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The Use of Model to Determine Ecological Variables Responsible for Soil Organic Carbon Sequestration in Derived Savanna Soils of Southwestern Nigeria

E. O. Adeosun[1*], B. S. Awe[1] and P. O. Ajewole[1]

[1]*Department of Agricultural and Bio-Environmental Engineering, School of Engineering, The Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between all authors. Authors EOA, BSA and POA carried out the soil analysis and field work as well as statistical analysis and modeling. Author EOA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study is to determine the influence of ecological variables on the stock of carbon using a stepwise regression model. The study was carried out at Itapaji, a farming community in the derived savanna zone in Ekiti North Senatorial District. Soil samples were collected from the identified horizons, and the profiles were described following the standard method. Data obtained were analysed using stepwise multiple regression analysis with the aid of SPSS 17. 0. A model that identifies the significant ecological variables that explained increased variability in the SOC sequestration of the study area was developed The model results are expected to be a guide for predicting SOC storage in different soil types with similar land types, agro-ecological conditions, and vegetation types. It is recommended that management practices such as cover crop, residue retention, zero tillage, appropriate use of fertiliser, long fallow period, controlled bush burning, and appropriate management technique suitable for the different topographic land type will enhance SOC sequestration in the study area.

**Corresponding author: Email: adeosuneo@gmail.com;*

Keywords: Itapaji; ecological variables; topographical land type; SOC; stepwise regression; upper slope; middle slope; valley bottom.

1. INTRODUCTION

Carbon sequestration is the removal of carbon dioxide (CO_2) from the atmosphere (source) into green plants (sink) where it can be stored indefinitely. The sink can either be above ground, in the soil or the deeper subsurface environments [1]. Qingren W et al. [2] noted that CO_2 occurs in the greatest concentration and its removal by terrestrial ecosystems through carbon sequestration and converting the sequestered carbon into soil organic carbon (SOC) has provided an excellent opportunity for shifting greenhouse gasses (GHGs) emission to mitigate the climate change. Paustian KJ et al. [3] observed that the soil is an ideal reservoir for storage of organic carbon since it has been depleted due to a long in a stay of land misuse and inappropriate management. Agricultural soils under appropriate management can contain substantial amounts of soil organic matter [4] and [5]. However, the efficiency of carbon sequestration by various vegetation and management in various systems depends largely on environmental factors such as soil types, elevation, slope position temperature, land use and moisture [3].

There are scanty studies on the determination of the influence of ecological variables on soil organic carbon sequestration using step-wise regression models [6] and [7]. The determination of the influence of ecological variables on soil organic carbon sequestration on soils of derived savanna zone of Ekiti State is essential in the enhancement of natural sinks of carbon to mitigate the challenges of climate change.

The overall aim of this research work was to determine the influence of ecological variables on SOC sequestration in the dominant soil types and topographical land type in the derived savanna zone of Ekiti State and identify the variables, which could predict the SOC contents optimally. The results will help in predicting the variables influencing SOC sequestration in other soils with similar ecological conditions.

2. METHODOLOGY

2.1 Study Area

Itapaji is a farming community near Ikole in IkoleLGA. It lies approximately between longitude 5^0 31' and 5^0 52' E and latitude 7^0 47' and 7^0 78' N in Ekiti North Senatorial District. The topography is undulating with dominant slopes and tracts of land found on a small plateau and in wide valley bottoms. The vegetation in this area is a mixture of grasses and scattered trees. The contour maps of selected locations A and B in this site are shown in Figs. 1 and 2. The climate of the study area is located within the tropical climate with two distinct seasons, the rainy season April to October and the dry season between November and March. Annual rainfall is about 1300mm with a bimodal distribution, the first peak occurs in June to July, while the second peak occurs in September to October. The mean temperatures range between 19.5- 23.1^oC with high humidity.

2.2 Fieldwork

The fieldwork was carried out during the raining season of the year 2015. At the site, an area of 10 ha was chosen and divided into two locations A and B of 5 ha each. Two distinct toposequences were identified at each location, and the topographic land type was recorded. At each location, the land types were delineated into the upper slope, middle slope, and valley bottom. In each land type, one profile pit (1m x 1m x 1.5m) was dug. Global Positioning System (GPS) was used to determine the coordinates of the profile location. The morphological characteristics of the soil profiles were described following the procedure in the Soil Survey Manual (Soil Survey Division Staff, 2003). 12 profile pits with 43 horizons were dug. Soil samples were taken from the horizons for physical and chemical analysis in the laboratory.

2.3 Soil Analysis

2.3.1 Soil samples

Soil samples were collected from the profiles were properly labelled and taken to the laboratory, air-dried, gently crushed to break up the peds and sieved with 2 mm sieve to get the fine earth fraction for laboratory analysis.

2.3.2 Bulk density

It was determined using the core method by Black and Hartge [8]. Undisturbed soil cores were taken with metal rings (5 cm diameter and 5 cm height) at each horizon. The weight of the peds was measured, these were then oven dried at 105^{0}C for 10 hours and the final the final weight of the dry soil peds was used to calculate the bulk density.

$$Bulkdensity = \frac{Weightofovendrysoil\ (g)}{Volumeofsoil\ (cm^3)}$$

2.3.3 Soil texture

It was determined by the hydrometer method by Day [9]. Sand, silt, and clay fractions were determined by the Bouyoucos hydrometer using 5% Calgon (Sodium hexametaphosphate) solution, by shaking on a reciprocating shaker for 24 hours to ensure complete dispersion of the soil and determining sizes and amount of particles settling at progressive intervals. The percentage of clay, silt, and sand were determined, and with the aid of soil textural triangle, the soil texture was determined.

2.3.4 Organic carbon

It was determined by the wet oxidation method [10]. The soil organic matter was digested with potassium dichromate (K_2Cr_2O7) using concentrated hydrogen tetraoxosulphate vi (H_2SO_4) to increase temperature and hasten the reaction. 1g of each of finely ground air-dried soil sample was weighed into 250ml Erlen Meyer flask, and 10 m/s of 1 M K_2Cr_2O7 added. Excess dichromate was back titrated with ferrous sulphate solution using barium diphenylamine sulphate as an indicator.

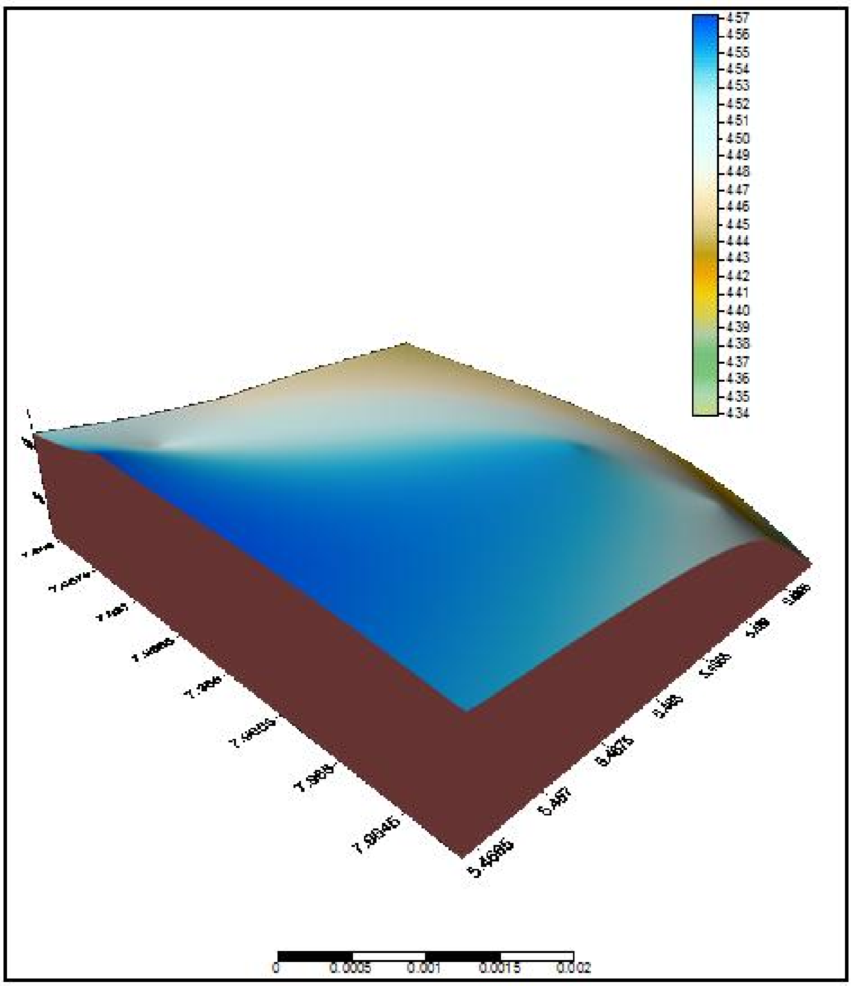

Fig. 1. Contour map showing location A at Itapaji site

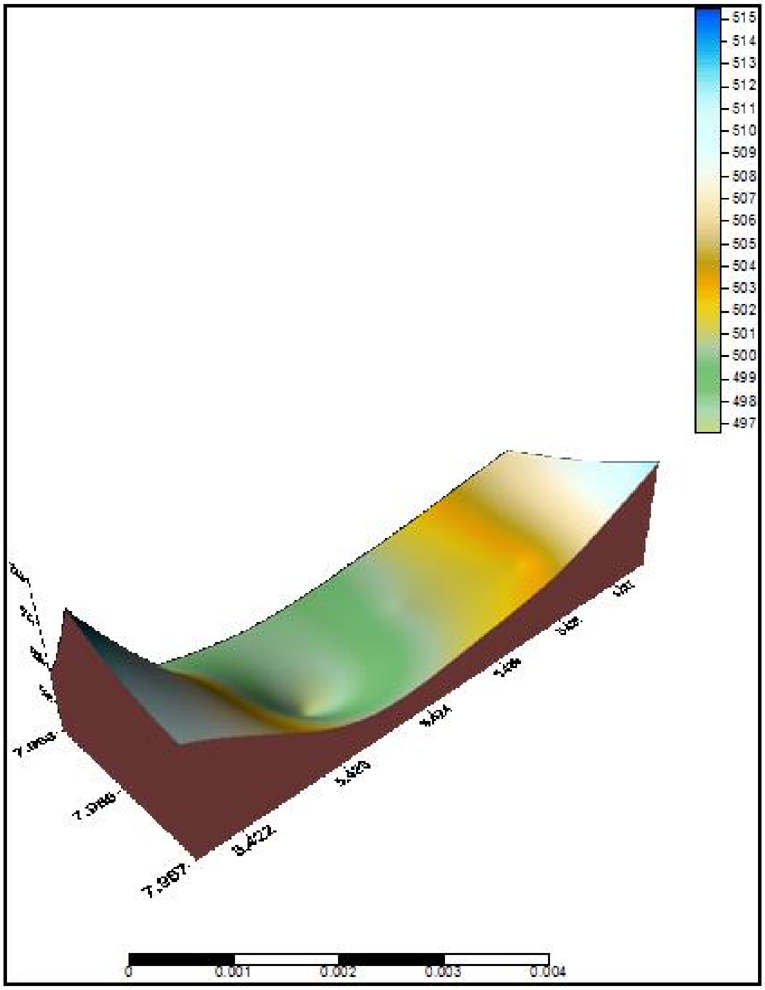

Fig. 2. Contour map showing location B at Itapaji site

The carbon content of the soil was obtained by:

$$\%C = M \times \frac{v_1 - v_2}{s} \times 0.39 \times mcf$$

Where:

M = Molarity of ferrous sulphate solution (from blank titration)
V_1 = ml ferrous sulphate solution required for blank
V_2 = ml ferrous sulphate solution required for sample
S = weight of air dry sample in gram

$$0.39 = 3 \times 10^3 \times 100\% \times 1.3 \;\; (3 = equivalentweightofcarbon)$$

mcf = moisture correction factor (factor 1.3 is a compensation factor for the incomplete combustion of the organic matter in this procedure).

Conversion of the % carbon to % organic matter was done by multiplying with the empirical factor 2: % organic matter = 2 x % carbon.

Total N was determined using the micro-Kjeldahl digestion-distillation method as described by Bremner and Mulvaney [11].

$$\%N = \frac{Titre \times Molarityofacid \times Volumeofextract \times Nfactor \times 100}{Volumeofaliquot \times Weightofsoil\ (g)}$$

2.3.5 Extractable phosphorus

It was determined using filtrates extracted by the Bray and Kurtz [12]. 1 g of soil was put in a test-tube and shaken for about five minutes. The content of the test-tube was filtered into another test-tube. Then 1 ml of a solution made of 5 ml of distilled water, 2 ml of ammonium molybdate, concentrated stannous chloride and 33 ml water was added to the filtrate, shaken and allowed to develop colour.

2.3.6 The extractable bases

The extractable bases (Ca, Mg, Na and K) were determined by atomic absorption spectrophotometer [13]. The micronutrients Fe, Mn, Zn, and Cu were extracted using buffered 0.005 M DPTA [14] and their concentrations determined by an Atomic Absorption Spectrophotometer (AAS) UNICAM 919 model.

The SOC stocks were calculated based on the formula given [15]:

$$SOC = \sum_{i=n}^{i=1}([(BDi \times (THi \times 0.01) \times [1 - \frac{CRi}{100}]\ ) \times Ci] \times 100)$$

Where: *SOC* (Mg/ha) = organic carbon stock in a full profile, *n* = total numbers of horizons in a full profile, *BDi* (g/cm^3) = bulk density of the horizon *I,THi* (cm) = thickness of the horizon *i*in cm, *Cri* (vol. %) = volume of coarse fragments by horizon *I,Ci* (%) = percentage of organic carbon in horizon *i.* The carbon stocks in each soil and topographical land type were obtained by the summation of carbon stocks of each horizon in the profile.

2.4 Statistical Analysis

Land uses (LU), topographical land type (LT) and SOC sequestration were ranked to determine their correlations. Land use ranking was done as follows: fallow = 1, oil palm/cocoa =2, cassava/maize-based = 3, yam based=4, sole cassava-based =5, sole maize-based = 6, and cowpea based =7. For the ranking, fallow was scored 1 because it is the land type with the potential of sequestering the highest amount of soil organic carbon. The other land uses were ranked according to the order of sequestering soil organic carbon.

Land type ranking was in the order: upper slope =1, middle slope =2 and valley bottom =3. For the ranking, the upper slope was scored 1 because of its higher topography. The other land types were ranked according to the order of their topography. Other soil variables used in the correlation are bulk density (BD), moisture content (MC), clay, silt clay ratio (SCR), soil acidity in water and HCl (pH_1, $pH_{2)}$, nitrogen (N), phosphorus (P), potassium (K), cation exchange capacity (CEC), iron oxide (Fe_20_3) and aluminum oxide (Al_20_3). The variables correlated with SOC would be used in step-wise multiple regression analysis for the determination of their influence on SOC contents.

2.4.1 Linear regression analysis

The different variables were subjected to regression analysis to study their individual contribution in the determination of SOC sequestration as indicated by R^2 values. The linear regression model used was:

$$Yi = \beta_o + \beta_1 xi + €, \text{ for } I = 1, 2, \ldots..n$$

The model is valid for n pairs of observations (X1, Y1), (X2, Y2)…….(Xn, Yn).

Where:

Yi = predicted SOC sequestered in the soil (dependent variable)

Xi = predictor variables (independent variables) i.e LU, LT, MC, and other physical and chemical variables.

β_o= intercept (a constant) for the relationship between X and Y

β_1 = regression coefficients of the variable that influence SOC sequestration in the relationships between X and Y.

€ = is the noise or error associated with the SOC values.

The model is called linear or simple regression because there is just one predictor variable in the model with linear β_o and β_1 parameters. Linear regression has the limitation that it handles one dependent variable at a time. A combination of variables cannot be factored into the model. Therefore, multiple regression analysis was used to evaluate the contribution of combined variables.

2.4.2 Multiple regression analysis

The variables that showed significant correlations with SOC stock were subjected to stepwise forward multiple regression analysis using the Statistical Analysis System (SAS) version 17.0 software. The SOC data from soil samples representing forty-three horizons from the twelve profiles were factored into the model for analysis. The model is described as follows:

$$Yn = a + b_1X_1 + b_2X_2 + \ldots..b_nX_n + €$$

Where:

Yn = predicted SOC sequestered in the soil (dependent variable)

X_1, X_2, X_n = variables which influence SOC content (independent variables)

a = intercept (a constant) for the relationships between X and Y

€ = is the noise or error associated with the SOC values. The goodness of the model was based on R^2 and probability levels.

3. RESULTS AND DISCUSSION

The ranges of the results of some soil physicochemical properties of the various sampling locations are presented in Tables 1a and b. The results of the parsons' correlation matrix (Table 2) showed high ($p<0.05$) positive correlation between SOC and land type (LT), land use (LU), moisture content (MC), and clay. A high negative correlation was obtained for bulk density and iron oxide (Fe_2O_3) respectively. Low positive correlation ($p< 0.05$) was obtained between SOC sequestered and phosphorus (P), cation exchange capacity (CEC), potassium (K), silt clay ratio and nitrogen (N) while a low negative correlation was indicated between SOC and pH. [6,7] have also established similar relationships between SOC contents and some of those variables above.

3.1 Influence of Ecological Variables on SOC Sequestration with Linear Regression

The results of the regression analysis showing the influence of the variables on SOC sequestration are presented in Table 3. Twenty-two variables were factored into the linear regression model, eleven variables showed strong influence to varying degrees (R^2 values). The eleven variables that show a significant influence on SOC sequestration are land type (LT), cocoa (Co), Moisture content (MC), Iron oxide (Fe_2O_3), Land use (LU), Bulk density(BD), Zink (Zn), Calcium (Ca), Tomatoes (T), Base Saturation (PBS) and clay (C). The topographical land type had the highest influence ($R^2 = 0.71$) on SOC sequestration, this was followed by the cocoa suitability land type ($R^2 = 0.67$), moisture content ($R^2 = 0.65$), and iron oxide ($R^2 = 0.57$) respectively.

The topographical land type showed a significant influence on SOC sequestration primarily by influencing the production of biomass and secondarily through its effects on soil water and temperature and thus on decomposition [16]. Liu et al. [17] observed that the slope angle had more important effects than did the land-cover on SOC content, clay content and nutrient concentration. Gregorich et al. [18] reported about a significant correlation between SOC and slope gradient and distance from summit positions. Norton et al. [16] indicated that total carbon concentrations were greatest on back slopes and lowest on summits and toe slopes due to localised accumulations of nutrients from surface run-on contributions whose concentrations gradually decreased down the slope.

The influence of LU on SOC sequestration is supporting the assertion made by some earlier researchers [19,20] and [21] that reported that land use influences change in soil carbon content. It was observed that agricultural and other land use practices have a significant influence on how much carbon that can be sequestered and how long it can be stored in the soil before it is returned to the atmosphere. it was also observed by Singh et al. [22] in his own research that the organic carbon contentment can significantly increase six years in agricultural land use over uncultivated soil because soil organic carbon is a factor that is important to soil fertility as well as to the environment because of huge carbon sequestration potential of the soils. It has an important influence on the chemical and physical properties of the soil, and it can release nutrients through mineralisation in forms available to plants over the uncultivated soil.

Table 1a. Physico-chemical properties of soils at location A

Profile ID	Horizon Designation	Depth Cm	Sand (%)	Silt (%)	Clay (%)	Silt/clay	Textural Class	M C (%)	BD (g/cm^3)	pH KCl	pH H_2O	OC %	N	P Mg/kg	K	CEC	Fe_2O_3	Al_2O_3
IA_1	Ap	0-15	85.3	3.0	11.7	0.26	LS	10.11	1.44	5.16	6.06	1.40	0.31	8.01	0.76	2.73	0.33	0.57
	Bt1	15-44	80.3	2.0	17.7	0.11	SL	10.35	1.40	4.47	5.39	0.10	0.41	3.50	1.05	4.03	0.10	0.21
	Bt2	44-95	72.3	7.0	20.7	0.04	SCL	11.13	1.50	4.63	5.91	0.86	0.01	3.42	0.32	2.75	0.27	0.25
	C	95-160	61.2	0.6	38.2	0.02	SC	11.45	1.52	4.65	5.72	0.60	0.00	8.01	0.41	6.93	0.24	0.40
IA_2	Ap	0-7	88.1	3.2	8.7	0.37	LS	10.13	1.59	4.85	5.81	1.00	0.19	3.97	0.34	2.24	0.31	0.77
	Bt	7-17	72.2	1.0	26.8	0.04	SCL	11.15	1.33	4.64	5.67	0.37	0.10	2.59	0.46	4.94	0.20	0.60
	R(Hard pan)	> 17																
IA_3	A	0-15	89.6	3.7	6.7	0.55	LS	12.59	1.65	4.53	6.03	4.79	0.57	3.60	0.63	2.95	0.99	0.45
	Bt1	15-62	80.7	3.7	15.6	0.24	LS	13.16	1.60	4.32	5.68	3.63	0.48	3.58	0.24	3.67	0.21	0.53
	Bt2	62-100	66.6	3.7	29.7	0.12	SCL	14.79	1.53	4.47	5.84	2.16	0.20	3.34	1.05	3.73	0.27	0.76
	C	100-150	66.6	10.7	22.7	0.47	SCL	15.82	1.60	4.48	5.88	1.77	0.15	3.27	0.63	5.02	0.19	0.77
IA_4	Ap	0-22	83.6	10.7	5.7	1.87	LS	11.02	1.37	4.53	5.96	1.15	0.48	4.72	0.88	5.41	0.34	0.57
	B	22-37	87.5	4.9	8.7	0.56	S	11.49	1.31	4.29	5.41	0.55	0.35	4.70	0.41	4.62	0.31	0.53
	Bt1	37-52	79.6	3.7	17.7	0.15	SL	12.02	1.17	4.36	5.63	0.41	0.21	3.63	0.23	3.81	0.26	0.76
	Bt2	52-100	66.4	10.7	20.7	0.13	SCL	12.13	1.30	3.87	5.33	0.17	0.10	3.42	0.17	7.25	0.23	0.60
	C	100-160	53.2	2.7	44.02	0.06	C	13.22	1.27	3.80	5.14	0.08	0.02	3.42	0.11	6.55	0.51	0.76
IA_5	Ap	0-23	85.2	11.6	3.7	3.13	LS	12.06	1.48	4.48	5.84	0.96	0.55	3.73	0.37	5.02	0.29	0.79
	Bt	23-60	54.1	6.2	39.7	0.16	SC	13.22	1.38	3.88	5.21	0.96	0.50	3.66	0.27	2.96	0.24	0.57
	C	60-120	52.3	3.7	44.0	0.08	C	14.00	1.32	3.40	5.11	0.39	0.48	3.11	0.12	2.88	0.14	0.57
IA_6	A	0-20	86.6	6.9	6.5	1.06	LS	12.31	1.40	4.03	5.60	4.60	0.55	3.82	0.76	2.99	1.40	0.57
	Bt1	20-60	85.2	3.0	14.8	0.25	LS	15.03	1.17	4.05	5.50	3.10	0.45	3.73	0.05	2.44	1.43	0.76
	Bt2g	60-150	66.8	2.0	31.2	0.06	SCL	20.12	1.40	4.43	5.40	2.33	0.32	3.34	0.56	3.56	1.29	0.76

Table 1b. Physico-chemical properties of soils at location A

Profile ID	Horizon Designation	Depth Cm	Sand (%)	Silt (%)	Clay (%)	Silt/clay	Textural Class	M C (%)	BD (g/cm^3)	pH KCl	pH H_2O	OC %	N	P Mg/kg	K	CEC	Fe_2O_3	Al_2O_3
IB_1	Ap	0-24	70.6	15.4	15.0	1.02	SL	10.06	1.28	4.83	5.74	0.92	0.54	3.97	0.46	2.32	0.33	0.83
	Bt1	24-32	70.2	14.4	15.4	0.94	SL	11.12	1.09	3.85	5.55	0.56	0.48	3.89	0.07	3.82	0.24	0.68
	Bt2	32-92	53.2	13.4	33.4	0.40	C	11.51	1.19	3.93	5.55	0.44	0.41	3.83	0.12	2.51	0.30	0.53
	C	92-160	52.0	11.8	36.2	0.33	C	12.00	1.17	3.95	5.56	0.40	0.40	3.42	0.17	4.51	0.19	0.47
IB_2	Ap	0-20	65.5	15.9	18.8	0.95	SCL	12.12	1.30	4.02	6.60	2.15	0.19	4.20	0.34	2.16	0.33	0.60
	Bt	20-60	62.6	13.6	23.8	0.57	SCL	13.00	1.21	4.10	5.19	1.32	0.11	3.97	0.46	4.74	0.11	0.42
	R(Hard)	>60																
IB_3	A	0-30	72.2	17.8	10.0	1.78	SL	10.11	1.62	3.63	5.34	3.00	0.08	3.60	0.46	2.40	1.47	1.36
	Bt1	30-40	75.6	8.7	15.7	0.55	SL	13.20	1.60	3.80	5.39	1.14	0.02	3.52	0.07	2.59	0.33	0.68
	Bt2	40-90	62.2	17.4	20.4	0.24	SCL	14.12	1.40	2.78	5.45	4.33	0.30	3.33	0.12	4.62	0.66	0.42
	C	90-120	60.1	6.9	33.0	0.20	SCL	15.06	1.40	3.80	5.62	5.97	0.44	2.23	0.17	4.79	0.16	0.79
IB_4	Ap	0-14	71.9	12.4	15.7	0.78	SL	10.11	1.60	4.18	5.50	1.37	0.25	4.36	0.54	1.13	0.51	0.83
	Bt1	14-58	65.3	2.5	32.2	0.07	SC	11.03	1.60	3.87	5.52	1.00	0.05	3.70	0.07	2.11	0.36	0.76
	Bt2	58-100	54.1	2.3	43.6	0.05	C	11.54	1.55	3.84	5.53	0.92	0.04	3.66	0.15	3.26	0.21	0.70
	C	100-150	50.0	1.0	49.0	0.02	C	12.02	1.50	3.82	5.54	0.16	0.04	3.34	0.20	4.15	0.14	0.68
IB_5	Ap	0-20	74.5	9.7	15.8	0.61	SL	12.62	1.48	4.30	5.78	1.39	0.54	4.59	0.46	2.52	0.34	0.76
	Bt1	20-60	78.2	5.1	16.7	0.31	SL	13.12	1.43	4.20	5.42	1.02	0.52	3.89	0.17	2.69	0.30	0.57
	Bt2	60-85	62.6	2.0	35.4	0.06	SCL	13.37	1.40	4.18	5.35	1.02	0.42	2.89	0.29	3.27	0.33	0.85
	C	85-160	52.6	9.7	37.7	0.26	C	14.02	1.38	4.10	5.30	0.10	0.40	2.02	0.21	3.40	0.20	0.76
IB_6	A	0-20	76.5	15.0	8.5	1.76	SL	13.22	1.56	4.21	5.71	5.07	0.41	4.60	0.54	1.33	0.57	0.68
	Bt1	20-55	75.2	1.0	23.8	0.04	SCL	14.16	1.45	4.15	5.63	4.08	0.23	3.66	0.24	1.68	1.03	0.57
	Bt2	55-100	66.7	1.0	32.3	0.03	SC	15.62	1.67	4.18	5.65	3.45	0.32	3.42	0.20	1.43	1.94	0.47
	C	100-160	67.2	11.0	21.8	0.50	SCL	16.13	1.68	3.06	4.65	3.07	0.13	2.66	0.16	3.73	2.60	0.19

Table 2. Pearson correlation matrix for variables which influences SOC

	LU	LT	MC	BD	Clay	Silt/clay	pH1	pH2	N	P	K	CEC	Fe2O3	Al2O3	SOC
LU	1														
LT	-0.778**	1													
MC	-0.620*	0.824**	1												
BD	-0.515	0.522	0.259	1											
Clay	0.745**	-0.486	-0.356	-0.021	1										
Silt/clay	0.330	0.194	0.193	-0.331	0.098	1									
pH1	-0.081	-0.286	-0.343	-0.009	-0.315	-0.635*	1								
pH2	-0.196	-0.095	-0.268	-0.047	-0.343	-0.345	0.619*	1							
N	0.169	0.220	0.413	-0.240	0.059	0.426	-0.106	-0.392	1						
P	0.181	-0.541	-0.381	-0.188	0.019	-0.327	0.455	0.382	-0.302	1					
K	0.463	0.025	-0.042	0.001	0.270	0.583*	-0.046	-0.197	0.445	-0.006	1				
CEC	0.193	-0.389	-0.368	-0.320	-0.343	0.024	0.294	0.232	-0.126	0.302	0.133	1			
Fe2O3	-0.617*	0.651*	0.797**	0.290	-0.346	0.042	-0.307	-0.412	0.133	-0.214	-0.216	-0.486	1		
Al2O3	0.008	0.204	0.111	0.032	0.161	0.083	-0.426	-0.424	0.180	-0.787**	-0.100	-0.064	-0.053	1	
SOC	0.799**	0.807**	0.615*	-0.697*	0.524	0.122	0.000	-0.060	0.010	0.387	0.171	0.319	-0.654*	0.000	1

*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed)*

Table 3. Results of prediction of SOC by linear regression analysis

Predictor variable	N	R^2	Regression equation
Land type (LT)	12	0.71	Y = 14.69 + 15.68 LT
Cocoa (Co)	12	0.67	Y = 81.41 – 25.06 Co
Moisture Content (MC)	12	0.65	Y = 81.45 + 7.76 MC
Fe_2O_3 (F)	12	0.57	Y = 3.24 + 26.07 Fe_2O_3
Land use (LU)	12	0.54	Y = 35.74 – 6.54 LU
Bulk Density (BD)	12	0.32	Y = - 80.54 + 68.89BD
Zink (Zn)	12	0.30	Y = 6.25 + 68.71 Zn
Calcium (Ca)	12	0.29	Y = 39.07 – 11.36 Ca
Tomatoes (T)	12	0.23	Y = - 29.20 + 16.68 T
Base Saturation (PBS)	12	0.21	Y = 120.59 – 1.35 PBS
Clay (C)	12	0.16	Y = 43.63 – 1.18C

Table 4. Step-wise multiple regression equations on the influence of ecological variables on SOC sequestration

Influencing variables	R^2	Regression equations
LT	0.71	Y = 14.69+15.68 LT
LT+Co	0.75	Y = 25.85+10.02LT-11.31Co
LT+Co+MC	0.76	Y = -6.28+8.45LT-7.85Co+2.08MC
LT+Co+MC+F	0.80	Y = 22.06+8.41LT-8.40Co-0.49MC+11.02F
LT+Co+MC+F+LU	0.81	Y = 19.08+7.88LT-7.64Co-0.20MC+10.43F-0.42LU
LT+Co+MC+F+LU+BD	0.83	Y= -63.46+4.77LT-1.62Co+2.54MC+7.90F-0.62LU+28.60BD
LT+Co+MC+F+LU+BD+Zn	0.84	Y = -82.63+5.64LT-1.00Co+2.63MC+0.17F-0.33LU+38.18BD+28.90Zn
LT+Co+MC+F+LU+BD+Zn+Ca	0.85	Y = -104.42+5.52LT+2.15Co+3.43MC-10.76F-0.49LU+45.96BD+60.16Zn-2.99Ca
LT+Co+MC+F+LU+BD+Zn+Ca+T	0.86	Y = -156.43+6.49LT+12.36Co+2.94MC-49.02F-0.57LU+68.12BD+183.23Zn-16.23Ca+9.47T
LT+Co+MC+F+LU+BD+Zn+Ca+T+PBS	0.88	Y = -448.99+14.08LT+30.53Co-6.39MC-134.98F+3.15LU+165.97BD+551.96Zn-64.66Ca+30.97T+2.91PBS
LT+Co+MC+F+LU+BD+Zn+Ca+T+PBS +C	0.99	Y=-2244.81+162.87LT+24.19Co-160.02MC-15.27F-47.90LU+121.89BD+1507.48Zn-206.67Ca+137.12T+38.09PBS+32.33C

The bulk density, iron oxide, moisture content, and clay contributed significantly to the prediction of SOC sequestration in the study area. Zinn et al. [23] reported about the contribution of Fe_2O_3 concerning the total (clay + silt) fraction to the retention of organic carbon in the soil. The extent to which the influence could be affected by combining the variables cannot be determined by simple linear regression. This was determined bymultiple regression, as discussed in Tables 3 and 4.

3.2 Influence of Ecological Variables on SOC Sequestration with Multiple Regression Analysis

From the results of the stepwise regression analysis, equations for determining the influence of ecological variables on SOC sequestration in Itapajiagro-ecological zone were established as shown in Table 4. In the first equation, LT significantly ($p<0.05$) contributed 71% of the influence on SOC contents. The inclusion of cocoa suitability land type in the model increased the influence ($P<0.05$) of SOC contents from 71% to 75%. The combination of all the ten variables (Co, MC, Fe2O3, LU, BD, Zn, Ca, T, PBS, and C) influenced the SOC sequestration from 71% to 99%. The additional contribution of individual variables in the stepwise regression of SOC contents were minimal. However, their combination improved the influence on SOC sequestration over LT alone by an additional 28%. These results show that LT had the strongest influence on SOC sequestration, followed by Co with smaller influence made by each of the other variables.

4. CONCLUSIONS

The results of this study indicated that LT had the strongest influence on SOC sequestration because it accounted for 71%, the inclusion of other variables influences the SOC by 28%. Hence, LT, Co-MC,and BD could be taken as the major ecological variables that influence the SOC sequestration in Itapajiagro-ecological zone of Ekiti State.

5. RECOMMENDATION

(a). Management practices such as cover crop, residue retention, zero tillage, appropriate use of fertiliser, long fallow period, and controlled bush burning should be carried out to improve the land use system of the study area.

(b). Appropriate management technique suitable for different topographic land type should be used to enhance SOC sequestration in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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