	4.9	3.80	0.07	0.62	26.28	28.07	104.10
		20-39	73	10	17	SL	1.63	4.9	3.40	0.08	0.08	23.12	19.10	111.80
		40-100	71	4	25	SCL	1.68	4.8	3.20	0.08	0.06	24.00	17.03	313.80
CPS-NDBDA-KPONG	MTC-PP_K	0-19	77	10	13	SL	1.33	4.702	2.60	0.13	0.06	20.17	19.37	72.50
		20-39	77	6	17	SL	1.33	4.40	2.80	0.13	0.07	17.06	16.07	73.80
		40-100	79	6	15	SL	1.50	4.70	1.80	0.09	0.07	16.89	17.27	172.20
ALV-NDBDA-ISIOKOLO	MTC-PP_I	0-19	85	6	9	LS	1.41	4.78	3.56	0.11	0.19	18.56	20.00	95.60
		20-39	75	10	15	SL	1.85	4.79	2.84	0.13	0.19	14.20	17.00	96.00
		40-100	75	4	21	SCL	2.15	4.82	1.57	0.10	0.12	15.20	15.10	217.90

Keys:

BD	=	Bulk density
CEC	=	Cation Exchange Capacity
TN	=	Total Nitrogen
SOC	=	Soil Organic Carbon
P	=	Phosphorus
K	=	Potassium
LUT	=	Land Utilization type

Table 2: Mean Values of physico-chemical properties of soils under continuously cultivated croplands (CCC)

			%						%		$cmolkg^{-1}$			
Parent material	Land use	Depth (cm)	Sand	Silt	Clay	Textural Class	BD (g/cm^3)	pH (H_2O)	SOC	TN	K	CEC	P (mgKg-1)	SOC Pool
CPS-FRIN-ISIEKE	CCC-CMT_F	0-19	79	11	10	SL	1.56	5.6	1.31	0.25	0.04	11.12	18.33	33.80
		20-39	75	7	18	SL	1.38	5.2	1.34	0.11	0.08	10.81	20.00	31.70
		40-100	66	5	30	SCL	1.66	4.9	0.80	0.34	0.01	12.15	26.67	58.20
SHL-NIHORT-OKIGWE	CCC-CMM	0-19	77	12	11	SL	1.70	4.7	0.87	0.13	0.05	13.00	26.63	27.80
		20-39	65	7	18	SL	1.88	4.9	0.57	0.40	0.05	16.00	18.54	23.60
		40-100	60	13	27	SCL	2.05	5.1	1.03	0.13	0.04	12.00	16.38	98.70
ICS-AIRBDA-AGBALA	CCC-CMO	0-19	80	5	15	SL	1.68	4.5	1.80	0.04	0.08	18.60	23.83	37.20
		20-39	70	5	21	SCL	1.62	4.8	0.91	0.13	0.07	16.40	21.32	26.60
		40-100	71	8	21	SCL	1.93	4.7	0.80	0.14	0.06	13.68	15.27	87.50
CPS-NDBDA-KPONG	CCC-CMY	0-19	81	8	11	LS	1.56	4.66	0.95	0.18	0.10	16.12	10.37	21.40
		20-39	77	6	17	SL	1.66	4.87	0.59	0.09	0.11	13.18	13.27	17.80
		40-100	78	7	15	SL	1.90	4.53	0.57	0.10	0.09	13.02	9.03	61.80
ALV-NDBDA-ISIOKOLO	CCC-MMT_I	0-19	80	11	9	LS	1.70	4.78	3.56	0.11	0.19	18.00	22.00	56.40
		20-39	80	9	11	SL	1.72	4.95	2.84	0.13	0.19	14.83	15.00	62.60
		40-100	75	8	17	SL	2.15	4.82	1.57	0.10	0.12	13.15	16.00	197.80

Keys:

LUD = Land Use Duratiom
BD = Bulk density
CEC = Cation Exchange Capacity
TN = Total Nitrogen
SOC = Soil Organic Carbon
P = Phosphorus
K = Potassium
LUT = Land Utilization type

SOIL ORGANIC CARBON POOL

- MTC had higher ($p<0.05$) SOC pool than CCC soils.

- The SOC pool in MTC Soil was within the ideal range for mitigating climate change and environmental quality control.

- FAO (2017), Lal (2014), Post and Kwom (2002) postulated > 120mgcha^{-1} as the threshold level for surface soil (0-100cm).

Table 4: Mean values of Soil Organic Carbon ($MgCha^{-1}$) pool under different parent materials of managed tree crop lands of the study areas

		Depth (cm)			
Parent material	Land use	0-19	21-39	40-100	Mean Total
CPS-FRIN-Isieke	PPF-PCP	133.40	107.60	334.80	575.80
SHL-NIHORT-Okigwe	MTC-IWP	88.00	104.10	326.80	518.90
ICS-AIRBDA-Agbala	MTC-OPP	102.10	111.80	313.80	527.70
CPS-NDBDA Kpong	MTC-PP_{IC}	72.50	73.80	172.20	318.50
ALV-NDBDA Isiokolo	MTC-PP_{I}	95.60	96.00	217.90	409.50
Mean Total		652.60	633.30	1664.60	2950.50

Table 5: Mean values of Soil Organic Carbon ($MgCha^{-1}$) pool under different parent materials of continuously cultivated croplands of the stud area

		Depth (cm)			
Parent material	**Land use**	**0-19**	**21-39**	**40-100**	**Mean Total**
CPS-FRIN-Isieke	CCC-CMT_F	33.80	31.70	58.20	123.70
SHL-NIHORT-Okigwe	CCC-CMM	27.80	23.60	98.70	150.10
ICS-AIRBDA-Agbala	CCC-CMO	37.20	26.60	87.50	151.30
CPS-NDBDA Kpong	CCC-CMY	21.40	17.80	61.80	101.00
ALV-NDBDA Isiokolo	CCC-CMT_1	56.40	62.60	197.80	316.80
Mean Total		176.60	162.30	504.00	842.90

SOIL ORGANIC CARBON POOL CONT'D

- Significant ($p<0.05$) influence of depth on SOC pool were observed in both land uses.

- The highest (212.70 $mgCha^{-1}$) was observed at 40-100cm soil depth in SHL-NIHORT –Okigwe, whereas the lowest (45-80 $mgCha^{-1}$) was observed at 20-39cm soil depth in CPS-NDBDA-Kpong.

- There was greater soil carbon accumulation in forest soils when compared with other soils.

SOIL ORGANIC CARBON POOL CONT'D

- Land use, depth and parent material; each significantly ($p<0.05$) influence SOC pool.

- There were interactions ($p<0.05$) between land use and depth, land use and parent material on SOC pool.

- Also, significant ($p<0.05$) interactions of land use, depth and parent material on SOC pool was observed.

- This is in line with the findings of Zhie et al. (2009)

Table 5: Effect of land use, depth and parent materials on SOC pool (MgCha-1) under MTC and CCC across the study locations

		Land use			
Parent Materia	**Depth (Cm)**	**MTC**	**CCC**	**Mean**	**Sub mean**
CPS-FRIN-Isieke	0-10	102.60	33.86	68.20	
	20-39	107.60	31.70	69.60	
	40-100	334.80	58.20	196.50	
Sub Mean		**181.70**	**41.20**		**111.50**
SHL-NIHORT-Okigwe	0-10	88.00	27.80	57.90	
	20-39	104.10	23.60	63.90	
	40-100	326.80	98.70	212.70	
Sub Mean		172.90	50.00		**111.50**
ICS-AIRBDA-Agbala	0-10	102.10	37.20	69.70	
	20-39	111.80	26.60	69.20	
	40-100	**313.80**	**87.50**	**200.70**	
Sub Mean		175.90	50.40		**113.20**
CPS-NDBDA-Kpong	0-10	72.50	21.40	46.90	
	20-39	73.20	17.80	45.80	
	40-100	172.20	61.80	117.00	
Sub Mean		**106.20**	**33.70**		**69.90**
ALV-NDBDA-Isiokolo	0-10	95.60	56.40	76.00	
	20-39	96.00	62.60	79.30	
	40-100	217.90	197.80	207.80	
Sub Mean		**136.50**	**105.60**		**121.00**
Total		**154.60**	**56.20**		
LSD (0.05) for Land use					**7.40***
LSD (0.05) for Depth					**6.93****
LSD (0.05) for Parent Material					**11.11****
LSD (0.05) for Land use x Depth					**11.14****
LSD (0.05) for land use x Parent Material					**15.28****
LSD (0.05) for Depth x Parent Material					**15.91****
LSD (0.05) for land use x Depth x Parent Material					**25.23****

CONCLUSION

- Soil organic carbon sequestration is a function of parent material, land use, depth, and soil aggregate sizes.

- Soils under long term managed tree/plantation crops LUTs enhanced carbon sequestration relative to soils under continuously cultivated arable crop.

- Amongst the Managed tree crops LUT C sequestration followed this trend: Pine forest> oilpalm plantation> Irvingia wombulu> plantain plantation.

- Coastal plain sands of FRIN-Isieke had highest amount of SOC pool (575.80 $mgCha^{-1}$) while the alluvial soils of NDBDA –Isiokolo gave the lowest (409.50 $mgha^{-1}$) .

- Pine forest, Oil palm, Irvingia, Plantain plantations and Citrus orchard soils sequestered more carbon across the soil depths and therefore hold a considerable

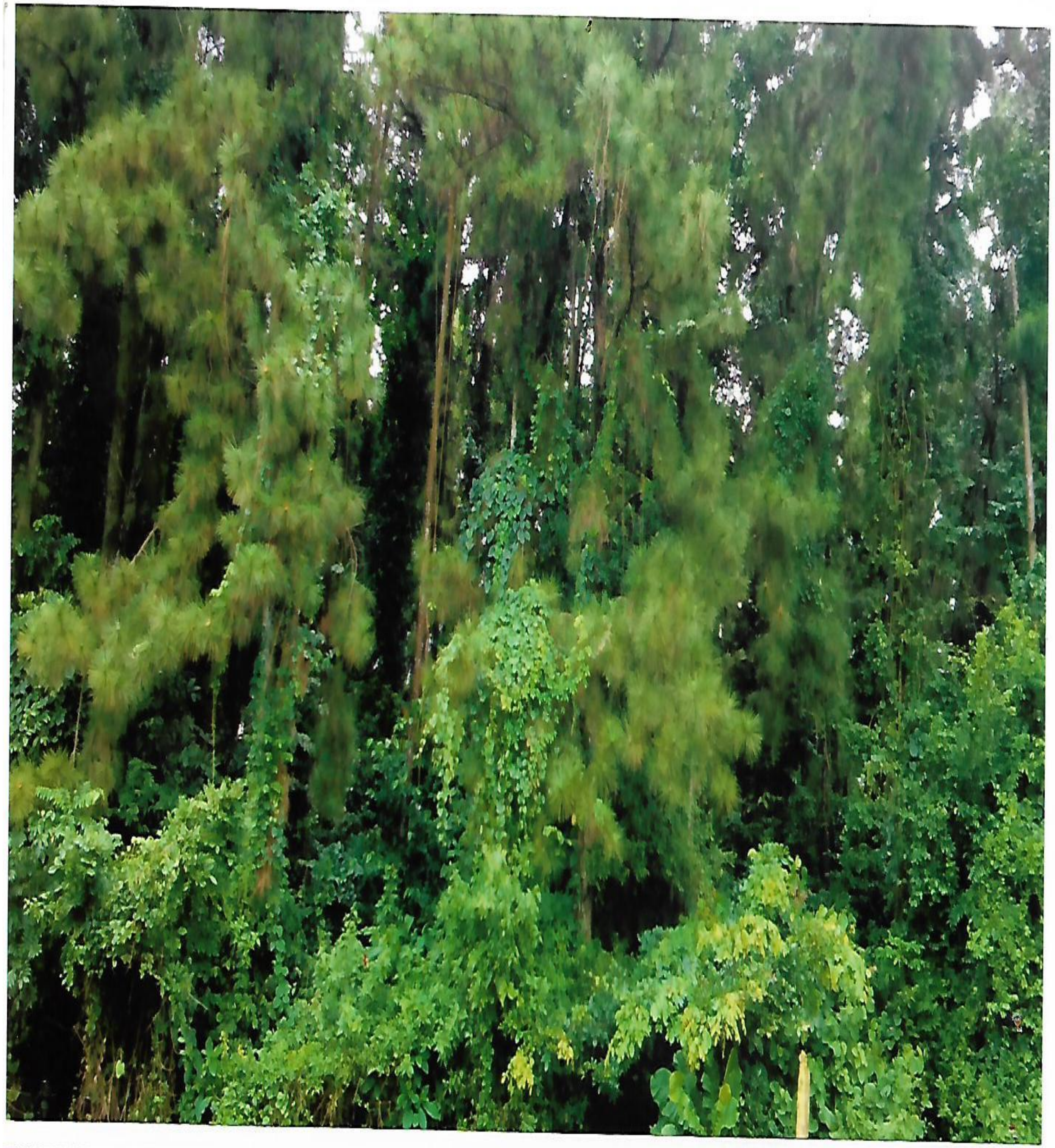
RECOMMENDATIONS

- The soil conservation practices associated with continuously cultivated croplands under the different parent materials in the studied area should be re-evaluated because they are inadequate to maintain the qualities of the soils on sustainable basis with special emphasis on organic mater content, aggregation and aggregate stability.

- Pine forest offered greatest potentials in carbon sequestration and mitigation of climate change. Therefore, pine plantation should be encouraged in the study area.

- Among all the tree croplands studied, soils under oil palm developed highest structural stability with very high SOC pool at 0-100cm depth.

- Therefore, oil palm plantation should be established for the conservation of soil threatened by physical degradation in southern Nigeria.



THANK

YOU

FOR

LISTENING............